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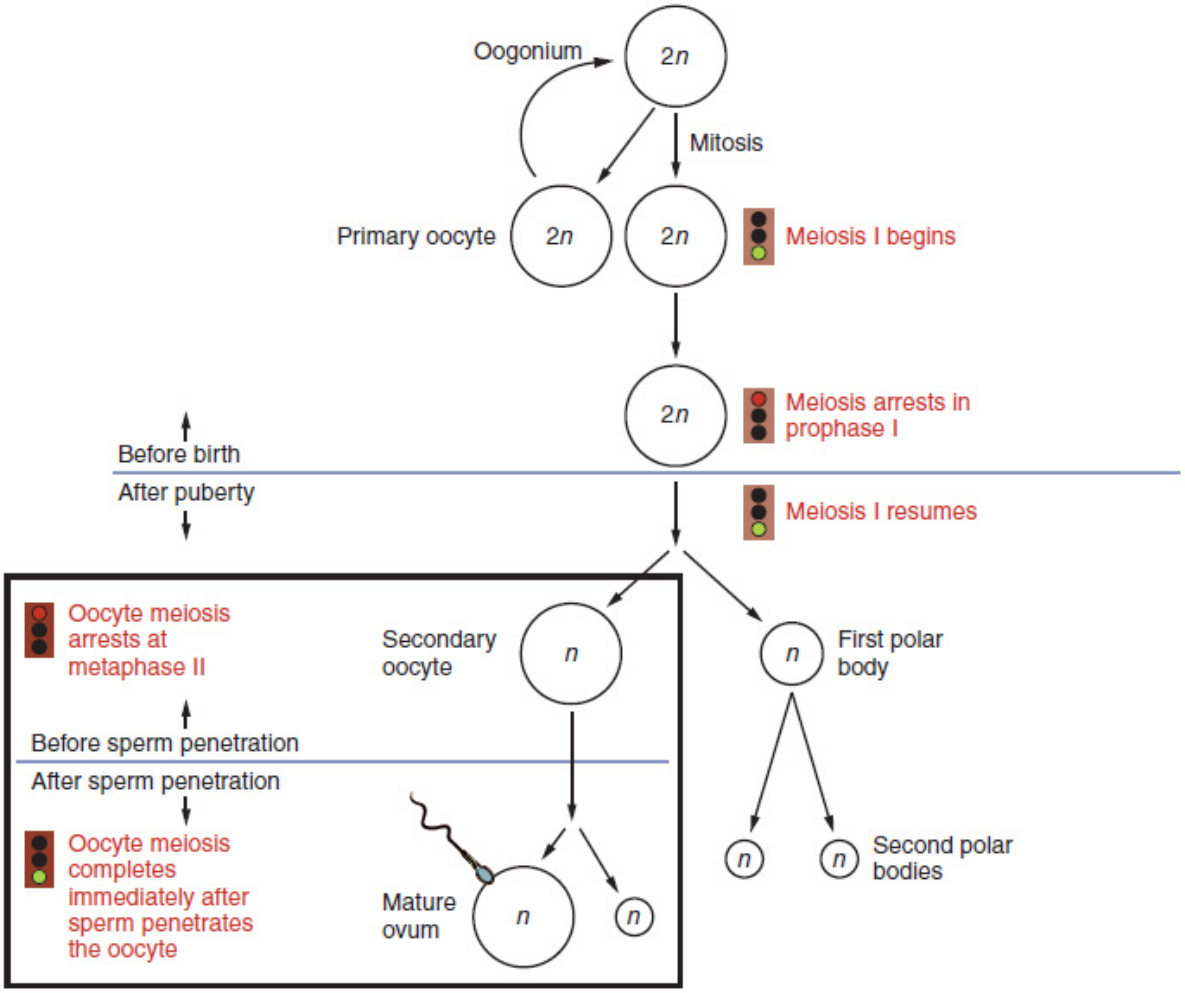
# Female Reproductive System: Oogenesis

By the end of the fourth month of fetal development there are roughly 7 million **oogonia** in the ovaries. Oogonia are analogous to spermatogonia and are the cells that will develop to become the egg or oocyte (also called an ovum). Unlike spermatogonia that remain quiescent until puberty, the oogonia begin meiosis I even before birth. However, the future ova, at this point, called primary oocytes, arrest in Prophase I where they will remain until puberty. Many of these oocytes degenerate and by birth only about 2 million remain.

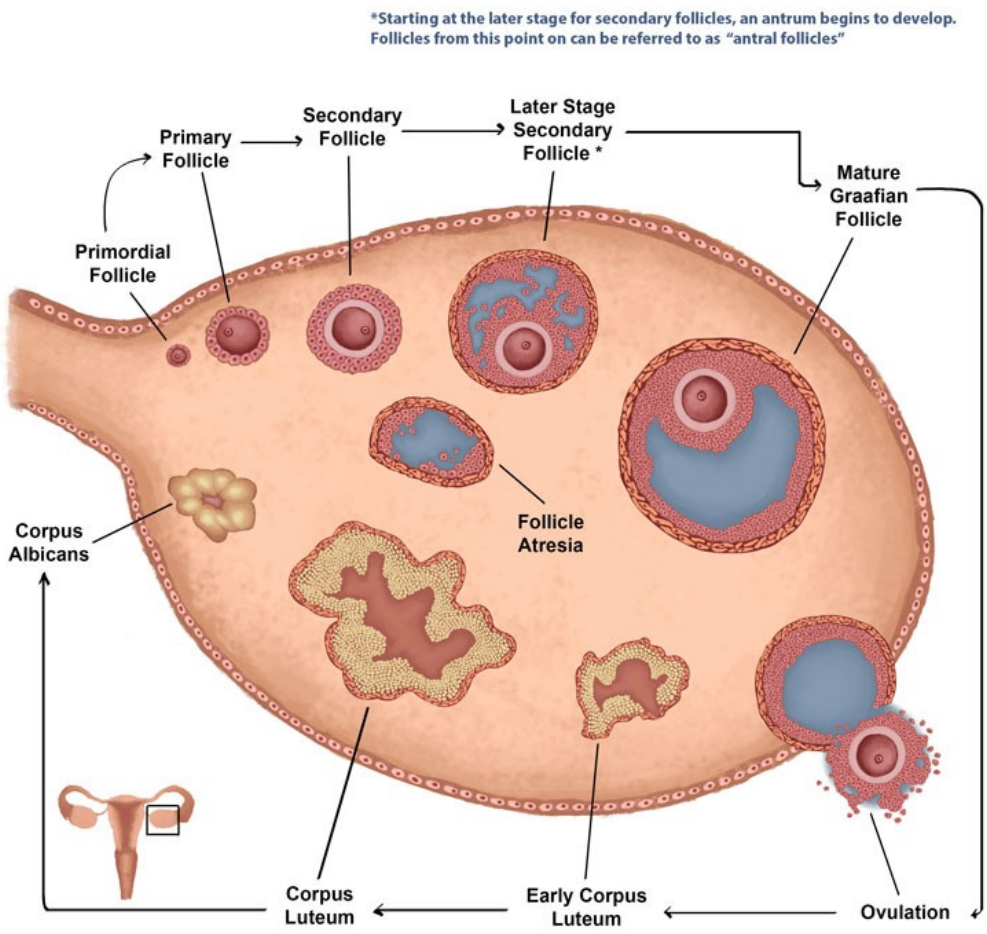



Oogenesis.



The process of attrition continues and by puberty there are only around 400,000 primary oocytes remaining, of which only 400 will be ovulated. Beginning at puberty and continuing throughout the reproduction years of the female, each menstrual cycle some oocytes will complete meiosis I to become secondary oocytes. These secondary oocytes begin meiosis II but again stop, this time at Metaphase II. Typically, only one oocyte will be ovulated each month and then, if it is fertilized, it will complete the second meiotic division. If it is not fertilized, it does not complete meiosis II and degenerates within about 24 hours after ovulation.

Recall that the two meiotic divisions of the spermatocytes result in the production of four spermatids. However, when the oocytes undergo meiosis the divisions produce only one daughter cell and one polar body.  It is essential that the ovum, when ovulated, have enough stored energy to keep the developing embryo alive until it implants in the uterine wall. Consequently, the meiotic divisions are unequal. The daughter cell retains all of the stored nutrients and cellular organelles while the polar body contains only the chromosomes from the nuclear division.




Stages of Folliculogenesis

Image by BYU-I Student Hannah C. Fall 2013

**Primordial Follicle**

Refer to the images above as you read the explanation of this process. The process of follicular development (**folliculogenesis**) begins even before the birth of the woman. In the fetal ovary, primary oocytes become surrounded by flat, squamous shaped cells that will later become granulosa cells. Granulosa cells are analogous to the Sertoli cells that surround and support the spermatogonia. Once the primary oocyte becomes surrounded by these pre-granulosa" cells, we call the group of cells, along with the basement membrane that surrounds it, a **primordial follicle**. Even though there are millions of primordial follicles in the fetus, by the onset of puberty, a female will have only about 400,000 primordial follicles. This is due to the continual process of **atresia** (apoptosis, or programmed cell death). It is not fully understood what regulates atresia and why some primordial follicles die and others do not. Beginning at puberty, primordial follicles may be recruited to develop further. It is also not known what regulates or determines which primordial follicles will begin further development, but it is known that several hormones are required for the process: the gonadotropins of the anterior pituitary, FSH and LH, as well as the ovarian hormone estrogen. The process is ongoing and during the female reproductive years there are always follicles in various stages of maturation and growth. Approximately 400 of the primary follicles will actually be released during a

woman’s reproductively active life.

**Primary Follicle**

Beginning at puberty small groups (cohorts) of primordial follicles start developing. The pre-granulosa cells that around the oocyte increase in size and become cuboidal in shape. At this point, we refer to these surrounding cells as **granulosa cells**. At the same time, the primary oocyte inside this layer of cells begins to increase in size and secrete proteins. Also, the granulosa cells nearest the oocyte secrete mucopolysaccharides. Together the proteins from the oocyte and the mucopolysaccharides from the granulosa cells form the **zona pellucida,** a clear layer between the oocyte and the granulosa cells. It is this barrier that the sperm will eventually have to penetrate in order to fertilize the ovum. The follicle is now a **primary follicle**.

**Secondary Follicle**

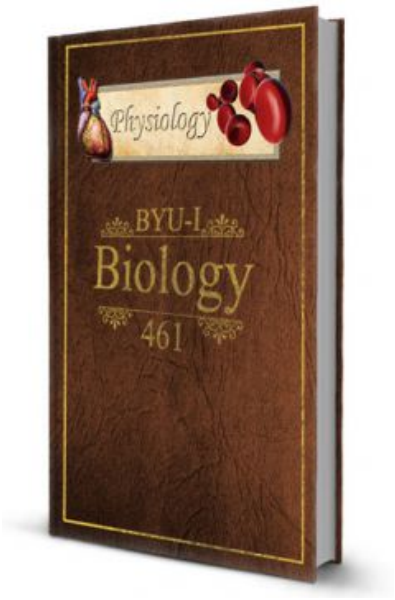
Next, the surrounding granulosa cells begin to divide by mitosis and form multiple layers. Simultaneously, stromal cells (connective tissue cells) are recruited by the follicle to form a layer of "**thecal**" **cells** just outside of the basement membrane. Once these processes are complete we call the follicle a **secondary follicle**.

**Graafian follicle**: As the follicle continues to develop, the thecal cells multiply forming several layers on the outside of the follicle. Additionally, the granulosa cells continue to increase in number and begin to secrete fluid (follicular fluid) resulting in the formation of fluid filled spaces among the granulosa cells. With the aid of the granulosa cells the primary oocyte continues to enlarge. Eventually all of the fluid filled spaces will coalesce into one large cavity called the antrum.

**Graafian Follicle**

The follicle is now called a mature **Graafian follicle**. Note that in the Graafian follicle the oocyte is located on one side of the antrum and is surrounded by several layers of granulosa cells, the **cumulus oophorus**. The Graafian follicle is now almost ready for ovulation. The final event, occurring several hours prior to ovulation, is completion of meiosis I to produce a secondary oocyte which immediately starts meiosis II. Once again however, the oocyte arrests, this time at the metaphase II stage where it will remain until it is fertilized by a sperm.

The predominant view is that once recruited, it requires three or four monthly cycles before the follicles reach full maturity (185 days). Typically, only one of the follicles will generally reach maturity and all of the others of that cohort will degenerate.




Shaw, J. & Hunt, J. (n.d.). *BIO 461 Principles of Physiology*. EdTech Books. https://edtechbooks.org/bio_461_principles_o