HUMAN REPRODUCTIVE SYSTEM GAMETOGENESIS

CONCEPT OF 'GAMETOGENESIS'

Gametogenesis is the process of production and development of haploid gametes by the primary sex organs, which are testes in males and ovary in females. The production of male gametes known as spermatozoa is known as spermatogenesis and the production of female gametes, known as eggs or ova is known as oogenesis.

The steps involved in spermatogenesis and oogenesis are different in many ways, as described in the next part.

SPERMATOGENESIS

- Immatures male germ cells in testes are known as spermatogonia. Spermatogenesis starts at the age of puberty when the amount of GnRH (Gonadotropin-Releasing Hormone) increases. This leads to an increase in LH and FSH hormones.
- LH or Luteinizing hormones act on the Leydig cells and increase the synthesis of androgens, these androgens stimulate spermatogenesis.
- FSH or Follicular cells act on Sertoli cells which secrete substances that help in spermatogenesis.
- Spermatogonia divide mitotically and form primary spermatocytes, primary spermatocyte divides meiotically and completes first meiotic division to form secondary spermatocyte.
- The secondary spermatocytes complete the second meiotic division and form four spermatids.
- The Spermatids develop and transform into spermatozoa by the process of spermiogenesis.

OOGENESIS

- The process of formation of a mature female gamete is called **oogenesis** which is markedly different from spermatogenesis.
- Unlike spermatogenesis, which begins in males at puberty, oogenesis is initiated during the **embryonic** development stage when 2 million gamete mother cells (**oogonia**) are formed within each foetal ovary; no more oogonia are **formed** or **added** after birth. Scattered ovarian follicles are embedded in the stroma of cortex.



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

OVARIAN FOLLICLE (HUMAN OVUM)

During fetal life:

- The primordial germ cells develop from extra embryonic mesoderm that migrate into the ovaries during early embryonic development multiply, by about 5 months of gestation (prenatal life) the ovaries contain approximately 2 million oogonia.
- An ovarian follicle consists of an oocyte, surrounded by one or more layers of follicular (flat epithelial) cells, the granulosa cells.

• The oogonial cells start division and enter into diplotene of prophase-I of the meiotic division, and get temporarily arrested at this stage called primary **oocytes**. Each primary oocyte gets surrounded by a layer of **granulosa** cells and then called **primary follicle**.

After birth:

 A large number of these follicles degenerate from birth to puberty. Degeneration of ovarian follicles is called follicular atresia and their disposal is done by phagocytes. Therefore, at puberty only 60,000 to 80,000 primary follicles are left in each ovary. Follicular atresia can happen due to deficiency of vitamin E.

At puberty:

- With the onset of puberty, around one dozen primary follicle begins to mature with each ovarian cycle. The follicular cells becomes cuboidal, divide by mitosis to form a stratified epithelium, the granulosa layer. So, the primary follicles get surrounded by more layers of granulosa cells and a new theca, called **secondary follicles. Granulosa** cells rest on a basement membrane and the surrounding stromal cells form theca folliculi.
- The **secondary follicle** soon transforms into a **tertiary follicle** which is characterized by a fluid filled cavity **antrum**, which appears between the granulosa cells. Initially, the antrum is crescent shaped, but with time it greatly enlarges. The fluid of antrum is **liquor folliculi**.
- Theca layer soon differentiates into inner layer of endocrine cells theca interna & outer layer of fibroblast like cells theca externa.
- The maturing oocytes adhere to the wall of the follicle through a pedicel/stalk, cumulus oophorus, formed by granulosa cells, and remains suspended in liquor folliculi. Theca interna is composed of cells having characteristics of steroid secretion, rich in blood vessels and theca externa gradually merges with ovarian stroma.
- The primary oocyte within the tertiary follicle grows in size and completes its first meiotic division at puberty. It is an unequal division resulting in the formation of a large haploid secondary oocyte and a tiny first polar body. The secondary oocyte retains the bulk of nutrient rich cytoplasm of the primary oocyte. The tertiary follicle changes into the mature follicle or Graafian follicle (is present in mammals only).
- The secondary oocyte forms a new membrane called Zona pellucida surrounding it. This thick coat of zona pellucida is composed of glycoproteins and synthesized by oocyte. Later the granulosa cells lying in close vicinity of the ovum and zona pellucida, become elongated to form the corona radiata. In the presence of LH hormone, the Graafian follicle now ruptures to release the secondary oocyte developing (ovum) from the ovary by the process called ovulation. After ovulation the ruptured follicle left in the ovary is converted to a structure called corpus luteum,

which secretes mainly progesterone but some amounts of estrogen and relaxin are also secreted.



(c) Secondary follicle

(d) Mature (graafian) follicle

Fig. Ovarian follicles



Fig. Stages of ovum and follicle development

REPRODUCTIVE CYCLE (REPRODUCTIVE PERIOD)

Estrous cycle:

- This type of cycle occur in non-primates and new world monkeys.
- The ovulation cycle in these animals go into estrus (heat) in approximate synchrony with ovulation.
- During estrus they use behaviors and other signals, such as pheromones, to indicate that they are sexually receptive. Estrus lasts, depending on the species, for a few hour to few days during each cycle.
- Based on frequency of cycles in a year, estrous animals can be of two types-
 - (i) Monoestrous: Dog, Fox, Deer, Bat.
 - (ii) **Polyestrous:** Mouse, Squirrel, Cow, Sheep, Pig, Horse etc.
- The whole cycle is divided into four phases (1) Pre-estrous (first step, oogenesis starts), (2)
 Estrous (Heat period, pheromones produced, (3) Meta Estrous (Pseudopregnancy, if

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fertilization occurs then lasts up to parturition) and **(4) Anestrous/Diestrous** (Interphase). Anestrous phase is longer in monoestrous as compared to polyestrous.



Fig.: Estrous Cycle