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COURSE: EMBRYOLOGY

Questions:

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

Answers:

1. Discuss Ovulation?

OVULATION

Ovulation is the release of a mature secondary oocyte from the ovarian follicle. Ovulation occurs as a result of LH surge. Ovulation usually follows the LH peak by 4-8 hours. Ovulation occurs in the middle of ovarian cycle and menstrual cycle since they both coincide with each other but it varies from woman to woman due to the duration of proliferative phase of menstrual cycle. Ovulation normally occurs on the 14^{th} day of a 28 day menstrual cycle. Few days before ovulation, under the influence of luteinizing hormone (LH) and follicle stimulating hormone (FSH), the secondary follicle will grow and acquire a diameter of 25mm or more, it is then referred to as mature vesicular/ mature secondary/ Graafian follicle. Also along with the final stages of maturation of vesicular follicle, there is an abrupt increase in the amount of LH due to high estrogen level in the blood i.e. LH surge which causes

- Completion of first meiotic division which gives rise to a secondary oocyte and first polar body.
- The ovarian follicle enters a pre-ovulatory mature vesicular stage.

The secondary oocyte begins second meiotic division but it is arrested at metaphase 2 by the cytostatic factor approximately 3 hours before ovulation. Due to the LH surge, the surface of the ovary begins to bulge locally and at the apex, an avascular spot known as stigma appears. Due to the abrupt increase in LH, an enzyme called collagenase is produced which helps to break down collagen fibers. The LH surge causes:

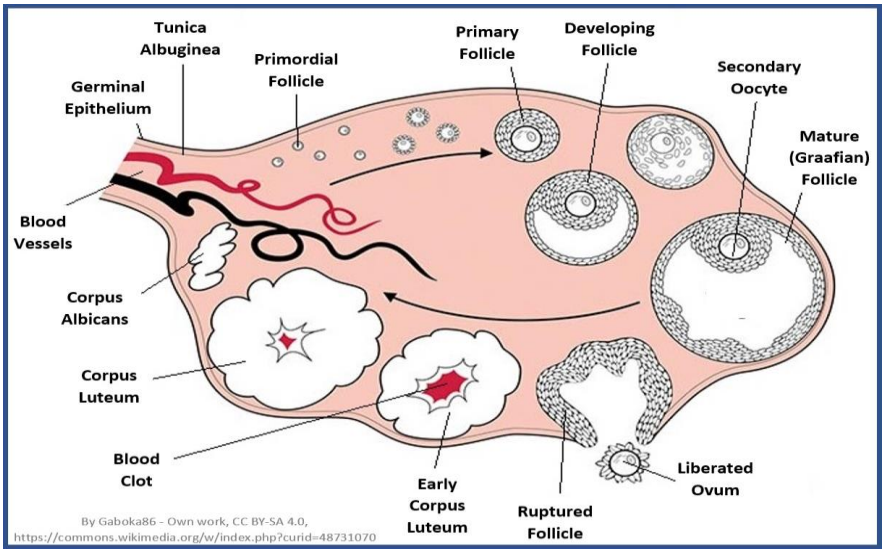
- Increase in collagenase activity which results in the digestion of collagen fibers (connective tissue) surrounding the follicle. This weakens the secondary follicle
- Prostaglandin levels to increase as well and this causes local muscular contractions in the wall of the ovary.

These contractions cause the secondary oocyte along with surrounded follicular cells from the region of cumulus oophorus to be extruded from the ovarian follicle. Ovulation then occurs in which the secondary oocyte along with the surrounding follicular cells are

extruded from the ovary. The surrounding follicular cells then rearrange themselves around the zona pellucida to give rise to the corona radiate. At this time, ovulation is completed.

Clinical correlates:

- During ovulation some women experience pain in their lower abdomen, it is known as mittleschmerz or middle pain because it occurs in the middle of the menstrual cycle. The pain in their lower abdomen is due to slight bleeding into the peritoneal cavity. Mittleschmerz could serve as a sign of ovulation but there are better signs of ovulation such as a slight drop in basal temperature.
- Change in cervical mucus could also serve as a sign of ovulation because when you're not ovulating, cervical mucus may appear sticky, creamy or entirely absent but when ovulating the cervical mucus becomes abundant and appears watery and takes a watery raw egg-white consistency and stretches up to an inch between the fingers.
- Other signs of ovulation include; increase in urge for sex, tenderness of breast, swollen vagina, etc.
- Some women fail to ovulate due to low concentration of gonadotropins, this is known as anovulation.
- The days when females are said to get pregnant easily are 2 days before ovulation and 3 days after ovulation.



2. Differentiate between Meiosis 1 and Meiosis 2?

Meiosis is a special type of cell division in sexually-reproducing organisms used to produce the gametes, such as sperm or egg cells. It involves two rounds of division i.e. meiosis 1 and meiosis 2 that ultimately result in four daughter cells with only one copy of each chromosome.

Meiosis 1 and Meiosis 2 both involve 4 stages; Prophase, Metaphase, Anaphase and Telophase.

	Meiosis 1	**Meiosis 2**
a.	It is a heterotypic division i.e. reduction division.	It is a homotypic division i.e. equational division (from 2n to n).
b.	It takes a longer duration.	It takes a shorter duration.
c.	It is preceded by interphase.	It is not preceded by interphase.
d.	It involves prophase 1, metaphase 1, anaphase 1 and telophase 1.	It involves prophase 2, metaphase 2 , anaphase 2 and telophase 2
e.	The number of chromosomes is reduced to half i.e. from diploid to haploid state from to 46 homologous duplicated chromosomes to 23 homologous duplicated chromosomes.	The number of chromosomes remains the same from 23 homologous duplicated chromosomes 23 single stranded chromosomes.
f.	In prophase 1, synapsis, crossing over and chiasma formation takes place.	In prophase 2, no synapsis, crossing over or chiasma formation occurs.
g.	In metaphase 1, the 46 homologous chromosomes align at the equatorial plate.	In metaphase 2, the 23 homologous chromosomes align at the equatorial plate.
h.	In anaphase 1, separation of 46 homologous duplicated chromosomes occur and the centromere does not split.	In anaphase 2, separation of 23 homologous duplicated chromosomes occur and the centromere does not split.
i.	In Telophase 1, two daughter cells are formed.	In Telophase 2, four daughter cells are formed.

3. Discuss the stages involved in fertilization?

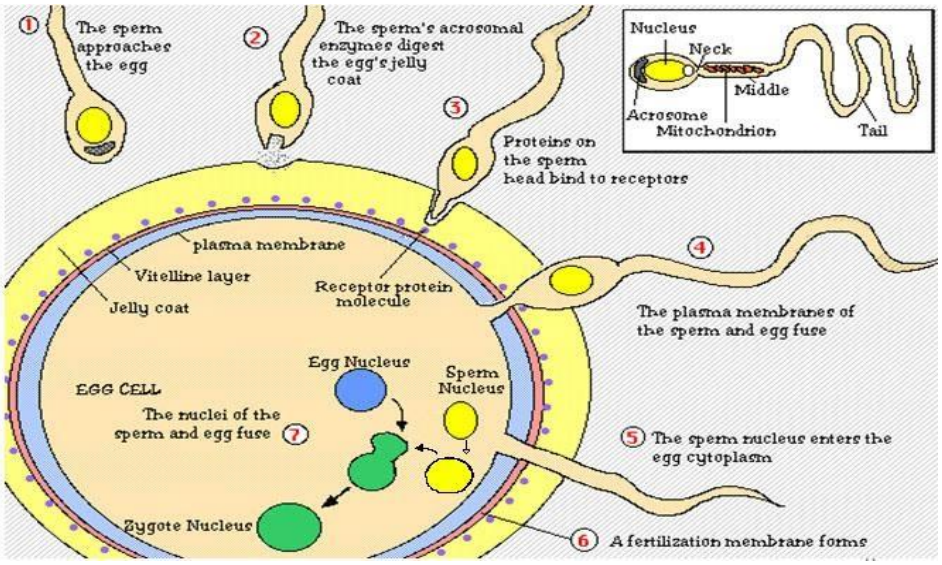
FERTILIZATION

Fertilization is the union of male gamete, spermatozoa with the female gamete, oocyte to form zygote. Fertilization occurs in the ampulla of uterine tube in female. The process of fertilization takes about 24 hours. The process of fertilization involves six stages which are:

A. Passage through corona radiata
B. Penetration of zona pellucida
C. Fusion of plasma membrane of sperm and oocyte
D. Completion of second meiotic division and formation of female pronucleus
E. Formation of male pronucleus
F. Formation of zygote.

A. **Passage through Corona Radiata:** For sperms to be able to pass through the corona radiata, they must have been capacitated (removal of the glycoprotein coat and seminal plasma proteins in the plasma membrane overlying the acrosomal region). Capacitation takes about 7 hours. Only capacitated sperms can pass through the corona radiata.
B. **Penetration of zona pellucida**: After the sperm passes through the corona radiata, it reaches the region of the zona pellucida. The zona pellucida is a glycoprotein shell surrounding the primary oocyte which facilitates sperm binding and induces acrosome reaction. On the surface of the zona pellucida, there are binding sites also known as receptors. The acrosome on the head of the sperm binds with these receptors which causes the release of enzyme acrosin. With the help of acrosin, the sperm penetrates the corona radiata. Many sperms are deposited in the vagina of the female, only few survive due to the acidic environment in the vagina. The surviving sperms swim to the ampulla of the female. Once a sperm passes through the corona radiata and reaches the plasma membrane of the oocyte, cortical granules are released from the plasma membrane, the cortical granules send message to the receptors on the zona pellucida to close their binding sites. This helps to block polyspermy and inactivate binding sites on the zona pellucida. This ensures that only one sperm fertilizes the oocyte.
C. **Fusion of Plasma membrane of sperm and oocyte:** The plasma membrane of the sperm and oocyte fuse and break down at the point of fusion. The head(without acrosome and cell membrane) with nucleus and tail of the sperm enter the cytoplasm of the oocyte leaving behind the plasma membrane of the sperm
D. **Completion of second meiotic division and formation of female pronucleus:** Upon entry of the head and tail of sperm, second meiotic division of the secondary oocyte is completed and a mature oocyte and second polar body is formed. The nucleus of the mature oocyte forms the female pronucleus.
E. **Formation of the male pronucleus:** Inside the oocyte, the tail of the sperm degenerates and the nucleus in the head enlarges and forms the male pronucleus. NOTE: The mitochondria in the zygote is from maternal origin because the tail of the sperm degenerates.

F. **Formation of zygote:** The 2 pronuclei is found within the oocyte. The oocyte is then referred to as an ootid. The male and female pronuclei will fuse together and the ootid becomes a zygote. The chromosomes in the zygote is then arranged on a cleavage spindle in preparation for cleavage of zygote.



Clinical correlates:

- **In vitro fertilization (IVF) and Embryo transfer**. In vitro fertilization is a process of fertilization where an egg is combined with sperm outside the body, in vitro (in a glass). The process involves monitoring and stimulating a woman's ovulatory process, removing an ovum or ova from the woman's ovaries and letting sperm fertilize them in a liquid in a laboratory. The fertilized egg is cultured for a few days and then transferred to the uterus of same or another woman.
- **Intracytoplasmic sperm Injection.** This involves the direct injection of the sperm into the cytoplasm of the oocyte. This is done when the sperm has difficulty in penetrating the oocyte. This technique has been successful for women whom IVF has failed for them.

4. Difference between monozygotic twins and dizygotic twins?

Twinning is the process by which two conceptuses are nurtured at the same time. Twinning occurs as a result of multiple pregnancy. Monozygotic twins (MZ, identical) produced from a single fertilization event (one fertilized egg and a single spermatozoa, form a single zygote), these twins therefore share the same genetic makeup while Dizygotic twins (DZ, fraternal, non-identical) arise from separate fertilization events involving two separate oocyte (egg, ova) and spermatozoa (sperm). These twins may also implant at different sites within the uterus. The main differences between monozygotic twins and dizygotic twins are written below:

	Monozygotic twins	**Dizygotic twins**
a.	They arise from a single zygote.	They arise from two zygotes.
b.	They result from the random division of the embryoblast of a single zygote into two embryos.	They result from two eggs fertilized by two sperms to give two embryos.
c.	The twins are of the same sex/gender.	The twins may have the same or different sex/gender.
d.	Monozygotic twins arise from a single zygote so they share the same DNA.	Dizygotic twins arise from two different zygotes so they have different DNAs.
e.	Monozygotic twins have the same appearance.	Dizygotic twins have the same or different appearances.
f.	Monozygotic twins have chance for the same characters, developments etc.	Dizygotic twins do not have chance for the same characters, developments etc.
g.	Monozygotic twins are usually diamniotic, monochorionic with a single placenta.	Dizygotic twins have separate amnion, chorion and placenta.
h.	It is not hereditary in nature.	It is usually hereditary in nature.
i.	They are often called conjoined twins.	They are not seen as conjoint twins.

Clinical correlates:

- **Parasitic twins**: This occurs when one member of a conjoint twin becomes rudimentary due to diminished blood supply and grows like a parasite from the body of the well-developed co-twin. It is termed parasitic twin. The parasitic twin may be completely enclosed within the body of the co-twin. The fetus is then termed fetus-in-fetu.
- **Superfecundation**: It is the fertilization of two or more oocytes at different times. This incidence is very rare in humans.
- **Conjoint (Siamese) twins**: This condition is seen in monozygotic twins in which the inner cell mass does not completely split. In this condition, the 2 fetuses are joined together by a tissue bridge. Depending on the site and extent of fusion, conjoint twins are classified into; Craniophagus (fusion of heads), Thoracophagus (fusion of thorax), Cephalothoracophagus (fusion of head and thorax), Sacrophagus (fusion of sacral regions). If the twins have no vital parts/organs in common, they can be separated by surgery.

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