CONCEPT OF 'GAMETOGENESIS'

Gametogenesis is the process of creating and growing haploid gametes, the reproductive cells. In males, this happens in the testes, while in females, it occurs in the ovaries. The making of male gametes, called spermatozoa, is called spermatogenesis, and for female gametes, known as eggs or ova, it's called oogenesis.

The steps in spermatogenesis and oogenesis differ in various ways, which we'll explore in the following section.

Spermatogenesis

- Young male germ cells in the testes are called spermatogonia. Spermatogenesis kicks in during puberty when the Gonadotropin-Releasing Hormone (GnRH) increases. This increase triggers more LH and FSH hormones.
- Luteinizing hormones (LH) impact the Leydig cells, boosting the production of androgens. These androgens, in turn, stimulate spermatogenesis.
- Follicular Stimulating Hormones (FSH) act on Sertoli cells, which release substances aiding in spermatogenesis.
- Spermatogonia divide through mitosis, forming primary spermatocytes. These primary spermatocytes go through meiotic division, resulting in secondary spermatocytes.
- Secondary spermatocytes undergo a second meiotic division, leading to the formation of four spermatids.
- The spermatids develop into mature spermatozoa through a process called spermiogenesis.

Oogenesis

- The creation of a mature female reproductive cell is known as oogenesis, and it's quite different from spermatogenesis.
- In contrast to spermatogenesis, which starts in males at puberty, oogenesis begins during embryonic development. Around 2 million gamete mother cells (oogonia) are formed in each fetal ovary during this stage. Importantly, no more oogonia are created or added after birth. Ovarian follicles are scattered throughout the cortex's stroma.

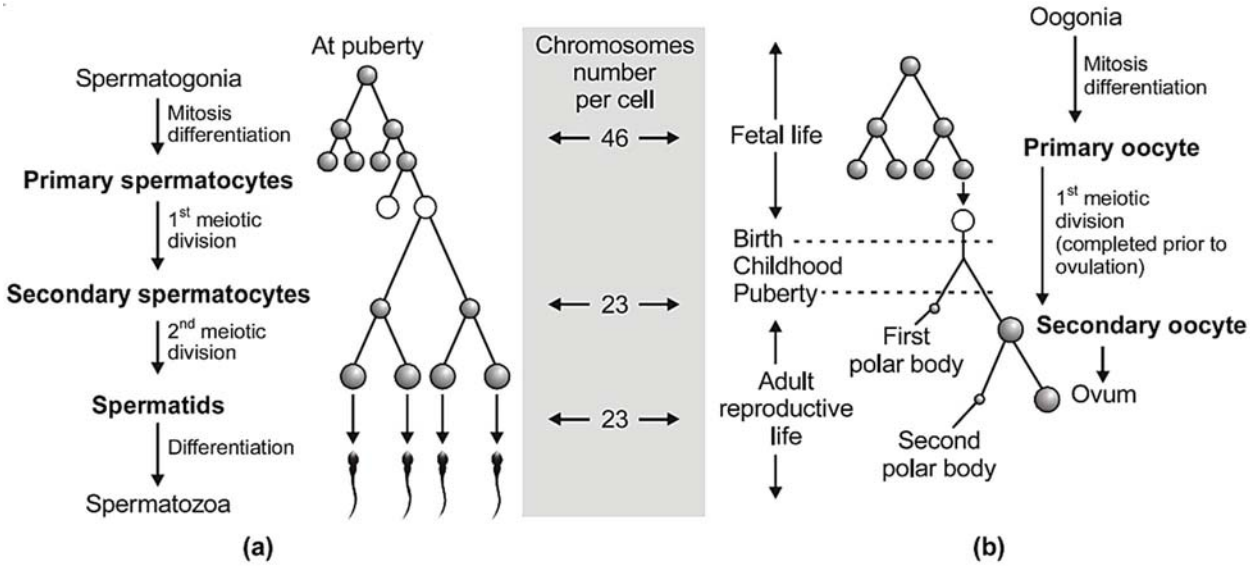

Fig.: Schematic representation of (a) Spermatogenesis; (b) Oogenesis

Ovarian Follicle (Human Ovum)

During fetal life:

- The initial germ cells, known as primordial germ cells, form from extra embryonic mesoderm. These cells move into the ovaries during early embryo growth and multiply. By about 5 months of gestation (before birth), the ovaries have around 2 million oogonia.
- An ovarian follicle is made up of an oocyte, which is encircled by one or more layers of flat epithelial cells called granulosa cells.
- The oogonial cells start dividing and reach the diplotene stage of the first meiotic division. They temporarily stop at this stage, becoming primary oocytes. Each primary oocyte is then surrounded by a layer of granulosa cells and is called a primary follicle.

After birth:

- Many of these follicles break down from birth until puberty. This breakdown is called follicular atresia, and phagocytes are responsible for getting rid of them. So, by the time puberty arrives, each ovary is left with only 60,000 to 80,000 primary follicles. A lack of vitamin E can contribute to follicular atresia.

At puberty:

- As puberty begins, around a dozen primary follicles start maturing in each ovarian cycle. The cells of the follicles change shape, dividing to form layers known as the granulosa layer. This means that primary follicles become surrounded by more granulosa cells and a new layer called the secondary follicles, with granulosa cells resting on a basement membrane and surrounding stromal cells forming theca folliculi.
- The secondary follicle transforms into a tertiary follicle with a fluid-filled space called an antrum, appearing between the granulosa cells. Initially crescent-shaped, the antrum enlarges over time, filled with liquor folliculi.
- The theca layer splits into the inner layer of endocrine cells (theca interna) and an outer layer of fibroblast-like cells (theca externa).
- The maturing oocytes attach to the follicle wall through a pedicel or stalk called the cumulus oophorus, formed by granulosa cells, and remain in the liquor folliculi. Theca interna is rich in blood vessels, while theca externa gradually merges with the ovarian stroma.
- The primary oocyte in the tertiary follicle grows and completes its first meiotic division at puberty, resulting in a large haploid secondary oocyte and a tiny first polar body. The secondary oocyte retains most of the nutrient-rich cytoplasm. The tertiary follicle becomes the mature Graafian follicle (present in mammals only).
- The secondary oocyte forms a new membrane, the zona pellucida, surrounding it. This thick coat, composed of glycoproteins and synthesized by the oocyte, is then surrounded by elongated granulosa cells forming the corona radiata. When stimulated by LH hormone, the Graafian follicle ruptures, releasing the developing secondary oocyte (ovum) from the ovary in a process called ovulation. After ovulation, the ruptured follicle turns into a structure called the corpus luteum, which primarily secretes progesterone, with some amounts of estrogen and relaxin.

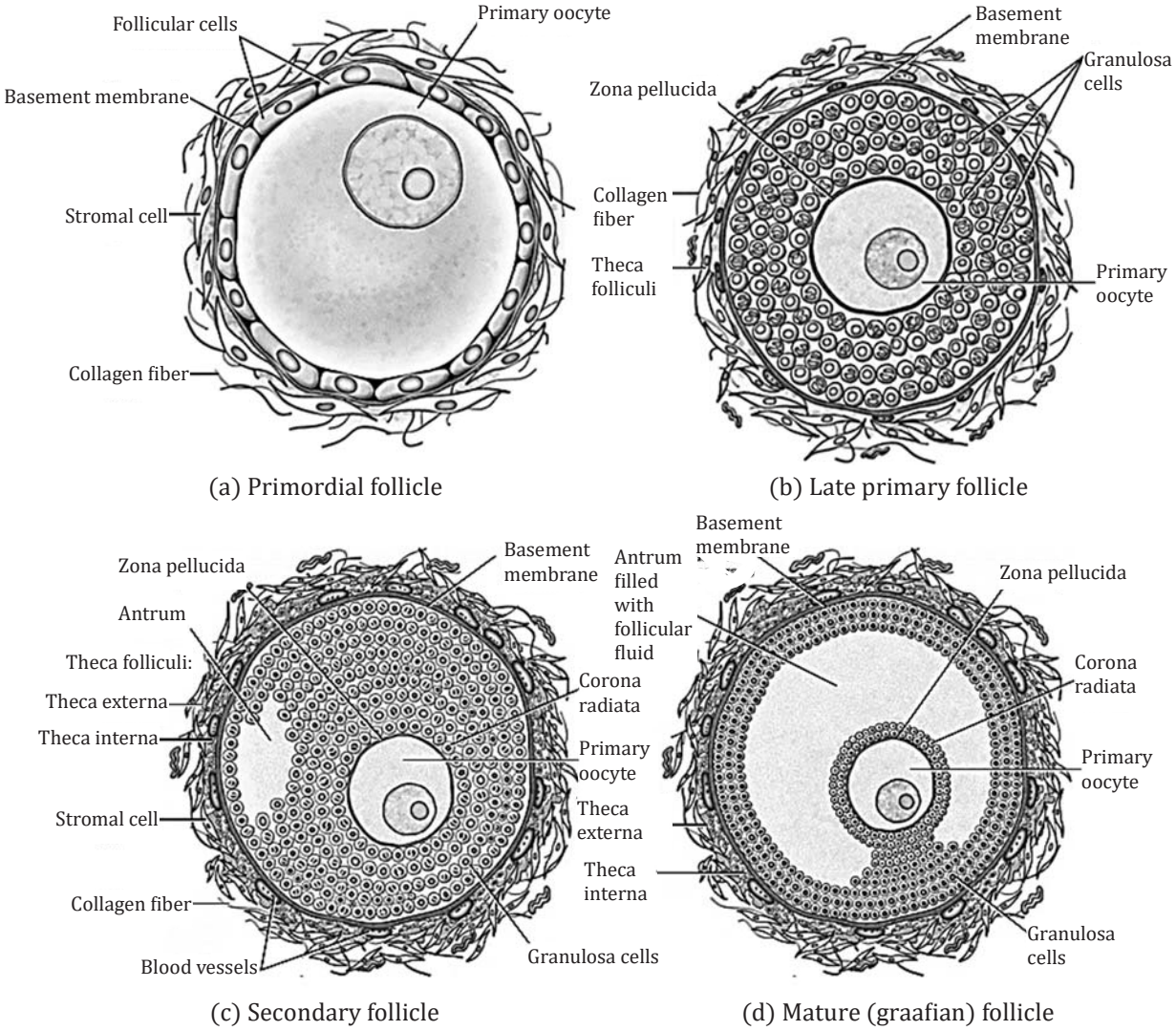

Fig. Ovarian follicles

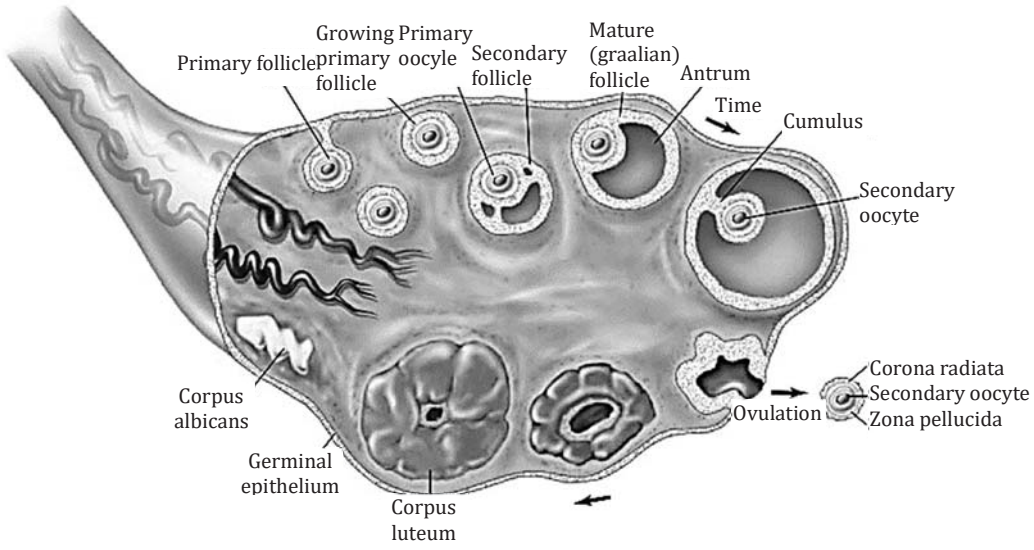

Fig. Stages of ovum and follicle

Reproductive Cycle (Reproductive Period)

Estrous cycle:

- This kind of cycle happens in non-primates and new world monkeys.
- In these animals, the ovulation cycle is linked with estrus (heat), occurring approximately at the same time as ovulation.
- During estrus, they display behaviors and release signals like pheromones to show they are ready for mating. Estrus lasts for a few hours to a few days, depending on the species.
- Based on how often they cycle in a year, estrous animals can be of two types:
  a. Monoestrous: Examples include dogs, foxes, deer, and bats.
  b. Polyestrous: Examples include mice, squirrels, cows, sheep, pigs, horses, etc.
- The entire cycle is divided into four phases:
  i. Pre-estrous (the start, oogenesis begins),
  ii. Estrous (Heat period, pheromones produced),
  iii. Meta Estrous (Pseudopregnancy, if fertilization happens, it lasts until parturition), and
  iv. Anestrous/Diestrous (Interphase). The anestrous phase is longer in monoestrous animals compared to polyestrous ones.

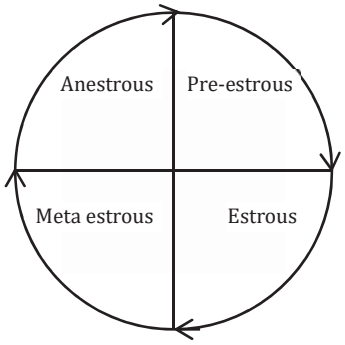

Fig.: Estrous Cycle