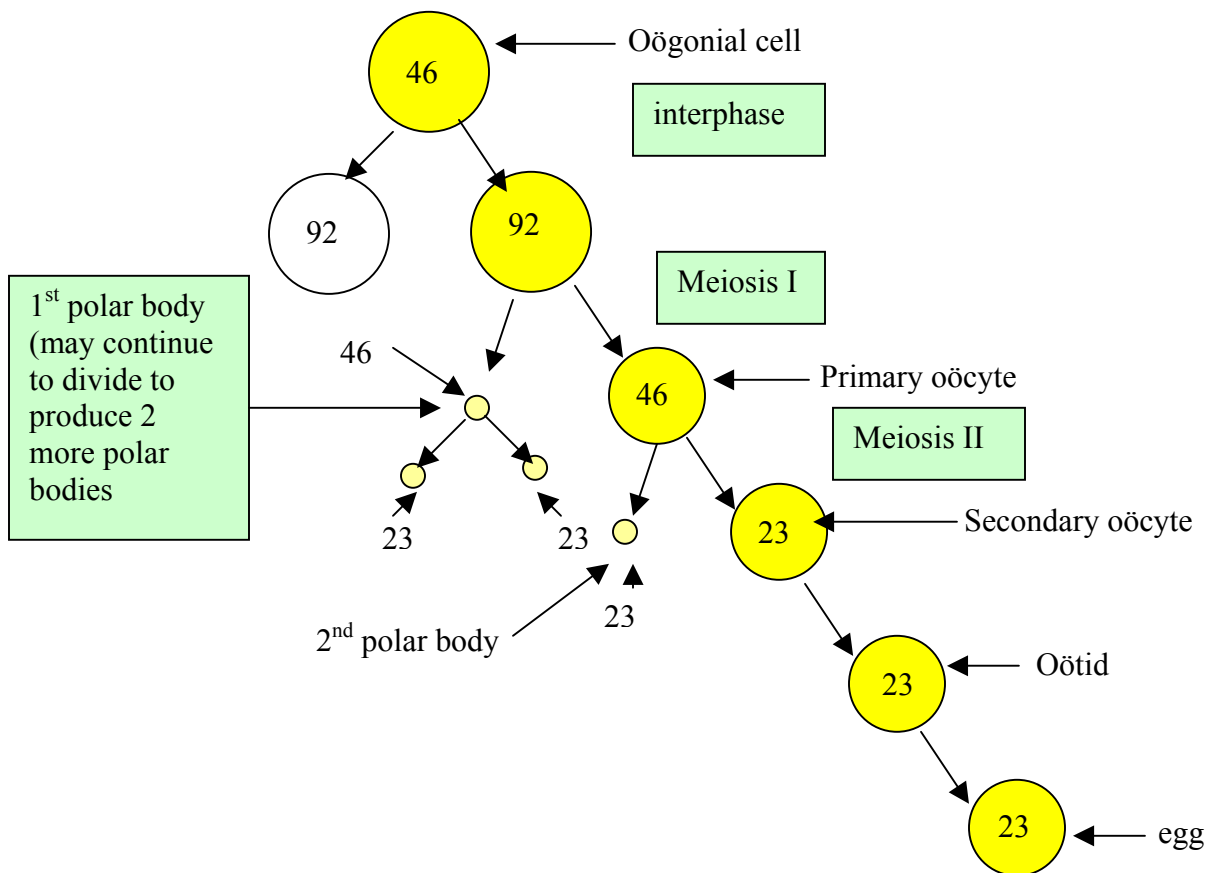


OÖGENESIS

Oögenesis

Oögenesis is the production of eggs in females. It follows the same basic pattern as spermatogenesis with one significant difference. There is an unequal division of the cytoplasm. Oögenesis begins with an oögonial cell with 46 chromosomes. The oögonial divides and undergoes interphase to produce the primary oöcyte with 92 chromosomes. The primary oöcyte undergoes Meiosis I and cytokinesis to produce two cells each with 46 chromosomes. One cell is the secondary oöcyte and is rather large. The other cell is called the first polar body and is quite small (budding off the nucleus to form a cell with virtually no cytoplasm). The first polar body often stays attached to the secondary oöcyte. The secondary oöcyte undergoes Meiosis II and cytokinesis. This results in the production of the oötid with 23 chromosomes and a second polar body with 23. The second polar body also remains attached to the now oötid. Sometimes the first polar body also divides and the result is one oötid and 3 polar bodies. (Technically, the process is hung up at metaphase I of meiosis until a sperm cell penetrates. When the sperm penetrates the secondary oöcyte, it kicks the oöcyte into the rest of meiosis and the production of the oötid and the three polar bodies. The oötid becomes the egg.

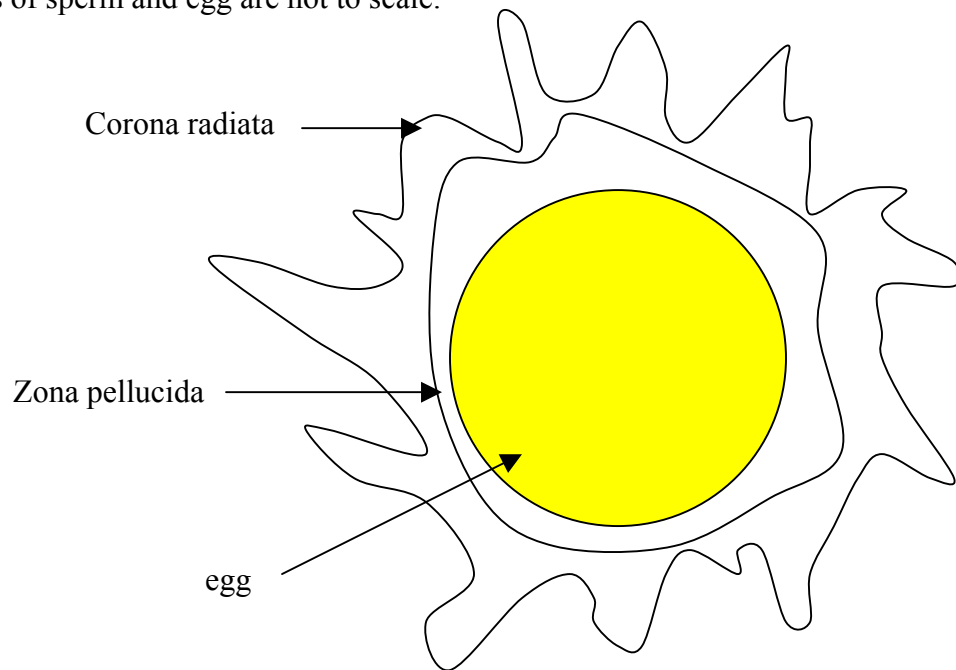
The whole purpose of unequal cell division (or budding of polar bodies) is to ensure at least one egg has enough yolk (nourishment) to be successful in fertilization. If mother nature divided the cytoplasm equally, there would be four very small eggs with little chance of survival because there would not be enough yolk.



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The egg is quite large, especially in comparison with the sperm. Technically, the egg still has 92 chromosomes in its nucleus even after ejection from the ovary. The nucleus is frozen in metaphase I of meiosis. Only when the sperm penetrates the egg does the egg nucleus complete meiosis to produce an egg with 23 chromosomes. Surrounding the egg is a very clear layer (zona pellucida) and around that region is an area that looks very much like the corona found associated with our sun. As a consequence, biologists call it the corona radiata. The sperm must penetrate these layers prior to fertilization.

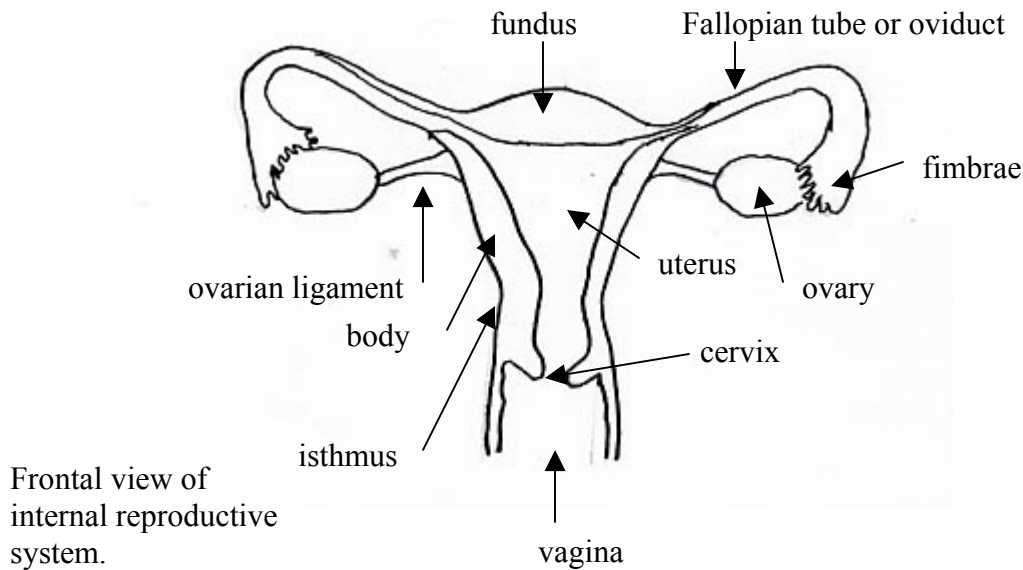
Illustrations of sperm and egg are not to scale.



Eggs (or ova) along with steroidal hormones, are produced in the female gonads or ovaries of females along with steroidal hormones. A single ovary is about the size of an almond – 3 cm long and 1.5 cm wide and 1 cm thick. Ovaries are recessed in a depression of the posterior pelvic wall.

Ova (ovum – singular) are enveloped by a fluid-filled follicle. However, only the ovum is pushed out of the ovary in a process called ovulation. Both ovaries are suspended within the body cavity by a pair of ovarian ligaments and suspensory ligaments.

OÖGENESIS



The Fallopian tubes or oviducts are approximately 10 cm long. The tubes are lined with cilia that beat downward towards the uterus. At each end of the oviduct is a swollen, hand-like structure called the fimbriae (fimbria – plural). The intent with the downward beating cilia and the fimbriae is for the ejected ovum to be caught by the fimbriae and propelled down the Fallopian tube to the uterus. It can take as long as three days for the ovum to travel this length, but in any case, the ovum can only survive 24 hours.

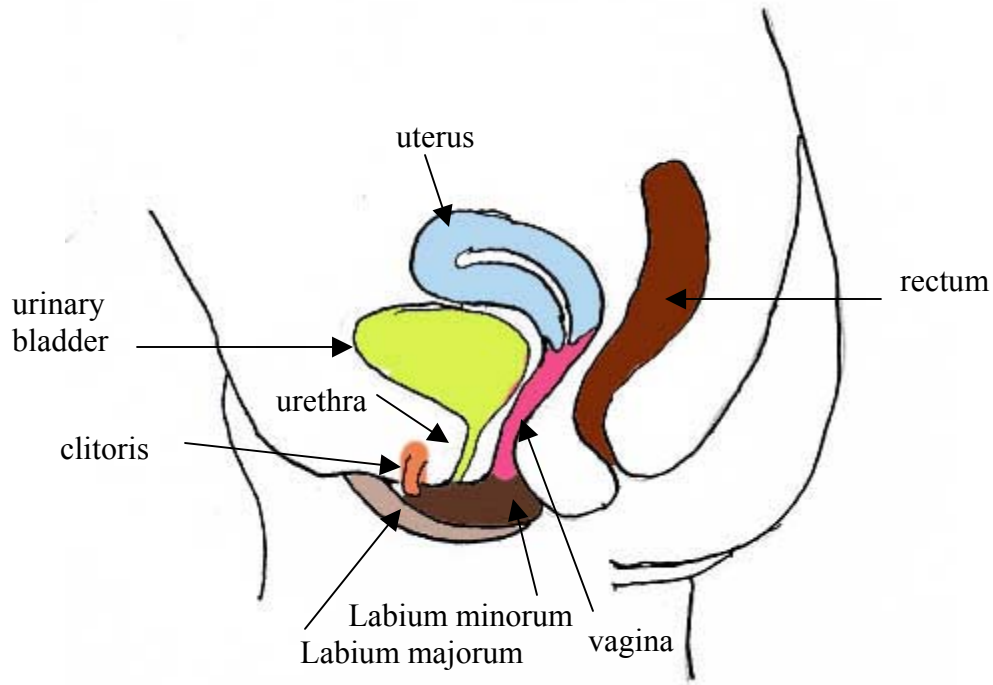
The uterus is divided into three regions: (1) fundus (2) body and (3) isthmus. The cervix is at the juncture of the uterus and vagina. The uterus, prior to pregnancy, is about the size of a large plum. Of course, during pregnancy, the uterus expands considerably to hold the developing fetus. It is also quite muscular in order to expel the fetus during birth.

The wall of the uterus is composed of three layers: (1) perimetrium – outer (2) myometrium – middle and (3) endometrium – inner. The myometrium is composed of smooth muscle which elongates during pregnancy and birth. The endometrium is a layer of epithelia with glands. Two thirds of this layer is shed during the menstrual cycle and the rest remains behind to regenerate the tissue that was shed. The endometrium is where the placenta attaches.

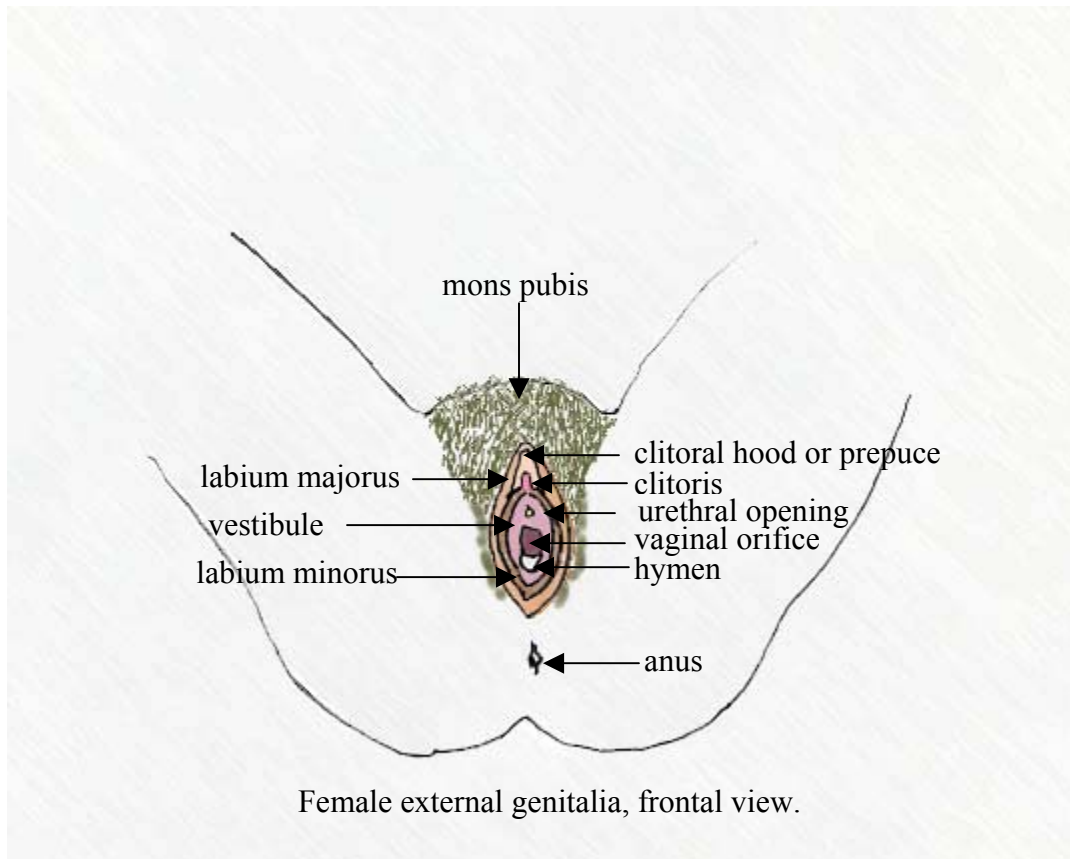
The vagina is a tube approximately 8 to 10 cm long that allows for the discharge of menstrual fluid, insertion of the penis, and reception of semen. There is a muscular layer associated with the middle layer of the vagina. There are no glands but the vagina is capable of “vaginal sweating” during sex to facilitate the insertion of the penis and lubrication during coitus.

The lower end of the vagina has a thin membrane, called the hymen, that covers the entrance to the vagina. There are small openings (finestre) that allow the passage of menstrual fluid, but this is generally ruptured during the first intercourse. Only the lower third of the vagina has significant nerve endings.

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Female reproductive system, side view.



Female external genitalia, frontal view.

OÖGENESIS

The term vulva refers to the (1) mons pubis (2) labia majora (labium majorum – singular) (3) labia minora (labium minorus – singular) and (4) clitoris.

The mons pubis is a mound of fatty tissue with a cartilaginous disc just above the genitalia. Just below the mons pubis are the labia. The mons pubis and the outer surface of the labia majora have hair. The inner surface of the labia majora and the entire labia minora are hairless. Before a woman gives birth, the labia minora are obscured by the labia majora. This condition is referred as multipary and the woman is said to be multiparous. After birth, the labia minora often flare out from the labia majora and this condition is referred to as nulliparous.

The area enclosed by the labia is called the vestibule. Where the labia minora meet anterior to the vestibule, a hood-like structure forms, the prepuce or foreskin. This is exactly homologous to the male prepuce. The prepuce covers the clitoris which is entirely homologous to the penis in males. The glans of the clitoris protrudes slightly from the prepuce. The main difference between the clitoris and the penis is there is no corpus spongiosum. Instead, The clitoris has corpora cavernosa. Just like the corpora of the penis, the clitoris becomes engorged with blood and becomes erect when the female becomes sexually excited.

The vestibule also contains the urethral opening and the vaginal opening. Unlike males where the urinary system and the reproductive system are combined, the female urinary system is separate from the reproductive system.

To either side of the vagina are a pair of small glands called Bartholin glands or greater vestibular glands. These are homologous to the bulbourethral glands of the male by providing secretions to lubricate the female for intercourse and to keep the vulva moist.

In addition, there are several lesser vestibular glands as well as a pair of Skene glands (also called paraurethral) which are homologous to the male prostate. Associated with the labia majora are a pair of erectile tissues called the vestibular bulbs which form a parenthesis-like appearance around the vagina. These become engorged with blood and cause the vagina to tighten around the penis to heighten sexual intercourse.

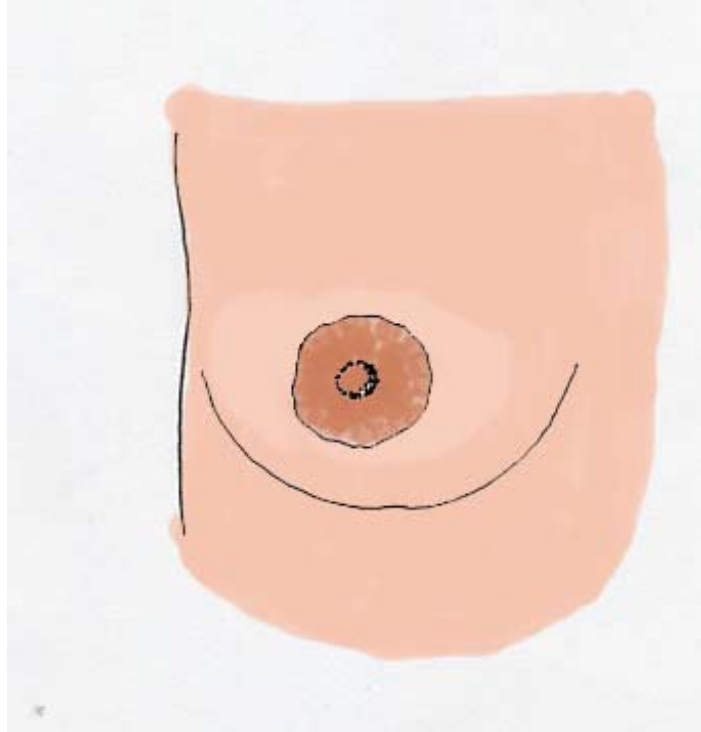
Secondary Sexual Characteristics

Just as the secondary sexual characteristics of males often serve as a sexual attractant to the female by sight, touch, smell, etc., the secondary sexual characteristics of females serve to attract males. Those features that represent secondary sexual characteristics in females include distribution of body fat, flare of the pelvis (the pear-shape), fine body hair, high pitched voice and breasts.

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Breasts

Breasts of females are mounds of tissue which are found over the pectoralis major muscles (as in males). There are two regions of the breasts: the body which has a nipple at its tip and the axillary tail which extends the breast towards the arm pits.

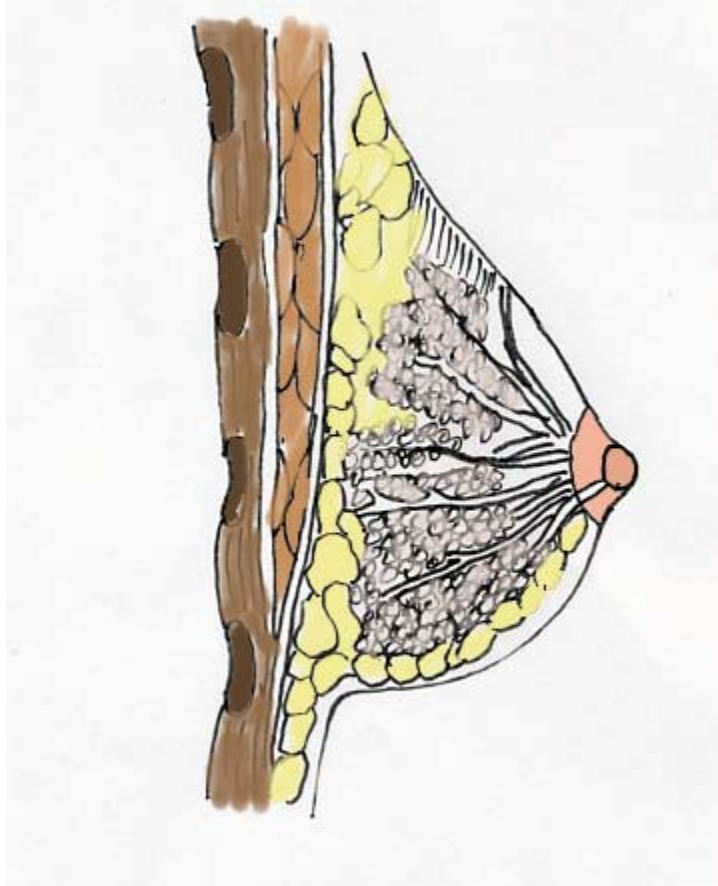


The body of the breast is characterized by the nipple and a colored portion surrounding the nipple called the areola. It's the areola that has blood vessels and nerves close to the surface which makes it more sensitive to touch and redder than the surrounding region of the breast. One unusual result of the color is during pregnancy, it becomes even darker. This leads some scientists to think it makes the nipple more distinct to a nursing infant.

Some of the nerve fibers in the areola stimulate the milk ejection reflex during nursing. The areola has little hair and a set of areolar glands with a role in preventing of chapping of the areola. As you might suppose, the areola is quite sensitive to temperature, touch, and therefore sexual arousal. When a female becomes sexually aroused through the touch of the areola, the areola wrinkles and the nipple becomes erect.

OÖGENESIS

Breasts are mostly adipose tissue and collagenous tissue in a female that is not lactating. The mammary gland is poorly developed in this type of female. However, once pregnant, the breast shifts to better development of the glandular portion of the breast.



Sexual Cycle in Females

The sexual cycle in females is governed by the ovary and changes in the uterus (not to be confused with estrus, or heat, in animals). The cycle may last anywhere from 20 to 45 days but the average is 28. The cycle is driven by hormonal changes.

There are three major phases of the cycle with some of the phases characterized by specific events. The three phases are (1) follicular phase (2) ovulation, and (3) postovulatory phase. Shown below are the major phases and the subcategories of each.

- I. Follicular Phase
 - a. Menstrual Phase
 - b. Preovulatory Phase
- II. Ovulation
- III. Postovulatory Phase
 - a. Luteal Phase
 - b. Premenstrual Phase

OÖGENESIS

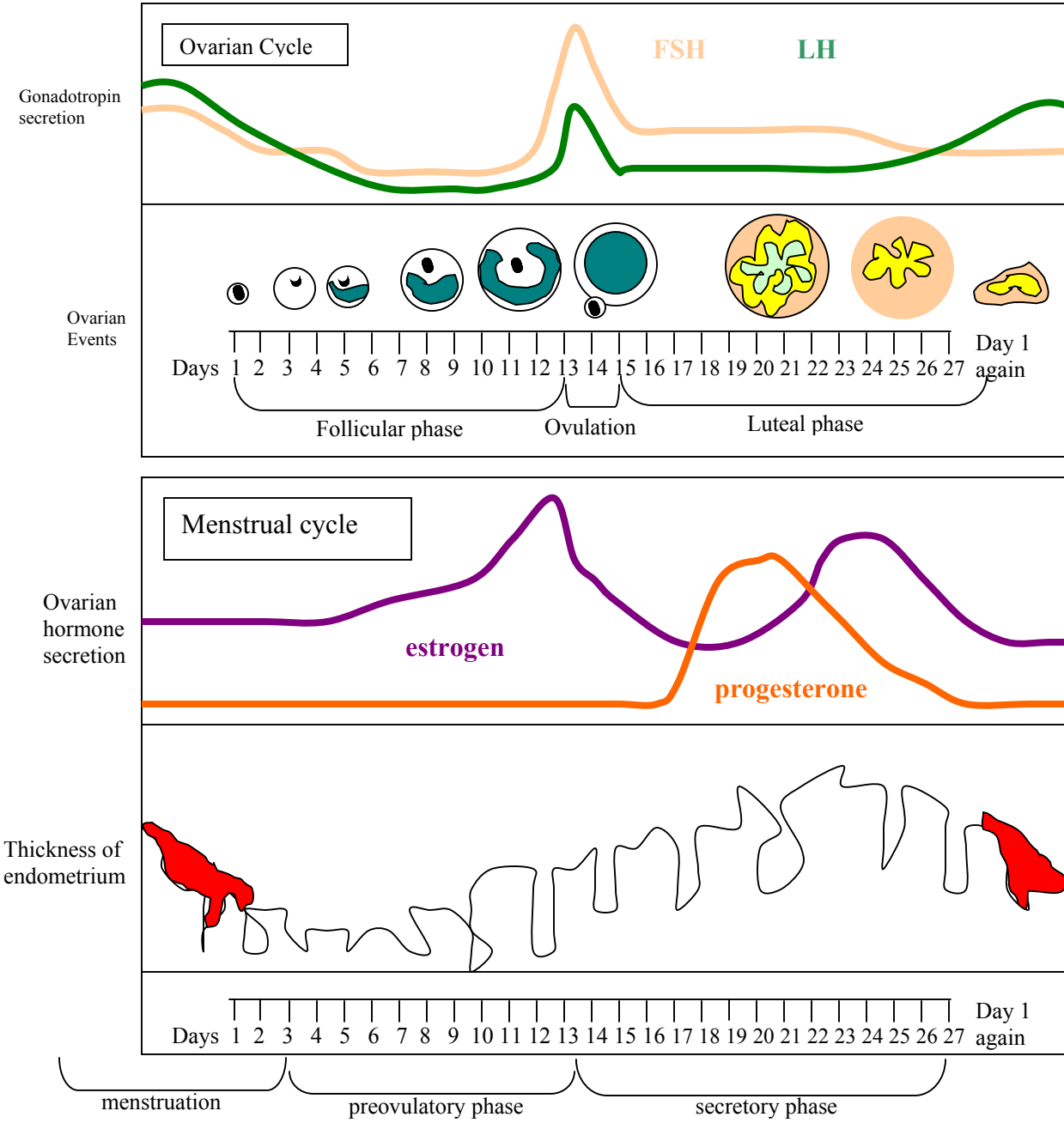
I. Follicular Phase

As seen above, the follicular phase is divided into the menstrual and preovulatory phase. It lasts an average of 14 days beginning with menstruation and ending with ovulation. This is the most variable phase and as a consequence, it's very difficult to predict the moment of ovulation, thus the noted failure of the rhythm method of birth control.

a. Menstrual Phase

Around day 25 of the just completed cycle, the ovary, under the influence of follicle stimulating hormone (FSH) stimulates around 20 to 25 primary oöcytes to complete meiosis I. Surrounding each oöcyte is a sheath of cells called the follicle.

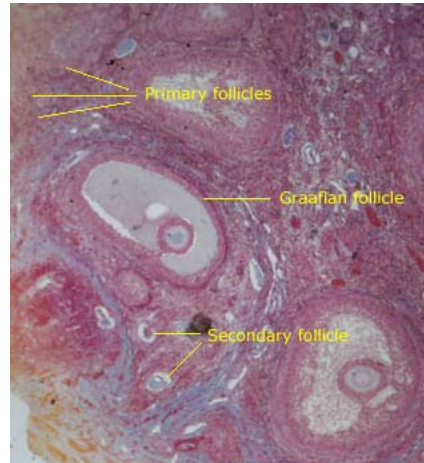
OÖGENESIS



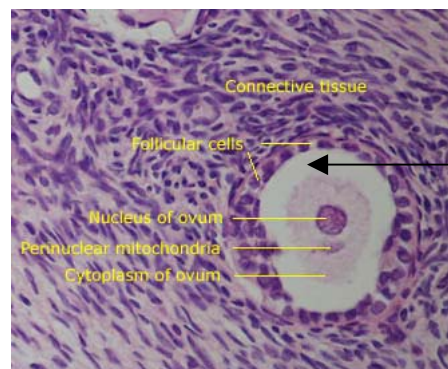
OÖGENESIS

FSH causes the follicular cells to multiply and thus enlarge to form the primary follicle. It's in the first few days of the primary follicle stage that estrogen is produced that forms around the oöcyte. It's at this point the primary follicle becomes the secondary follicle. At the time of the production of the secondary follicle, menstruation phase stops (around day 5 of the sexual cycle).

A section through the ovary showing primary and secondary follicles along with the mature follicle – the Graafian follicle. The Graafian follicle moves to the inner surface of the ovary and forms a blister-like bump on the surface.



The Graafian follicle contains the primary oöcyte which completes meiosis I. The primary oöcyte now becomes the secondary oöcyte but stops at metaphase II of meiosis II. Ovulation occurs at this point.



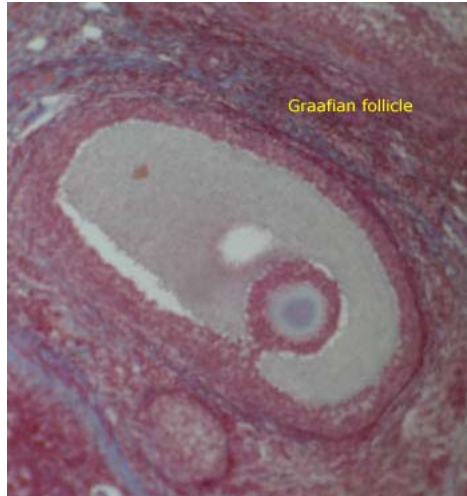
estrogen rich follicular fluid

The estrogen produced inside the follicle has two effects. First, it stimulates the follicular cells to become very sensitive to FSH. The FSH present causes the follicle to produce even more estrogen. Second, and somewhat contradictory, estrogen now inhibits FSH production by the pituitary, lowering the levels of FSH. This has an important function. It causes the less developed follicles not to develop any further and thus degenerate.

b. Preovulatory Phase

The menstrual phase runs approximately from day 1 to day 5. The preovulatory phase begins around day 6 and lasts around 8 days. This phase results in the endometrium of the uterus (which was shed during menstruation, to begin to redevelop in anticipation of implantation of the fetus. After menstruation, the endometrium is around 2 mm thick. By day 14, it is around 4 mm thick. At the same time, estrogen causes the endometrium to become sensitive to progesterone. The one follicle that outpaces the development of the others is called the Graafian follicle.

OÖGENESIS



Graafian Follicle in the ovary.

II. Ovulation

This phase is characterized by the expulsion of the oöcyte from the ovary. Remember, the Graafian follicle has formed a blister on the surface of the ovary. The oöcyte is explosively released from the ovary, much like a volcanic eruption. This process is so violent, some females can tell the moment the oöcyte is ejected. The site of the expulsion scars over. This expulsion of the secondary oöcyte usually occurs during day 15 of the sexual cycle (remember, this varies from individual to individual).

Ovulation is triggered by hormonal changes. Estrogen levels were high in the postovulatory phase. Estrogen increases the amount of GnRH produced by the hypothalamus which in turn stimulates the anterior pituitary to increase FSH and leutenizing hormone (LH) [also known as ICSH].

This increase in LH keys ovulation. The Fallopian tubes begin the downward beating of cilia to propel the oöcyte down the Fallopian tubes. There is only 24 hours for the egg to be fertilized. After that, it dies.

Postovulatory Phase

The most predictable stage of the sexual cycle is the postovulatory phase. It generally runs from day 15 to day 28 of the sexual cycle. The first 12 of those days is called the luteal phase and the last two are called the premenstrual phase.

OÖGENESIS

a. Luteal Phase

Once the oöcyte has been ejected, the follicle which held it remains behind. It begins to fill up with cells and turns somewhat yellow in appearance, thus its name – the corpus luteum. It's the corpus luteum that secretes androgen which stimulates the production of progesterone which causes the uterus to continue to increase the thickness of the endometrium for the fetus.

The corpus luteum also produces inhibin which suppresses FSH which in turn shuts down follicle production. If pregnancy occurs, the corpus luteum remains active for about 3 months, continuing to govern hormone production.

b. Premenstrual Phase

If pregnancy does not occur, the corpus luteum begins to degenerate while increasing production of progesterone. This shuts down GnRH and LH secretion. The decrease in LH causes the corpus luteum to shrink which causes progesterone levels to decrease. The decrease in progesterone causes the endometrium to become necrotic and be shed in the form of menses. What remains of the corpus luteum becomes scar tissue inside the ovary. This is now called the corpus albicans since the pigment that colored the corpus luteum is now gone. It's now time to begin the cycle once again.

Puberty in females occurs around the age of 8 to 13 and one characteristic of reaching puberty is the first menstrual flow. The female is said to undergo menarche at her first period. Interestingly, the age of menarche in females has steadily decreased from 16.5 years in 1860 to 13 in 1960. Women, when placed in a group environment (such as dormitory rooms) will synchronize their menstrual cycle to the dominant female.

Menopause

Unlike males who can produce sperm until the day they die, women have a limited time of fertility. Females are born with all the eggs they will ever produce – approximately 250,000 per ovary! Fortunately for women, not all develop into eggs (as discussed above). Many of these primary oöcytes become less sensitive to hormones and thus development never occurs. The result is atrophy of the uterus, vagina and breasts. Sexual intercourse, or coitus, becomes uncomfortable, vaginal infections are more common, and the vagina becomes drier. Cholesterol levels rise which increase the chance of cardiovascular disease. Bone mass declines leading to osteoporosis. Because of shifting hormone balances, the female experiences hot flashes. Hot flashes may occur several times a day and are characterized by a flushing of skin of the abdomen, chest, neck and face accompanied by a sensation of heat. Because of the increase (and decrease) in blood to the skin, headaches often occur after the hot flash. Menopause may cause depression, irritability, and other changes in mood.

Menopause usually occurs between the ages of 45 and 55 but the age is increasing and it now averages 52 years old. Since menopause is somewhat akin to going “cold turkey” with drugs, some physicians prescribe hormone replacement therapy (HRT) by providing low doses of progesterone and estrogen. There is great debate on the benefits and liabilities of this type of therapy.

OÖGENESIS

Female Sexual Response

Females undergo the same stages of sexual response as males: excitement, plateau, orgasm, and resolution.

Excitement

This stage is very similar to the male as far as the physiology. The heart rate and blood pressure increases, myotonia occurs, the respiration rate increases, and vasodilation occurs. However, the difference between females and males occurs in the genitalia.

Blood flows into the labia. The labia minora may actually protrude from the labia majora. The labia majora become reddened, enlarged, and flattened to expose the vaginal orifice. The vaginal wall becomes purple due to blood flow and it becomes very lubricated. The clitoris become engorged with blood and often expands and further pushes up under the clitoral hood. Breasts enlarge due to vasodilation and nipples become erect.

Plateau

Only the lower 1/3 of the vagina has significant nerve endings. The lower 1/3 of the vagina constricts to grip the penis and the upper 2/3 expands. The uterus, which typically points toward the outer abdominal wall before excitement now tilts upward and away from the abdominal wall. This process is called tenting. The result is to pull the cervix up and away from the vagina in order to pull semen into the uterus.

Often, women have a series of involuntary contractions that cause the pelvis to thrust upward. This is followed by 1 to 2 seconds of stillness prior to orgasm.

Orgasm

The sense of orgasm that most women experience begins with a sensation spreading from the clitoris through the pelvis with a sense of warmth about the entire body. Orgasmic contractions are about 0.8 seconds apart and three to five in number. The anal and urinary sphincters contract and the uterus undergoes peristaltic waves similar to labor contractions. The paraurethral glands which are homologous to the prostate often expel fluid. Heart rate and breathing increase further as do the breasts. The areola becomes highly engorged. Most women produce a “flush” along the lower abdomen, chest, neck and face.

Resolution

The uterus now returns to its normal resting place and the cervix moves down towards the vagina. The sex flush disappears, the vagina returns to normal size, and areola, nipples, and breasts undergo vasodilation.

Where men have a refractory period of 10 to 15 minutes up to several hours before they are ready for intercourse again, females do not have a refractory period and may quickly have additional orgasms if stimulated.