Oogenesis, Female Gametogenesis

The process of the maturation of the female gametes through the meiotic division.

About Oogenesis

Oogenesis, illustrated in Pic. 1, occurs in the outermost layers of the ovaries. As with sperm production, oogenesis starts with a germ cell, called an oogonium (plural: oogonia), but this cell undergoes mitosis to increase in number, eventually resulting in up to about one to two million cells in the embryo.

The process of oogenesis

The process of oogenesis starts in the fetal ovaries with the development of oogonia from primordial germ cells (PGCs). Oogonia are formed during fetal development (in the process called oocytogenesis), and divide via mitosis, much like spermatogonia in the testis. In other words, primary oocytes reach their maximum development at 20 weeks of gestational age, when approximately seven million primary oocytes have been created; however, at birth, this number has already been reduced to approximately 1-2 million. The process of oogenesis/folliculogenesis is highly regulated by hormones and other substances.

Oocytogenesis

Oogenesis starts with the process of developing oogonia, which occurs via the transformation of primordial follicles into primary oocytes, a process called oocytogenesis. Oocytogenesis is complete either before or shortly after birth.
Ootidogenesis

The succeeding phase of ootidogenesis occurs when the primary oocyte develops into an ootid. This is achieved by the process of meiosis. In fact, a primary oocyte is, by its biological definition, a cell whose primary function is to divide by the process of meiosis:

a) Meiosis I

Meiosis I of ootidogenesis begins during embryonic development, but halts in the diplotene stage of prophase I until puberty. The mouse oocyte in the dictyate (prolonged diplotene) stage actively repairs DNA damage, whereas DNA repair is not detectable in the pre-dictyate (leptotene, zygotene and pachytene) stages of meiosis. For those primary oocytes that continue to develop in each menstrual cycle, however, synapsis occurs and tetrads form, enabling chromosomal crossover to occur. As a result of meiosis I, the primary oocyte has now developed into the secondary oocyte and the first polar body (PB 1).

b) Meiosis II

Immediately after meiosis I, the haploid secondary oocyte initiates meiosis II. However, this process is also halted at the metaphase II stage until fertilization, if such should ever occur. When meiosis II has completed, an ootid and another polar body (PB 2) have now been created. Both polar bodies disintegrate at the end of meiosis II, and their function is to discard the extra haploid sets of chromosomes that have resulted as a consequence of meiosis. Meiosis of a secondary oocyte is completed only if a sperm succeeds in penetrating its barriers. Meiosis II then resumes, producing one haploid ovum that, at the instant of fertilization by a (haploid) sperm, becomes the first diploid cell of the new offspring (a zygote).

Cell types in the oogenesis cycle consecutively:

- oogonium
- primordial follicles
- primary oocyte
- secondary oocyte
- mature ovum

Hormonal control of oogenesis

Follicle development signals the beginning of the menstrual cycle:

- at the start of the menstrual cycle (day 1), some 12-20 primary follicles
begin to develop under the influence of elevated levels of follicle stimulating hormone (FSH) to form secondary follicles.

- **day 9 of the cycle** - only one healthy secondary follicle remains, with the rest having been reabsorbed into the ovary. The remaining follicle is called the dominant follicle and is responsible for producing large amounts of estrogen during the late follicular phase.

- **day 14 of the cycle** - a lutenizing hormone (LH) surge occurs, which is triggered by the positive feedback of estrogen. This causes the secondary follicle to develop into a tertiary follicle, which then leaves the ovary 24–36 hours later. An important event in the development of the tertiary follicle occurs when the primary oocyte completes the first meiotic division, resulting in the formation of a polar body and a secondary oocyte. The empty follicle then forms a corpus luteum which later releases the hormone progesterone to maintain the potential pregnancy.

### News and future perspectives

In spite of generally accepted dogma that the total number of follicles and oocytes is established in human ovaries during the fetal period of life rather than forming de novo in adult ovaries, some new evidence in the field challenges this understanding. Several studies have shown that different populations of stem cells, such as germinal stem cells and small round stem cells with diameters of 2 to 4 µm, that resembled very small embryonic-like stem cells and expressed several genes related to primordial germ cells, pluripotency, and germinal lineage are present in adult human ovaries and originate in ovarian surface epithelium. These small stem cells were pushed into the germinal direction of development and formed primitive oocyte-like cells in vitro. Moreover, oocyte-like cells were also formed in vitro from embryonic stem cells and induced pluripotent stem cells. This indicates that postnatal oogenesis is not excluded. It is further supported by the occurrence of mesenchymal stem cells that can restore the function of sterilized ovaries and lead to the formation of new follicles and oocytes in animal models. Both oogenesis in vitro and transplantation of stem cell-derived "oocytes" into the ovarian niche to direct their natural maturation represent a big challenge for reproductive biomedicine in the treatment of female infertility in the future and needs to be explored and interpreted with caution, but it is still very important for clinical practice in the field of reproductive medicine.

### Find more about related issues

- Diagnoses
**Amenorrhoea**
The absence of a menstrual period in women of reproductive age.
Learn more at: [www.fertilitypedia.org/therapy/diag/amenorrhoea](http://www.fertilitypedia.org/therapy/diag/amenorrhoea)

**Anorexia Nervosa**
An eating disorder characterized by the maintenance of a body weight below average, fear of gaining weight, and a distorted body image.
Learn more at: [www.fertilitypedia.org/therapy/diag/anorexia-nervosa](http://www.fertilitypedia.org/therapy/diag/anorexia-nervosa)

**Anovulation**
Failure of the ovaries to release an oocyte over a period of time generally exceeding 3 months.
Learn more at: [www.fertilitypedia.org/therapy/diag/anovulation](http://www.fertilitypedia.org/therapy/diag/anovulation)

**Endometriosis**
Endometriosis is a state in which pieces of the tissue alike to the lining of the uterus (endometrium) grow in other parts of the body.
Learn more at: [www.fertilitypedia.org/therapy/diag/endometriosis](http://www.fertilitypedia.org/therapy/diag/endometriosis)

**Hematosalpinx**
Hematosalpinx is a medical condition involving bleeding into the fallopian tube.
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**Hydrosalpinx**
A hydrosalpinx is an abnormal pouch containing liquid in a fallopian tube.
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**Hyperprolactinemia**
The presence of abnormally high levels of prolactin in the blood.
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**Hypogonadism**
It is a medical term which describes a diminished functional activity of the gonads – the testes and ovaries in males and females, respectively.
Learn more at: [www.fertilitypedia.org/therapy/diag/hypogonadism](http://www.fertilitypedia.org/therapy/diag/hypogonadism)
Menopause
The time in most women's lives when menstrual periods stop permanently, and the woman is no longer able to have children.
Learn more at: www.fertilitypedia.org/therapy/diag/menopause

Obesity
A disease of excess body fat that can have a negative effect on health, leading to reduced life expectancy and other health problems.
Learn more at: www.fertilitypedia.org/therapy/diag/obesity

Oligomenorrhea
Light or infrequent menstrual flow at intervals of 39 days to 6 months or 5–7 cycles in a year.
Learn more at: www.fertilitypedia.org/therapy/diag/oligomenorrhea

Ovariectomy
Surgical removal of one or both ovaries.
Learn more at: www.fertilitypedia.org/therapy/diag/ovariectomy

Pelvic Inflammatory Disease
Infection of the upper part of the female reproductive system and a common complication of some sexually transmitted diseases.
Learn more at: www.fertilitypedia.org/therapy/diag/pelvic-inflammatory-disease-do-rf

Premature ovarian failure
The loss of function of the ovaries before age 40.
Learn more at: www.fertilitypedia.org/therapy/diag/premature-ovarian-failure

Uterine fibroids
The most common benign smooth muscle tumors of the uterus encountered in women of reproductive age.
Learn more at: www.fertilitypedia.org/therapy/diag/uterine-fibroids

Reproductive cells

Cumulus oophorus
The cell aggregation surrounding an oocyte before and after ovulation serving as a nursing and protective layer.
Learn more at: www.fertilitypedia.org/edu/reproductive-cells/cumulus-oophorus
The unequal cell division of oogenesis produces one to three polar bodies that later degrade, as well as a single haploid ovum, which is produced only if there is penetration of the secondary oocyte by a sperm cell.

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