ZOO501 - Developmental Biology

1. Note on protostomes? 5

Greek, "mouth first"), which include the mollusc, arthropod, and worm phyla, are so called because the mouth is formed first, at or near the opening to the gut, which is produced during gastrulation. The anus forms later at another location.

There are two major branches of the protostomes.

The **Ecdysozoa** includes those animals that molt. Its major constituent is Arthropoda, a phylum containing insects, arachnids, mites, crustaceans, and millipedes.

The second major group of protostomes are the **Lophotrochozoa**. They are characterized by a common type of cleavage (spiral), a common larval form, and a distinctive feeding apparatus. These phyla include annelids, molluscs, and flatworms.

2. Blastocyst? 2

A blastomere is a cell derived from cleavage in an early embryo. A blastula is an embryonic structure composed of blastomeres. The cavity in the blastula is the blastocoel. A mammalian blastula is called a blastocyst.
During a process called **cavitation**, the trophoblast cells secrete fluid into the morula to create a blastocoel. The inner cell mass is positioned on one side of the ring of trophoblast cells. The resulting structure, called the **blastocyst**,

3. Cadherin types? 2

E-cadherin P-cadherin N-cadherin Protocadherins

4. difference B/W protocadherin and other Cadherin?

Protocadherins: Calcium-dependent adhesion proteins that differ from the classic Cadherins in that they lack connections to the cytoskeleton through catenins. Protocadherins have been found to be very important in separating the notochord from the other mesodermal tissues during Xenopus gastrulation.
E-cadherin: Epithelial cadherin is expressed on all early mammalian embryonic cells, even at the 1-cell stage. Later, this molecule is restricted to epithelial tissues of embryos and adults.
P-cadherin: Placental cadherin appears to be expressed primarily on the trophoblast cells (those placental cells of the mammalian embryo that contact the uterine wall) and on the uterine wall epithelium.
N-cadherin: Neural cadherin is first seen on mesodermal cells in the gastrulating embryo as they lose their Ecadherin expression. It is also highly expressed on the cells of the developing central nervous system.

5. Reasons why snail cytoplasm don't diffuse during development? 5

At one extreme are the eggs of sea urchins, mammals, and snails. These eggs have sparse, equally spaced yolk and are thus **isolecithal** (Greek, "equal yolk"). In these species, cleavage is **holoblastic** (Greek *holos,* "complete"). meaning that the cleavage furrow extends through the entire egg.
Zygotes containing large accumulations of yolk undergo **meroblastic** cleavage, wherein only a portion of the cytoplasm is cleaved. The cleavage furrow does not penetrate into the yolky portion of the cytoplasm.
The eggs of insects have their yolk in the center (i.e., they are **centrolecithal**), and the divisions of the cytoplasm occur only in the rim of cytoplasm around the periphery of the cell (i.e., **superficial** cleavage).
The eggs of birds and fishes have only one small area of the egg that is free of yolk (**telolecithal** eggs), and therefore, the cell divisions occur only in this small disc of cytoplasm, giving rise to the **discoidal** pattern of cleavage.

6. Somit,tadpole and neural tube? 3

Somite: The mesodermal tissue adjacent to the notochord becomes segmented into somites, the precursors of the frog's back muscles, spinal cord, and dermis
Neurul Tube: Notochard is a rod of mesodermal cells in the most dorsal portion of the embryo. At this stage, the embryo is called a Neurula. The neural precursor cells elongate, stretch, and fold into the embryo forming the neural tube.
Tadpole: Somites appear as blocks of mesodermal tissue. The embryo develops a mouth and an anus, and it elongates into the typical tadpole structure.

7. What is the process of primary neurulation...2 final term topic

n **primary neurulation**, the cells surrounding the neural plate direct the neural plate cells to proliferate, invaginate, and pinch off from the surface to form a hollow tube.

8. What is cavitation2

During a process called **cavitation**, the trophoblast cells secrete fluid into the morula to create a blastocoel. The inner cell mass is positioned on one side of the ring of trophoblast cells. The resulting structure, called the **blastocyst**, is another hallmark of mammalian cleavage.

9. What are two main startegie of developmental commitment? 3

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

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.

10. what is the differences between primary and secondary neurulation.3 final term topic

In **primary neurulation**, the cells surrounding the neural plate direct the neural plate cells to proliferate, invaginate, and pinch off from the surface to form a hollow tube.

➢In **secondary neurulation**, the neural tube arises from a solid cord of cells that sinks into the embryo and subsequently hollows out to form a hollow tube.

11. Primary neurulation .in final term topic

During primary neurulation, the original ectoderm is divided into three sets of cells.

▪ The internally positioned neural tube, which will form the brain and spinal cord.

▪ The externally positioned epidermis of the skin.

The neural crest cells. The neural crest cells form in the region that connects the neural tube and epidermis, but then migrate elsewhere; they will generate the peripheral neurons and glia, the pigment cells of the skin, and several other cell types.

12. Blastocoels .2

A fluid-filled cavity, the blastocoel, forms in the animal hemisphere. This cavity will be important for allowing cell movements to occur during gastrulation

13. Difference B/W Somatic Cell and Germ and Cell blastomere ?

Germ Cell: In many species a specialized portion of egg cytoplasm gives rise to cells that are the precursors of the gametes (the sperm and egg). The gametes and their precursor cells are collectively called germ cells, and they are set aside for reproductive function.

Somatic Cell: All the other cells of the body are called Somatic cells. This separation of somatic cells (which give rise to the individual body) and germ cells (which contribute to the formation of a new generation) is often one of the first differentiations to occur during animal development.

blastomeres

After fertilization, the development of a multicellular organism proceeds by a process called **cleavage**, a series of mitotic divisions whereby the enormous volume of egg cytoplasm is divided into numerous smaller, nucleated cells. These cleavage-stage cells are called **blastomeres**.

14. Gray and white matter.

the mantle zone, containing the neuronal cell bodies, is often referred to as the **Gray matter**; the axonal, marginal layer is often called the **White matter**. In the spinal cord and medulla, this basic three-zone pattern of ependymal, mantle, and marginal layers is retained throughout development. The gray matter (mantle) gradually becomes a butterfly-shaped structure surrounded by white matter; and both become encased in connective tissue

15. **Modes of commitment 5**

Three basic modes of commitment are,
Autonomous specification
Conditional specification
Syncytial specification
Autonomous specification: Specification by differential acquisition of certain cytoplasmic molecules present in the egg. Characteristic of most invertebrates. Cell type specification
Conditional specification: Characteristic of all vertebrates and few invertebrates. Specification by interactions between cells. Relative positions are important. Variable cleavages produce no invariant fate assignments to cells. o Massive cell rearrangements and migrations precede or accompany specification. o Capacity for "regulative" development: allows cells to acquire different functions.
Syncytial specification: • Characteristic of most insect classes. • Specification of body regions by interactions between cytoplasmic regions prior to cellularization of the blastoderm. Modes of commitment
• Variable cleavage produces no rigid cell fates for particular nuclei. • After cellularization, conditional specification is most often seen.

16. ROLE AND CAUSE OF MPF.?

Role of MPF in Early Developmental Processes
The transition from fertilization to cleavage is caused by the activation of mitosis promoting factor (MPF).
MPF was first discovered as the major factor responsible for the resumption of meiotic cell divisions in the ovulated frog egg.

> Blastomeres generally progress through a cell cycle consisting of just two steps: M (mitosis) and S (DNA synthesis). Cleaving cells can be experimentally trapped in S phase by incubating them in an inhibitor of protein synthesis. When MPF is microinjected into these cells, they enter M. Their nuclear envelope breaks down and their chromatin condenses into chromosomes. After an hour, MPF is degraded and the chromosomes return to S phase.

What causes this cyclic activity of MPF?

Mitosis-promoting factor contains two subunits.

- The large subunit is called **cyclin B**.
- Small subunit of MPF, the **cyclin-dependent kinase**
- **Cyclin B** is often encoded by mRNAs stored in the oocyte cytoplasm, and if the translation of this message is specifically inhibited, the cell will not enter mitosis. The presence of cyclin B depends upon its synthesis and its degradation. Cyclin B regulates the small subunit of MPF, the **cyclin-dependent kinase**.

17. Syncatiam.2

> In early embryos of these insects, cell division is not complete. Rather, the nuclei divide within the egg cytoplasm. This creates many nuclei in the large egg cell.

A cytoplasm that contains many nuclei is called a **syncytium**.

18. **What is gastrulation? 2**

Gastrulation is a phase early in the embryonic development of most animals, during which the single-layered blastula is reorganized into a multilayered structure known as the gastrula.

19. Blastodisc.3

the embryo-forming portion of an egg with discoidal cleavage usually appearing as a small disc on the upper surface of the yolk mass — see egg illustration.

20. Early and late response of egg sperm.3

The responses of the egg to the sperm can be divided into "early" responses, which occur within seconds of the cortical reaction, and "late" responses, which take place several minutes after fertilization begins.
Early responses:

Contact between sea urchin sperm and egg activates the two major blocks to polyspermy: the fast block, initiated by sodium influx into the cell, and the slow block, initiated by the intracellular release of calcium ions. The activation of all eggs appears to depend on an increase in the concentration of free calcium ions within the egg. Such an increase can occur in two ways:
calcium ions can enter the egg from outside, or calcium ions can be released from the endoplasmic reticulum within the egg.

Late responses:

Shortly after the calcium ion levels rise in a sea urchin egg, its intracellular pH also increases. The rise in intracellular pH begins with a second influx of sodium ions, which causes a 1:1 exchange between sodium ions from the seawater and hydrogen ions from the egg.
This loss of hydrogen ions causes the pH to rise. It is thought that the pH increase and the calcium ion elevation act together to stimulate new protein synthesis and DNA synthesis.
The late responses of fertilization brought about by these ionic changes include the activation of DNA synthesis and protein synthesis.

21. Process of gene regulation.5

The regulation of gene expression can be accomplished at several levels
Differential gene transcription: It regulates that which of the nuclear genes is transcribed into RNA.
Selective nuclear RNA processing: It regulating which of the transcribed RNAs (or which parts of such a nuclear RNA) enter into the cytoplasm to become messenger RNAs.
Selective messenger RNA translation: It regulates that which of the mRNAs in the cytoplasm becomes translated into proteins.

Differential protein modification: It regulates that which proteins are allowed to remain or function in the cell.

22. Define Marginal zone, Area pellucida, Sub germinal cavity, Area opaca.

Between the blastoderm and the yolk is a space called the **sub-germinal cavity**. This space is created when the blastoderm cells absorb fluid from the albumin ("egg white") and secrete it between themselves and the yolk. At this stage, the deep cells in the center of the blastoderm are shed and die, leaving behind a onecell- thick **area pellucida**. This part of the blastoderm forms most of the actual embryo. The peripheral ring of blastoderm cells that have not shed their deep cells constitutes the **area opaca**.Between the area pellucida and the area opaca is a thin layer of cells called the **marginal zone** (or **marginal belt**).

23. Transcription factor 5

Transcription factors are proteins that bind to enhancer or promoter regions and interact to activate or repress the transcription of a particular gene. Most transcription factors can bind to specific DNA sequences. Transcription factors have three major domains. 1. DNA-binding do-
main 2. Protein-protein interaction domain 3. Trans-activating domain

24. Why ascidian are called tunicates.3

Ascidians, members of the tunicate subphylum, are fascinating animals for several reasons, but the foremost is that they are invertebrate chordates. They have a notochord as larvae (and therefore are chordates), but they lack vertebrae.
As larvae, they are free-swimming tadpoles; but when the tadpole undergoes metamorphosis, it sticks to the sea floor, its nerve cord and notochord degenerate, and it secrete a cellulose tunic (which gave the name "tunicates" to these creatures).

25. The acrosomal reaction in sea urchins.3

In most marine invertebrates, the acrosomal reaction has two components:
The fusion of the acrosomal vesicle with the sperm plasma membrane (an exocytosis that results in the release of the contents of the acrosomal vesicle).The extension of the acrosomal process. The acrosomal reaction in sea urchins is initiated by contact of the sperm with the egg jelly. Contact with egg jelly causes the exocytosis of the sperm's acrosomal vesicle and the release of proteolytic enzymes that can digest a path through the jelly coat to the egg surface**.** In sea urchins, the acrosomal reaction

is thought to be initiated by a fucose-containing polysaccharide in the egg jelly that binds to the sperm and allows calcium to enter into the sperm head. The exocytosis of the acrosomal vesicle is caused by the calcium-mediated fusion of the acrosomal membrane with the adjacent sperm plasma membrane. The second part of the acrosomal reaction involves the extension of the acrosomal process. This protrusion arises through the polymerization of globular actin molecules into actin filaments. The egg jelly factors that initiate the acrosomal reaction in sea urchins are often highly specific to each species.

26. Marginal belt.2

Between the area pellucida and the area opaca is a thin layer of cells called the **marginal zone** (or **marginal belt**).

27. Define zona pellucida 2 marks

Zona pellucida: The strong membrane that forms around an ovum as it develops in the ovary. The membrane remains in place during the egg's travel through the fallopian tube. To fertilize the egg, a sperm must penetrate the thinning zona pellucida. If fertilization takes place, the zona pellucida disappears, to permit implantation in the uterus

28. Cleavage is found in sea urchins

Sea urchins exhibit **radial holoblastic cleavage**. The first and second cleavages are both meridional and are perpendicular to each other. That is to say, the cleavage furrows pass through the animal and vegetal poles.
The third cleavage is equatorial, perpendicular to the first two cleavage planes, and separates the animal and vegetal hemispheres from one another. The fourth cleavage, however, is very different from the first three. The four cells of the animal tier divide meridionally into eight blastomeres, each with the same volume. These cells are called **mesomeres**. The vegetal tier, however, undergoes an unequal equatorial cleavage to produce four large cells, the **macromeres**, and four smaller **micromeres** at the vegetal pole.

29. Difference between sex and reproduction.

Sex and reproduction are two distinct and separable processes. Reproduction involves the creation of new individuals. Sex involves the combining of genes from two different individuals into new arrangements.

30. Differentiate between animal pole and vegetable pole 3

vegetal pole. :the point on the surface of an egg that is diametrically opposite to the animal pole and usually marks the center of the protoplasm containing more yolk, dividing more slowly and into larger blastomeres than that about the animal pole,

31. Role of calcium in fusion of sperm and egg.3

The third step is the cell fusion event itself. As in most membrane fusions, calcium ions are critical, and fusion can be activated by **calcium ionophores, such as A23187**, that carry calcium ions across cell membranes.
Fusion appears to be mediated by a set of metalloproteinases called **meltrins**. These proteins were discovered during a search for myoblast proteins that would be homologous to **fertilin**, a protein implicated in sperm-egg membrane fusion.

32. Role of calcium and bicarbonate in capactation.2

Calcium and bicarbonate ions may be critical in activating cAMP (Cyclic adenosine monophosphate) production and in facilitating the membrane fusion events of the acrosomal reaction

33. Zp3 and its role in

Thus, ZP3 is the specific glycoprotein in the mouse zona pellucida to which the sperm bind. ZP3 also initiates the acrosomal reaction after sperm have bound to it.

34. Developmental genetics? 2

Developmental genetics is the discipline that examines how the genotype is transformed into the phenotype, and the major paradigm of developmental genetics is differential gene expression from the same nuclear repertoire.

35. Transcription Factor Domain?

Transcription factors have three major domains. 1. DNA-binding domain 2. Protein-protein interaction domain 3. Trans-activating domain.

36. Estrogen and progesterone.

If the frog is mature, the pituitary gland secretes hormones that stimulate the ovary to make estrogen. **Estrogen** is a hormone that can instruct the liver to make and secrete the yolk proteins, which are then transported through the blood into the enlarging eggs in the ovary. The yolk is transported into the bottom portion of the egg.

Another ovarian hormone, **progesterone**, signals the egg to resume its meiotic division. This is necessary because the egg had been "frozen" in the metaphase of its first meiosis. When it has completed this first meiotic division, the egg is released from the ovary and can be fertilized.

37. Embryonic shield.

The cells of both the epiblast and hypoblast intercalate on the future dorsal side of the embryo to form a localized thickening, the **embryonic shield.**

38. The interaction of sperm and egg generally proceeds according to five basic step:

- ➢ The chemo-attraction of the sperm to the egg by soluble molecules secreted by the egg.
- ➢ The exocytosis of the acrosomal vesicle to release its enzymes.
- ➢ The binding of the sperm to the extracellular envelope (vitelline layer or zona pellucida) of the egg.
- ➢ The passing of the sperm through this extracellular envelope.
- ➢ Fusion of egg and sperm cell plasma membranes.

39. Difference between identical and frontal twins.

Fraternal twins are the result of two separate fertilization events, whereas identical twins are formed from a single embryo whose cells somehow dissociated from one another.
Identical twins occur in roughly **0.25%** of human births. About **33%** of identical twins have two complete and separate chorions, indicating that separation occurred before the formation of the trophoblast tissue at **day 5.**

40. Function of egg jelly.

Many eggs contain ultraviolet filters and DNA repair enzymes that protect them from sunlight; some eggs contain molecules that potential predators find distasteful; and the yolk of bird eggs even contains antibodies. Many types of eggs have glycoprotein meshwork called **egg jelly** outside the vitelline envelope which is used either to attract or to activate sperm. The egg, then, is a cell specialized for receiving sperm and initiating development.

41. Write typical factors which determine the interior – posterior axis in bird.

In birds, gravity is critical in determining the anterior-posterior axis, while pH differences appear crucial for distinguishing dorsal from ventral. The left-right axis is formed by the expression of *nodal* on the left side of the embryo.

42. What is difference between biciod and nanos.

In *Drosophila,* for instance, the anterior most portion of the egg contains an mRNA that encodes a protein called **Bicoid**.
The posterior most portion of the egg contains an mRNA that encodes a protein called **Nanos**..

43. What is meant by MHP.

In birds and mammals, the cells at the midline of the neural plate are called the **medial hinge point** (**MHP**) **cells**. They are derived from the portion of the neural plate just anterior to Hensen's node and from the anterior midline of Hensen's node.

44. Explain the causes of MHP.

Different **neural tube defects** are caused when various parts of the neural tube fail to close.

45. What are the factor that activate the mitosis promoting factor.

Mitosis-promoting factor contains two subunits.

- The large subunit is called **cyclin B**.
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- **Cyclin B** is often encoded by mRNAs stored in the oocyte cytoplasm, and if the translation of this message is specifically inhibited, the cell will not enter mitosis. The presence of cyclin B depends upon its synthesis and its degradation. Cyclin B regulates the small subunit of MPF, the **cyclin-dependent kinase**.