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DEPARTMENT: - MBBS

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QUESTION: -

1. Discuss ovulation.
2. Differentiate between meiosis 1 and 2.
3. Discuss the stages involved in fertilization.
4. Differentiate between monozygotic and dizygotic twins.

ANSWER

1) Ovulation is the release of an egg from one of a woman's ovaries. After the egg is released, it travels down the fallopian tube, where fertilization may occur by a sperm cell. Ovulation typically lasts one day and occurs in the middle of a woman's menstrual cycle, about 2 weeks before she expects her period.

Around the middle of the ovarian cycle, the ovarian follicle, under the influence of FSH and LH, sudden growth spurt, producing a cystic swelling or bulge on the surface of the ovary. A small avascular spot, the stigma, soon appears on this swelling. Before ovulation, the secondary oocyte and some cells of the cumulus oophorus detach from the interior of the distended follicle.

Ovulation is triggered by a surge of LH production. Ovulation usually follows the LH peak by 12 to 24 hours. The LH surge, elicited by high oestrogen level in the blood appears to cause the stigma to balloon out, becoming a vesicle. The stigma soon ruptures, expelling the secondary oocyte with the follicular fluid. Expulsion of the oocyte is a result of intrafollicular pressure, and possibly by contraction of smooth muscle in the theca externa owing to stimulation by prostaglandins.

Mitogen-activated protein kinases 3 and 1 (MAPK 3/1), also known as extracellular signal-regulated kinases (ERK 1/2), in ovarian follicular cells seem to regulate signalling pathways that control ovulation. Plasmin and matrix metalloproteins appear to play a role in controlling the rupture of the follicle. The expelled secondary oocyte is surrounded by the same zona pellucida and one or more layers of follicular cells, which are radially arranged as the corona radiata, forming the oocyte-cumulus complex. The LH surge also seems to induce resumption of the first meiotic division of the primary oocyte. Hence, mature ovarian follicles contain secondary oocytes. The zona pellucida is composed of 3 glycoproteins (ZPA, ZPB and ZPC), which usually form a network of filaments with multiple pores. Binding of the sperm to zona pellucida (sperm-oocyte interactions) is a complex and critical event during fertilization.

2) The differences between meiosis 1 and 2 includes the following:

- ✓ In meiosis 1, the cells start as diploid; ends as haploid, but in meiosis 2, the cells start as haploid and ends as haploid.
- ✓ In meiosis 1, there is reductive division, but in meiosis 2, there is equational division.
- ✓ In meiosis 1, homologous chromosome pairs separate, but in meiosis 2, sister chromatids separate.
- ✓ In meiosis 1, crossing over happens, but in meiosis 2, crossing over happens.
- ✓ In meiosis 1, complicated division happens, but in meiosis 2, simple division process occurs.
- ✓ Meiosis 1 has a long duration, but meiosis 2 has a short duration.
- ✓ Meiosis 1 is preceded by S-phase and G-phase, but meiosis 2 is preceded only by G-phase.
- ✓ In meiosis 1, sister chromatids in prophase have convergent arms, but in meiosis 2, sister chromatids in prophase have divergent arms.
- ✓ In meiosis 1, equatorial plane is centred, but in meiosis 2, equatorial plane is rotated 90 degrees.
- ✓ In meiosis 1, prophase split into 5 sub-phases, but in meiosis 2, prophase does not have sub-phases.
- ✓ Meiosis 1 ends with 2 daughter cells, but meiosis 2 ends with 4 daughter cells.

3) The stages of fertilization include:

- ➢ Passage of a sperm through the corona radiata.
- ➢ Penetration of zona pellucida.
- ➢ Fusion of plasma membrane of sperm and oocyte.
- ➢ Completion of the second meiotic division and formation of the female pronucleus.
- ➢ Formation of male pronucleus.
- ➢ Formation of zygote.

- <u>Passage of a sperm through the corona radiata</u>: -

Dispersal of the follicular cells of the corona radiata surrounding the oocyte and zona pellucida appears to result mainly from the action of the enzyme *hyaluronidase* released from the acrosome of the sperm, but the evidence is not equivocal. Tubal mucosal enzymes also appear to assist the dispersal. Movements of the tail of the sperm are also important in its penetration of the corona radiata.

Capacitation is the removal of the glycoprotein coat material and seminal plasma membrane of sperm head when passing through corona radiata exposing the acrosome.

- <u>Penetration of the zona pellucida</u>: -

Passage of a sperm through the zona pellucida is the important phase in the initiation of fertilization. Formation of a pathway also results from the action of enzymes released from the acrosome. The enzymes esterase, acrosin, and neuraminidase appear to cause **lysis** (dissolution or loosening) of the zona pellucida, thereby forming a path for the sperm to enter the oocyte. The most important of these enzymes is **acrosin**, a proteolytic enzyme.

Once the sperm penetrates the zona pellucida, a ***zona reaction***, a change in the properties of the zona pellucida, occurs that makes it impermeable to other sperms. The composition of this extracellular glycoprotein coat changes after fertilization. The zona reaction is believed to result from the action of lysosomal enzymes released by cortical granules near the plasma membrane of the oocyte. The contents of these granules, which are released into the perivitelline space, also cause changes in the plasma membrane that make it to other sperms.

- Fusion of cell membranes of the oocyte and sperm: -

The plasma or cell membranes of the oocyte and sperm fuse and break down in the area of fusion. The head and tail of the sperm enter the cytoplasm of the oocyte, but the sperm's cell membrane (plasma membrane) and mitochondria remain behind.

- Completion of the second meiotic division and formation of the female pronucleus: -

Penetration of the oocyte by a sperm activates the oocyte into completing the second meiotic division and forming a mature oocyte and a second polar body. Following the decondensation of the maternal chromosomes, the nucleus of the mature oocyte becomes the female pronucleus.

- Formation of the male pronucleus: -

Within the cytoplasm of the oocyte, the tail of the sperm degenerates and the nucleus of the sperm enlarges to become pronucleus. Morphologically, the male and female pronuclei are indistinguishable. During the growth of the pronuclei, they replicate their DNA. The oocyte containing the two haploid pronuclei is called an ootid, the nearly matured oocyte after the first meiotic divisions have been completed.

- Formation of zygote: -

As the pronuclei fuse into a single diploid aggregation of chromosomes, the ootid becomes a zygote. The chromosomes in the zygote become arranged on a cleavage spindle in preparation for cleavage of the zygote.

4) The differences between monozygotic and dizygotic twins include:

- Monozygotic twins are the two offspring that develop from one zygote, while dizygotic twins are that two offspring that develop from separate zygotes.
- Monozygotic twins and dizygotic twins originate from the same fertilized egg, and fertilized by the same sperm so, they share the same DNA, while dizygotic twins originate from two fertilized eggs and fertilized by two sperms; therefore, they do not share the same DNA.
- Zygotes for monozygotic twins only share the outer layer of the amniotic sac and have the two placentas, but changes if divided within 4-8 days, while for dizygotic twins, they have a separate placenta, amniotic sac and chorion.

- Monozygotic twins have same gender, but dizygotic twins can be of the same or different gender.
- Monozygotic twins almost have the same appearance, but dizygotic twins may have the same appearance or different appearance.
- Monozygotic twins have the chance for the same characters, developments, etc, while dizygotic twins don't have the same characters, developments, etc.
- They are not hereditary, while dizygotic twins are.