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Popular Article

Oogenesis, Folliculogenesis, and Ovulation

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Abstract

Oocytes develop within distinct follicles in the cortex of the ovary during development. Prenatal follicles that have been dormant become active and go through progressive development at regular intervals starting in the late fetal period and continuing into maturity. After becoming activated, follicles and oocytes in a cohort either develop to maturity and ovulation or experience atresia, which eventually causes the ovaries to become devoid of germ cells. This article explains briefly Oogenesis, folliculogenesis, and Ovulation to its readers.

Introduction

The biological processes of ovarian oogenesis and folliculogenesis are intricately synchronized and need a sequence of actions to cause morphological and functional changes in the follicle that result in cell differentiation and egg formation. To get a better perspective the readers are introduced to the following terminologies. A gamete is defined as an egg or sperm. Gametogenesis is the production of eggs or sperm. Oogenesis is the production of eggs. Follicles are where the eggs mature in the ovary. Ovulation is the release of the egg from the follicle. The polar body is a non-functional product of meiotic divisions in oogenesis. A zygote is a Fertilized egg. Oogonia are mitotically dividing cells in the ovary, which will become Oocytes. Ovum is an Ovulated egg, ready to be fertilized. If fertilized, a second meiotic division will take place, producing another polar body. In fetal life, LHRH begins to secrete shortly after the sex differentiation and temporarily regresses. Secretions of LHRH remain low up to the onset of puberty. As the animal reaches the pubertal age the GnRH secretion increases (also in castrated animals). The increasing level of GNRH removes the inhibitory control of CNS. During early fetal life, oogonia proliferate into a primary oocyte from daughter oogonia by the process of mitosis. This process continues up to birth. No oogonia are found in the ovary after the birth.

OOGENESIS

Primordial germ cells, also known as oogonia, go from the yolk sac endoderm to the genital ridge (forming ovary) early in development. These several mitotic divisions of these diploid oogonia either before or soon after parturition furnish the developing ovary with a significant number of future oocytes (eggs). Oogonia are referred to as primary oocytes when they initiate the initial meiotic division before the female reaches sexual maturity, primary oocytes are halted in the prophase of Meiosis I. A cow fetus has a 2.7 M oocyte at 110 days of gestation and has only 70 k oocytes at birth. Follicle-stimulating hormone (FSH) induces a limited percentage of primary oocytes to progress through Meiosis I when the female achieves sexual maturity. The number of chromosomes decreases from the diploid number (2N) to the haploid number throughout this process (1N). The chromosomes are divided evenly, but the majority of the cytoplasm remains with the egg, making this division unequal. The smaller polar body will eventually degenerate since it only has a little quantity of cytoplasm and just half of the chromosomes. A primary oocyte is referred to as a secondary oocyte once it has undergone the first meiotic division (1N). Meiosis I is finished immediately before ovulation in the majority of animals (release of the ovum from the ovary). Meiosis I, on the other hand, is finished after ovulation in horses and dogs. A secondary oocyte will deteriorate if a sperm does not penetrate it. A new cycle will start if fertilization and pregnancy do not take place, in which the pituitary gland's FSH will encourage a few more primary oocytes to go through Meiosis I. But occasionally, a sperm will pass through the zona pellucida, stimulating the secondary oocyte to progress through Meiosis II and produce a mature ovum and a second polar body (1N). Again, the polar body gradually degenerates since it only has a little amount of cytoplasm and half of the chromosomal material. Two pronuclei, which carry genetic material from the ovum or the sperm, develop once a sperm penetrates the cytoplasm of the ovum. When the two pronuclei combine and restore the diploid chromosome number, fertilization is complete. The zygote goes through numerous mitotic modifications to produce an embryo if fertilization is successful; if not, it degenerates.

Folliculogenesis

The growth of follicles occurs in three stages: 1. pre-ovulation 2. Ovulation 3. post-ovulation. The pituitary gland is the process of follicular development and maturation by the secretion of 1. gonadotropic hormones FSH (follicle stimulating hormone) 2. LH (luteinizing hormone) 3. prolactin (in some species). The primordial follicle consists of a primary oocyte and a single layer of flattened follicular cells. Yolk granules are produced by the main oocyte, and the follicular cells transform from being flat to becoming cuboidal or columnar. The number of follicular cells grows as development progresses through mitosis, generating many layers surrounding the main oocyte. Before ovulation, these cells emit steroid hormones called estrogens, with estradiol being the primary one, as they grow. The membrana granulosa, also known as the secondary follicle, is made up of numerous layers of cuboidal/columnar follicular cells that start to release follicular fluid. The main oocyte and the membrana granulosa are separated by a thick, amorphous layer called the zona pellucida. The theca interna and the theca externa, two separate layers of stromal cells that were previously undifferentiated, now form a protective barrier surrounding the growing follicle. The theca interna contains big, rounded, epithelial-like cells, while the theca externa contains fibroblasts, which are smaller in size. A basement membrane separates the theca cells' two layers from the follicle's membrana granulosa cells. Small pockets of fluid between granulosa cells start to form when the follicular fluid released by the membrana granulosa cells builds up. The presence of follicular fluid pockets inside the membrana granulosa distinguishes the secondary-vesicular follicle from other types. The several fluid-filled pockets combine to create a single, sizable pocket known as the follicular antrum as the follicle continues to grow. The oocyte is still a primary oocyte at this stage of the follicular antrum's development and is stalled in the Meiosis I prophase. Granulosa cells that are connected to the membrana granulosa that surround the edge of the developing follicle still encircle it. Two regions in granulosa cell layers 1. The corona radiata cells remain attached to the oocyte after ovulation and are in close contact with the oocyte through cytoplasmic processes which pass through the zona pellucida and contact microvilli of the oocyte. 2. The cumulus oophorus cells surround the oocyte and are continuous with the displaced cells of the membrana granulosa but remain in the ovary after ovulation. The other granulosa cells are separated by a basal membrane from theca interna cells. The pre-ovulatory follicle is also known as the mature follicle. In certain species, shortly before ovulation, the mature follicle's primary oocyte completes meiosis I, resulting in the formation of a secondary oocyte and a polar body. After ovulation, bleeding typically occurs in the follicular remnants, resulting in a structure known as a corpus hemorrhagicum. The corpus luteum eventually replaces this temporary structure. Corpus luteum: In most species, LH produced by the pituitary gland starts this luteinisation process and prompts the granulosa cells to release progesterone. The granulosa cells are transformed into granulosa lutein cells due to the accumulation of a yellow lipid pigment (lutein). The resulting structure is highly vascular. The corpus luteum endures and secretes progesterone if fertilization takes place. The corpus luteum degenerates and is replaced by connective tissue to produce corpus albicans if fertilization is not successful.

Ovulation

Preovulatory follicles undergo three changes: 1. Cytoplasmic and nuclear maturation of the oocyte. 2. Disruption of cumulus cell cohesiveness among the cells of the granulosa cell. 3. External follicular wall thinning and follicular wall rupture. These changes are due to the shift of the FSH effect to the LH effect.

Most vascular follicle ovulates under the effect of LH. On the follicular enlarged surface, at only one point, the blood supply is less and this avascular area becomes the point of rupture in ovulation. Lysozyme releases hydrolases (under the effect of PGF2alpha) which destroy thecal cells and this causes thinning of follicle epithelial cove at a point of stigma. Stigma bulges over the surface of the ovary Ovarian contraction and pressure of the antral fluid cause rupture at the stigma. PGF2alpha also acts to produce a plasminogen activator. Nuclear maturation means reversing the meiotic arrest at prophase 1 and driving the progression of meiosis to metaphase II. Cytoplasmic maturation means the process that prepares the egg for activation and preimplantation development. Granulosa cells: Completely dissociate only at the follicular apex and finally disappear. Theca cells: Increase in follicular volume and follicular fluid pressure leads to an increase in follicular wall elasticity. This results in looser cohesion between cells owing to invasive oedema and collagen fibre dissociation. Apex changes Thinned wall of the follicle known as the stigma.

Conclusion

Oogenesis is the process through which female gametes are created. The process of ovarian follicle development known as folliculogenesis begins with a reserve of dormant primordial follicles created early in life and ends with either ovulation or follicular death via atresia. Because it enables ovulation and the production of the important sex steroid hormones estradiol and progesterone, folliculogenesis is crucial for ovarian function and the survival of the species. The discharge of the female gamete occurs during ovulation. A few days prior, a certain behaviour—the estrus behaviour, which is sometimes referred to as "estrus"—occurred. Animal reproduction and the physiological changes that take place in the female to accomplish reproduction depend on these mechanisms.