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Matric No: 18/MHS01/079
College: MHS
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Level: 200

1.) Discuss ovulation

Ovulation is the process by which the dominant follicle ruptures and the cumulus-oocyte complex is released from the ovary. Prior to ovulation is a luteinization hormone (LH) surge, which induces the progression of meiosis of the primary oocyte from its arrested state into the secondary oocyte and a polar body. After some time, it also causes a decrease in estrogen production, which is coupled with an elevation in the levels of progesterone. The resulting progressive rise in progesterone levels around the periovulatory period exerts a negative feedback to cease the LH surge, and prepares the body for pregnancy.

A combination of hormonal changes and enzymatic effects is responsible for the actual release of the secondary oocyte in the middle of the menstrual cycle (between the follicular phase and the luteal phase). Before ovulation, the large preovulatory follicle presses against the ovarian surface, generating a poorly vascularized bulge of the ovarian wall called the macula pellucid or follicular stigma. The LH surge induces the release of inflammatory cytokines and activates proteolytic enzymes (especially plasminogen) from the theca and granulosa cells. These secreted components lead to the breakdown the follicle wall, tunica albuginea, and surface epithelium in the vicinity of the stigma. Other preovulatory factors include;

- Increase in the volume and pressure of the antral fluid,
- Follicule-stimulating hormone (FSH) induced deposition of hyaluronic acid between the oocyte-cumulus complex and the stratum granulosum, which separates them, causes the cumulus cells surrounding the zona pellucid of the secondary oocyte to expand, and causes the cumulus-oocyte complex to float freely within the antral fluid prior to rupture, and
- Prostaglandin-induced inflammatory response and contraction of the smooth muscle fibers in the theca externa layer

At the end of this process, the stigma ruptures, and the antral cavity becomes continuous with the peritoneal cavity, and the cumulus-oocyte complex is released.

At the time of ovulation, the fimbriae of the uterine tube become closely apposed to the surface of the ovary, and the cumulus-oocyte complex is then gently swept by the fimbriae into the infundibulum of the uterine tube for fertilization. The cumulus mass firmly adheres to the fimbriae and is actively transported by the ciliated cells lining the uterine tube, preventing its passage into the peritoneal cavity (thus preventing ectopic pregnancy). After ovulation, the secondary oocyte remains viable for approximately 12 to 24 hours. If

fertilization does not occur during this period, the secondary oocyte degenerates as it passes through the uterine tube.

2.) Differentiate between meiosis I and meiosis II

	Meiosis I	Meiosis II
1.	DNA replication takes place before meiosis I	DNA replication does not take place before meiosis II
2.	Synapsis, chiasma formation and DNA recombination take place in prophase I	Synapsis, chiasma formation and DNA recombination do not take place in prophase II
3.	Homologous duplicated chromosomes separate in anaphase I	Sister chromatids separate in anaphase II
4.	The centromeres do not split in metaphase I	The centromeres split in metaphase II
5.	2 haploid 2N daughter cells are formed after cytokinesis	4 haploid 1N daughter cells are formed after cytokinesis

3.) Discuss the stages involved in fertilization

i. Passage of the Sperm through the Corona Radiata:

When the capacitated spermatozoa first encounter the ovulated egg in the ampullary part of the uterine tube, they are confronted by the corona radiata. They undergo hyperactivation and swim faster and vigorously. The corona radiata matrix is composed predominantly of hyaluronic acid, and the sperm have a membrane-bound hyaluronidase, which breaks down hyaluronic acid. The fast-vigorous swimming together with the hyaluronidase enables the sperm to digest and swim through this layer.

ii. Binding to and Penetration of the Zona Pellucida:

The next obstacle the sperm encounters is the zona pellucida, an extracellular coat made up of three glycoproteins called zona protein1 (ZP1), zona protein2 (ZP2), and zona protein3 (ZP3). The sperm contains one or more ZP3 receptors. Sperm binding to ZP3 triggers the acrosome reaction, in which the inner sperm plasma membrane fuses with the outer acrosomal membrane to release the contents of the acrosomal vesicle. The enzymes released from the acrosomal vesicle then digest the zona pellucida. After the acrosome reaction, the sperm loses ZP3 receptors, and it undergoes a secondary binding instead to ZP2. The sperm is thus held in place as the enzymes from the acrosome digest a hole in the zona pellucida and the sperm can go through to reach the egg plasma membrane.

iii. Fusion of the Sperm Plasma Membrane and the Oolemma:

After penetrating the zona pellucida, the spermatozoon enters the perivitelline space between the zona pellucida and the oolemma (oocyte's plasma membrane). Here, the sperm plasma membrane fuses with the oolemma. This process, called the impregnation of the oocyte, allows the contents of the sperm (the head, mid piece and tail) to be incorporated into the cytoplasm of the oocyte. The mitochondria and flagella disintegrate, while the nucleus and centrosomes remain intact.

iv. Prevention of Polyspermy:

When a sperm has fused with an oocyte, the entry of other spermatozoa into the egg (polyspermy) must be prevented, or abnormal development is likely to result. Three blocks to polyspermy i.e. fast block to polyspermy, cortical reaction and zona reaction, are typically present in vertebrate fertilization. The fast block to polyspermy cosists of a long-lasting (up to three minutes) depolarization of the oolemma, which creates a transient electrical block to polyspermy. The changes in the polarity of the oolemma then trigger release of Ca^{2+} from the ooplasmic stores. The Ca^{2+} propagates a cortical reaction wave in which cortical granules move to the surface and fuse with the oolemma. The contents (hydrolase-containing vesicles) of the cortical granules are released into the perivitelline space through exocytosis. These enzymes modify ZP2, generating ZPf, and degrade the glycoprotein oocyte plasma membrane receptors for sperm binding, which blocks binding of any acrosome-reacted sperm. They also form the perivitelline barrier by cross-linking proteins on the surface of the zona pellucida. This event creates the final and permanent block to polyspermy.

v. Oocyte Activation and Zygote Formation:

The oocyte is metabolically activated by intracellular release of Ca^{2+}. This generates a molecular signal for resumption and termination of the second meiotic division. This division transforms the secondary oocyte into a mature oocyte and triggers the expulsion of the second polar body into the perivitelline space. Once the egg has completed meiosis, a male pronucleus forms around the female chromosomes as well. A centrosome, contributed by the sperm, becomes a microtubule-organizing center from which microtubules extend until they contact the female pronucleus. The male and female DNAs replicate as the two pronuclei are pulled together. Once the pronuclei contact each other, the nuclear membranes break down, the chromosomes align on a common metaphase plate, and the first embryonic cleavage occurs.

4.) Differentiate between monozygotic twins and dizygotic twins

	Monozygotic Twins	Dizygotic Twins
1.	Also known as identical twins, are as a result of splitting of the zygote usually at the blastocyst stage into two separate	Also known as fraternal twins, result from simultaneous shedding of two oocytes and separate fertilization

	groups of cells within the same blastocyst cavity.	
2.	They have the same genetic constitutions and therefore they are born with identical phenotype (including sex)	They have different genetic constitutions, and therefore are born with different phenotypes
3.	They share the same placenta and chorionic cavity, and sometimes a common amniotic cavity (depending on when they split)	They both develop their own amniotic cavity, chorionic cavity and placenta
4	They occur approximately at the rate of 1 in 250 and there is little variation	They occur approximately at the rate of 1 per 80 but there is much variation from one country to another