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Question one

Ovulation refers to the release of an egg during menstruation in females.

Part of the ovary called the ovarian follicle discharges an egg. The egg is also known as an ovum, oocyte, or female gamete. It is only released on reaching maturity.

After release, the egg travels down the fallopian tube, where it may be met by a sperm and become fertilized.

Ovulation and hormonal release during the menstrual cycle are controlled by a part of the brain called the hypothalamus. It sends signals instructing the anterior lobe and pituitary gland to secrete luteinizing hormone (LH) and follicle- stimulating hormone (FSH).

It is useful to know when ovulation is likely to occur, as a woman is most fertile during this time, and more likely to conceive.

Phases of menstrual cycle

Menstrual phase:

The menstrual phase is the first phase of the menstrual cycle. This is the part of the cycle when a person has their period.

The cycle starts when the egg from the previous menstrual cycle does not become fertilized. Hormone levels of estrogen and progesteroneI will break down and shed. This lining and the egg then exit through the vagina during the menstrual period.

The period consists of a combination of uterus tissue, mucus, and blood. The menstrual phase can last for 3–8 days.

Follicular phase:

The follicular phase, which some people call the proliferative phase, also starts on the first day of a person's period. It is simultaneous with the menstrual phase.

At the start of the cycle, a brain region called the hypothalamus signals the pituitary gland to release follicle stimulating hormone (FSH).

FSH stimulates the ovaries to create several small sacs called follicles. These each contain an immature egg. The healthiest egg will mature while the rest of the follicles will absorb back into the body.

As the follicle matures, the body releases extra estrogen. This stimulates the uterine lining to thicken. The thickened lining can provide the necessary nutrients to a fertilized egg.

The follicular phase typically lasts around 10–16 days. This phase will end when a person ovulates.

Ovulation phase:

The ovulation phase starts when rising estrogen levels signal the pituitary gland to release luteinizing hormone (LH). LH stimulates the process of the ovary releasing a mature egg. This process is called ovulation.

During ovulation, the mature egg travels from the ovary, down the fallopian tube, and into the uterus. At any time during the egg's journey, sperm can fertilize it.

People who wish to conceive can watch for signs such as thick, white discharge from the vagina and a slight increase in their basal body temperature. A person can measure their basal temperature at home using a sensitive thermometer.

Ovulation typically occurs in the middle of the menstrual cycle. The egg can survive for about 24 hours before it needs to be fertilized. If it does not become fertilized during that time, the egg will dissolve.

Luteal phase:

The final phase of the menstrual cycle is called the luteal phase.

During the luteal phase, the follicle morphs into a mass of cells called the corpus luteum. The corpus luteum releases progesterone, which will keep the uterine wall thick and ready for a fertilized egg to implant.

If the egg becomes fertilized, the body will produce human chorionic gonadotropin (hCG). hCG helps keep the uterine lining thick for the fertilized egg to develop into an embryo.

However, if the egg does not become fertilized during ovulation, the corpus luteum will dissolve into the body. Both estrogen and progesterone levels will drop, which marks the beginning of the menstrual phase.The length of the luteal phase can vary, but it tends to be around 14 days on average.

Question two

Differences between meiosis I and meiosis II

Meiosis I	***Meiosis II***
It is heterotypic or reduction division.	It is homotypic or equational division.
The chromosomes remain in the replicated state.	The two chromatids of a replicated chromosome separate.
The number of chromosomes is reduced to half, i.e., from diploid to haploid state.	The number of chromosomes remain the same, i.e., from haploid to haploid state.

Crossing over occurs which makes the two chromatids of a chromosome different.	The generally different chromatids of a chromosome are separated.
It is complicated and long duration division.	It is simple and short duration division.
An interphase having both growth phases and synthetic phase precedes meiosis I.	The interphase or interkinesis has only growth phase. S phase is absent.
In prophase I, sister chromatids have convergent arms.	In prophase II, the sister chromatids have divergent arms

<u>Question three</u>

Fertilization is more a chain of events than a single, isolated phenomenon. Indeed, interruption of any step in the chain will almost certainly cause fertilization failure. The chain begins with a group of changes affecting the sperm, which prepares them for the task ahead.

Successful fertilization requires not only that a sperm and egg fuse, but that not more than one sperm fuses with the egg. Fertilization by more than one sperm - polyspermy - almost inevitably leads to early embryonic death. At the end of the chain are links that have evolved to efficiently prevent polyspermy.

In overview, fertilization can be described as the following steps:

Sperm Capacitation

Freshly ejaculated sperm are unable or poorly able to fertilize. Rather, they must first undergo a series of changes known collectively as capacitation. Capacitation is associated with removal of adherent seminal plasma proteins, reorganization of plasma membrane lipids and proteins. It also seems to involve an influx of extracellular calcium, increase in cyclic AMP, and decrease in intracellular pH. The molecular details of capacitation appear to vary somewhat among species.

Capacitation occurs while sperm reside in the female reproductive tract for a period of time, as they normally do during gamete transport. The length of time required varies with species, but usually requires several hours. The sperm of many mammals, including humans, can also be capacitated by incubation in certain fertilization media.

Sperm that have undergone capacitation are said to become hyperactiviated, and among other things, display hyperactivated motility. Most importantly however, capacitation appears to destabilize the sperm's membrane to prepare it for the acrosome reaction, as described below.

Sperm-Zona Pellucida Binding

Binding of sperm to the zona pellucida is a receptor-ligand interaction with a high degree of species specificity. The carbohydrate groups on the zona pellucida glycoproteins function as sperm receptors. The sperm molecule that binds this receptor is not known with certainty, and indeed, there may be several proteins that can serve this function.

The Acrosome Reaction

Binding of sperm to the zona pellucida is the easy part of fertilization. The sperm then faces the daunting task of penetrating the zona pellucida to get to the oocyte. Evolution's response to this challenge is the acrosome - a huge modified lysosome that is packed with zona-digesting enzymes and located around the anterior part of the sperm's head - just where it is needed.

The acrosome reaction provides the sperm with an enzymatic drill to get throught the zona pellucida. The same zona pellucida protein that serves as a sperm receptor also stimulates a series of events that lead to many areas of fusion between the plasma membrane and outer acrosomal membrane. Membrane fusion (actually an exocytosis) and vesiculation expose the acrosomal contents, leading to leakage of acrosomal enzymes from the sperm's head.

As the acrosome reaction progresses and the sperm passes through the zona pellucida, more and more of the plasma membrane and acrosomal contents are lost.

By the time the sperm traverses the zona pellucida, the entire anterior surface of its head, down to the inner acrosomal membrane, is denuded. The animation to the right depicts the acrosome reaction, with acrosomal enzymes colored red.

Sperm that lose their acrosomes before encountering the oocyte are unable to bind to the zona pellucida and thereby unable to fertilize. Assessment of acrosomal integrity of ejaculated sperm is commonly used in semen analysis.

Penetration of the Zona Pellucida

The constant propulsive force from the sperm's flagellating tail, in combination with acrosomal enzymes, allow the sperm to create a tract through the zona pellucida. These two factors - motility and zona-digesting enzymes- allow the sperm to traverse the zona pellucida. Some investigators believe that sperm motility is of overriding importance to zona penetration, allowing the knife-shaped mammalian sperm to basically cut its way through the zona pellucida.

Sperm-Oocyte Binding

Once a sperm penetrates the zona pellucida, it binds to and fuses with the plasma membrane of the oocyte. Binding occurs at the posterior (post-acrosomal) region of the sperm head.

The molecular nature of sperm-oocyte binding is not completely resolved. A leading candidate in some species is a dimeric sperm glycoprotein called fertilin, which binds to a protein in the oocyte plasma membrane and may also induce fusion. Interestingly, humans and apes have inactivating mutations in the gene encoding one of the subunits of fertilin, suggesting that they use a different molecule to bind oocytes.

Egg Activation and the Cortical Reaction

Prior to fertilization, the egg is in a quiescent state, arrested in metaphase of the second meiotic division. Upon binding of a sperm, the egg rapidly undergoes a number of metabolic and physical changes that collectively are called egg activation. Prominent effects include a rise in the intracellular concentration of calcium, completion of the second meiotic division and the so-called cortical reaction.

The cortical reaction refers to a massive exocytosis of cortical granules seen shortly after sperm-oocyte fusion. Cortical granules contain a mixture of enzymes, including several proteases, which diffuse into the zona pellucida following exocytosis from the egg. These proteases alter the structure of the zona pellucida, inducing what is known as the zona reaction. Components of cortical granules may also interact with the oocyte plasma membrane.

The Zona Reaction

The zona reaction refers to an alteration in the structure of the zona pellucida catalyzed by proteases from cortical granules. The critical importance of the zona reaction is that it represents the major block to polyspermy in most mammals. This effect is the result of two measurable changes induced in the zona pellucida:

1. The zona pellucida hardens. Crudely put, this is analogous to the setting of concrete. Runner-up sperm that have not finished traversing the zona pellucida by the time the hardening occurs are stopped in their tracks.

2. Sperm receptors in the zona pellucida are destroyed. Therefore, any sperm that have not yet bound to the zona pellucida will no longer be able to bind, let alone fertilize the egg.

The loss of sperm receptors can be demonstrated by mixing sperm with both unfertilized oocytes (which have not yet undergone the zona reaction) and two-cell embryos (which have previously undergone cortical and zona reactions). In this experiment, sperm attach avidly to the zona pellucida of oocytes, but fail to bind to the two-cell embryos.

Post-fertilization Events

Following fusion of the fertilizing sperm with the oocyte, the sperm head is incorporated into the egg cytoplasm. The nuclear envelope of the sperm disperses, and the chromatin rapidly loosens from its tightly packed state in a process called decondensation. In vertebrates, other sperm components, including mitochondria, are degraded rather than incorporated into the embryo.

Chromatin from both the sperm and egg are soon encapsulated in a nuclear membrane, forming pronuclei. The image to the right shows a one-cell rabbit embryo shortly after fertilization - this embryo was fertilized by two sperm, leading to formation of three pronuclei, and would likely die within a few days. Pass your mouse cursor over the image to identify pronuclei.

Each pronucleus contains a haploid genome. They migrate together, their membranes break down, and the two genomes condense into chromosomes, thereby reconstituting a diploid organism.

Question four

Differences between monozygotic and dizygotic twins

Monozygotic twins	***Dizygotic twins***
Developed from a single egg which was fertilized by a single sperm cell	Developed from two eggs fertilized by two different sperm cells
Two fetuses grow in the same placenta	Two fetuses grow in two different membranes
Always of the same sex	May be of the same or opposite sex
May have the same physical and mental characteristics	May look alike or different; may behave similarly or differently
Also called “identical twins”	Also called “fraternal twins”
Have almost identical genetic profile	Completely different genetic profile