

## 1. Details of Module and its structure

Module Detail	
Subject Name	Biology
Course Name	Biology 03 (Class XII, Semester - 1)
Module Name/Title	Human Reproduction – Part 2
Module Id	lebo_10302
Pre-requisites	Knowledge about the process of sexual reproduction and male reproductive system
Objectives	After going through this lesson, the learners will be able to understand the following: <ul style="list-style-type: none"><li>• The Female Reproductive System</li><li>• Female accessory glands (Mammary gland)</li><li>• Oogenesis</li><li>• Menstruation Cycle</li><li>• Role of Hormones</li></ul>
Keywords	Ootid, polar body, Graafian follicles, Vulva, Clitoris, Hymen, Cervix, Uterus, Fallopian tube, Mammary glands, Corpus luteum.

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### **1. Introduction**

Sexual reproduction cannot happen without the sexual organs called gonads. Both sexes have gonads: in females, the gonads are the ovaries. The female gonads produce female gametes (eggs). Besides ovaries the female reproductive system includes the fallopian tubes, uterus, vagina, vulva, mammary glands and breasts. These organs are involved in the production and transportation of gametes and the production of sex hormones. The female reproductive system also facilitates the fertilization of ova by sperm and supports the development of offspring during pregnancy.

The fertilization usually occurs in the oviducts, but can happen in the uterus itself. The zygote then implants itself in the wall of the uterus, where it begins the processes of embryogenesis and morphogenesis.

### **2. The female reproductive system**

#### **External Genitals**

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##### **Vulva**

The external female genitalia is referred to as vulva. It consists of the labia majora and labia minora (while these names translate as "large" and "small" lips, often the "minora" can protrude outside the "majora"), mons pubis, clitoris, opening of the urethra (meatus), vaginal vestibule, vestibular bulbs, vestibular glands.

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## **Labia Majora**

The **labia majora** are the outer "lips" of the vulva. They are pads of loose connective and adipose tissue, as well as some smooth muscle. The labia majora wrap around the vulva from the mons pubis to the perineum. The labia majora generally hides, partially or entirely, the other parts of the vulva.

## **Labia Minora**

Medial to the labia majora are the labia minora. The **labia minora** are the inner lips of the vulva. They are thin stretches of tissue within the labia majora that fold and protect the vagina, urethra, and clitoris. There is no pubic hair on the labia minora, but there are sebaceous glands. The labia minora protect the vaginal and urethral openings. Both the inner and outer labia are quite sensitive to touch and pressure.

## **Clitoris**

The **clitoris**, visible as the small white oval between the top of the labia minora and the clitoral hood, is a small body of spongy tissue that functions solely for sexual pleasure.

During sexual excitement, the clitoris erects and extends, the hood retracts, making the clitoral glans more accessible. The size of the clitoris is variable between women.

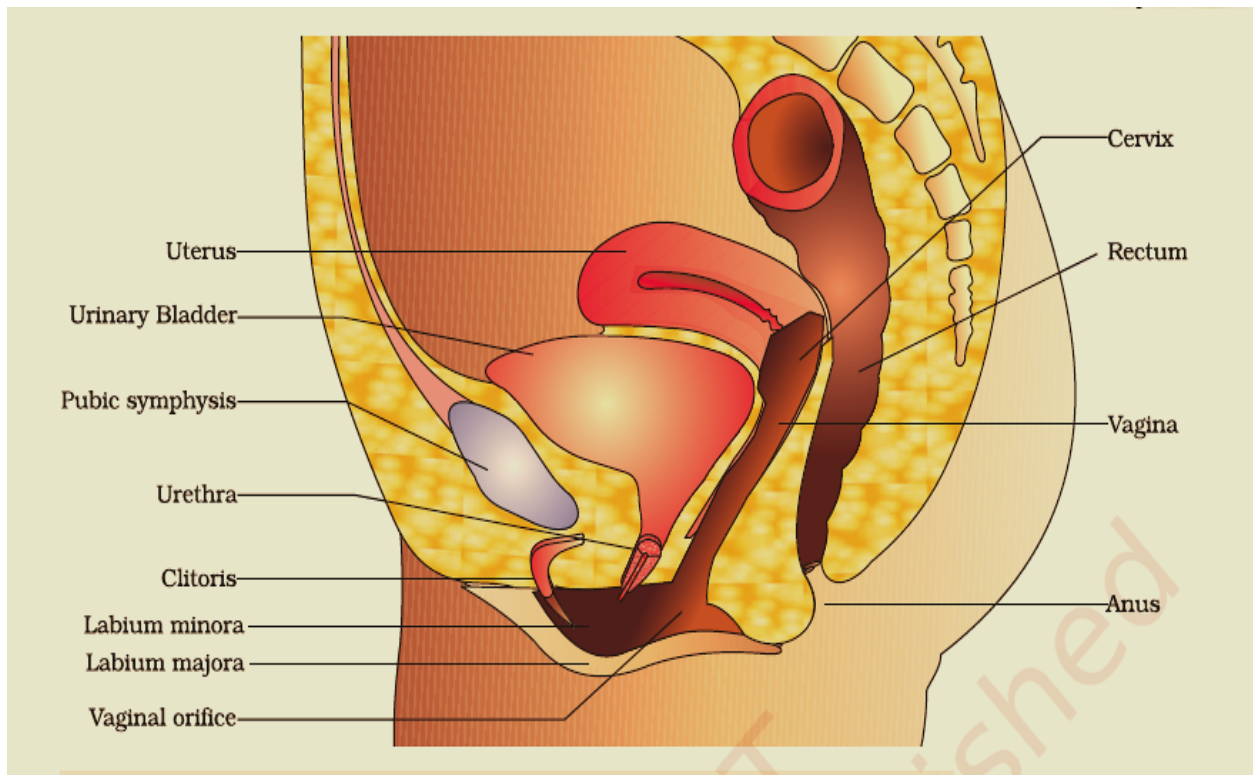
## **Urethra**

The opening to the urethra is just below the clitoris. Although it is not related to sex or reproduction, it is included in the vulva. The **urethra** is actually used for the passage of urine. The urethra is connected to the bladder. In females the urethra is 1.5 inches long, compared to males whose urethra is 8 inches long. ***Because the urethra is so close to the anus, women should always wipe themselves from front to back to avoid infecting the vagina and urethra with bacteria.***

## **Hymen**

The hymen is a thin fold of mucous membrane that separates the lumen of the vagina from the urethral sinus.

*The hymen is a poor indicator of whether a woman has actually engaged in sexual intercourse because a normal hymen does not completely block the vaginal opening. The normal hymen is never actually "intact" since there is always an opening in it. Furthermore, there is not always bleeding at first vaginal penetration. The hymen can also be broken by a sudden fall or jolt, insertion of a vaginal tampon, active participation in some sports like horseback riding, cycling, etc. In some women the hymen persists even after coitus. In fact, the presence or absence of hymen is not a reliable indicator of virginity or sexual experience.*



The female reproductive organs

## Internal Genitals

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### **Vagina**

The **vagina** is a muscular, hollow tube that extends from the vaginal opening to the cervix of the uterus. It is situated between the urinary bladder and the rectum. It is about three to five inches long in a grown woman. The muscular wall allows the vagina to expand and contract. The vagina

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receives sperm during sexual intercourse from the penis. The sperm that survive the acidic condition of the vagina continue on through to the fallopian tubes where fertilization may occur.

### **Purposes of the Vagina**

- Receives a male's erect penis and semen during sexual intercourse.
- Pathway through a woman's body for the baby to take during childbirth.
- Provides the route for the menstrual blood (menses) from the uterus, to leave the body.
- May hold forms of birth control, such as a diaphragm, or female condom.

### **Cervix**

The **cervix** is the lower, narrow portion of the uterus where it joins with the top end of the vagina.

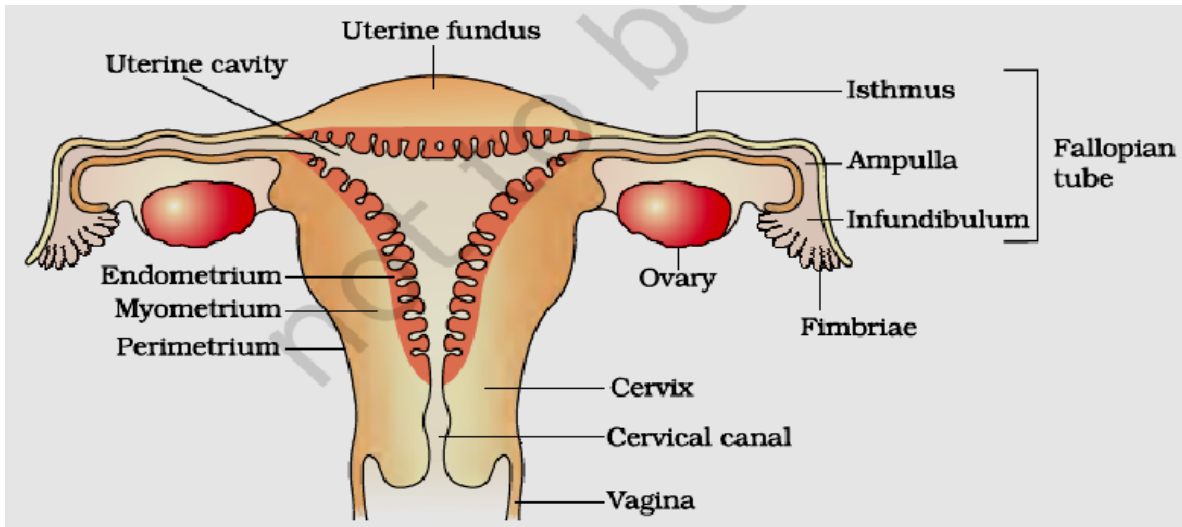
During childbirth, contractions of the uterus will dilate the cervix up to 10 cm in diameter to allow the child to pass through.

### **Uterus**

The **uterus** is shaped like an upside-down pear, with a thick lining and muscular walls. Located near the floor of the pelvic cavity, it is hollow to allow a blastocyst, or fertilized egg, to implant and grow. It also allows for the inner lining of the uterus to build up until a fertilized egg is implanted.

The uterus contains some of the strongest muscles in the female body. These muscles are able to expand and contract to accommodate a growing fetus and then help push the baby out during labor. These muscles also contract rhythmically during an orgasm in a wave like action. It is thought that this is to help push or guide the sperm up the uterus to the fallopian tubes where fertilization may be possible.

The uterus is only about three inches long and two inches wide, but during pregnancy it changes rapidly and dramatically. The wall of the uterus has three layers of tissue. The external thin membranous perimetrium, middle thick layer of smooth muscle, myometrium and inner glandular layer called endometrium that lines the uterine cavity. The endometrium undergoes cyclical changes during menstrual cycle while the myometrium exhibits strong contraction during delivery of the baby.



## Fallopian Tubes

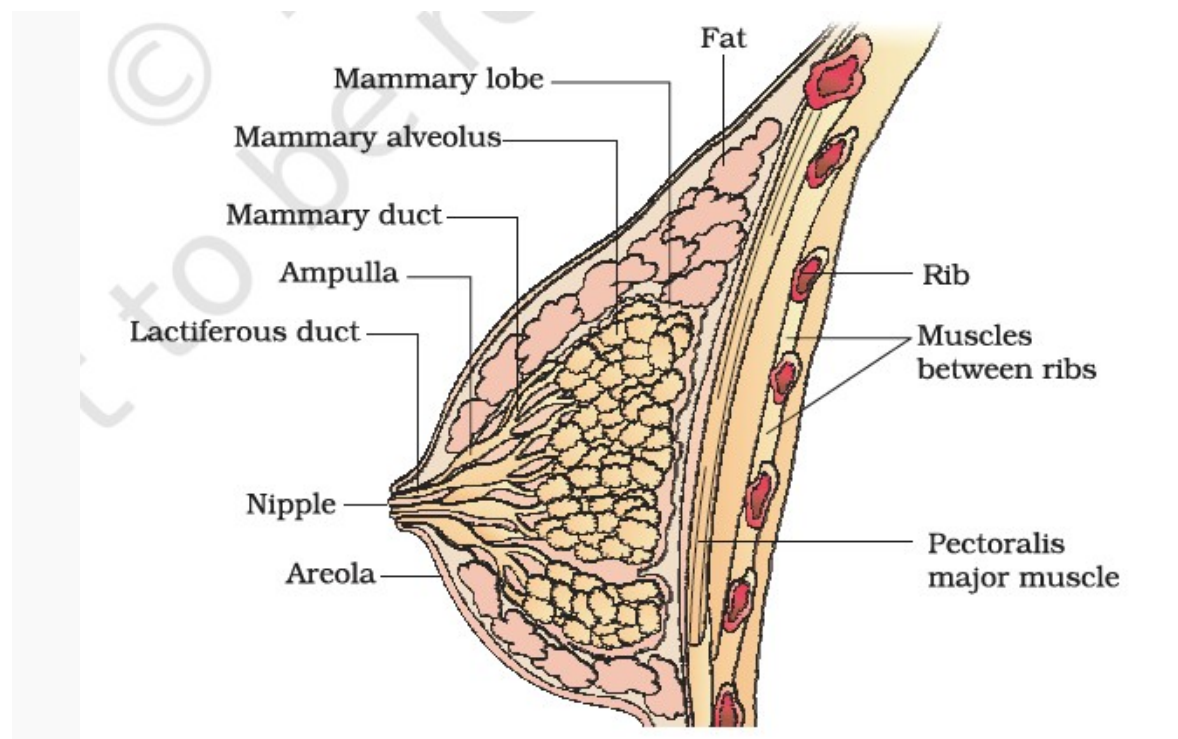
At the upper corners of the uterus are the **fallopian tubes**. There are two fallopian tubes, also called the uterine tubes or the oviducts. Each fallopian tube attaches to a side of the uterus and connects to an ovary. They are positioned between the ligaments that support the uterus. The fallopian tubes are about four inches long. Within each tube is a tiny passageway no wider than a sewing needle. At the other end of each fallopian tube is a fringed area that looks like a funnel. This fringed area, called the infundibulum, lies close to the ovary, but is not attached. The ovaries alternately release an egg. When an ovary does ovulate, or release an egg, it is swept into the lumen of the fallopian tube by the fimbriae.

Once the egg is in the fallopian tube, tiny hairs in the tube's lining help push it down the narrow passageway toward the uterus. The oocyte, or developing egg cell, takes four to five days to travel down the length of the fallopian tube. If enough sperm are ejaculated during sexual intercourse and there is an oocyte in the fallopian tube, fertilization will occur. After fertilization occurs, the zygote, or fertilized egg, will continue down to the uterus and implant itself in the uterine wall where it will grow and develop.

*If a zygote doesn't move down to the uterus and implants itself in the fallopian tube, it is called a ectopic or tubal pregnancy. If this occurs, the pregnancy will need to be terminated to prevent permanent damage to the fallopian tube, possible hemorrhage and possible death of the mother.*

### 3. Mammary glands

**Mammary glands** are the organs that produce milk for the sustenance of a baby. These exocrine glands are enlarged and modified sweat glands.



Cross section of the breast of a human female.

#### Structure

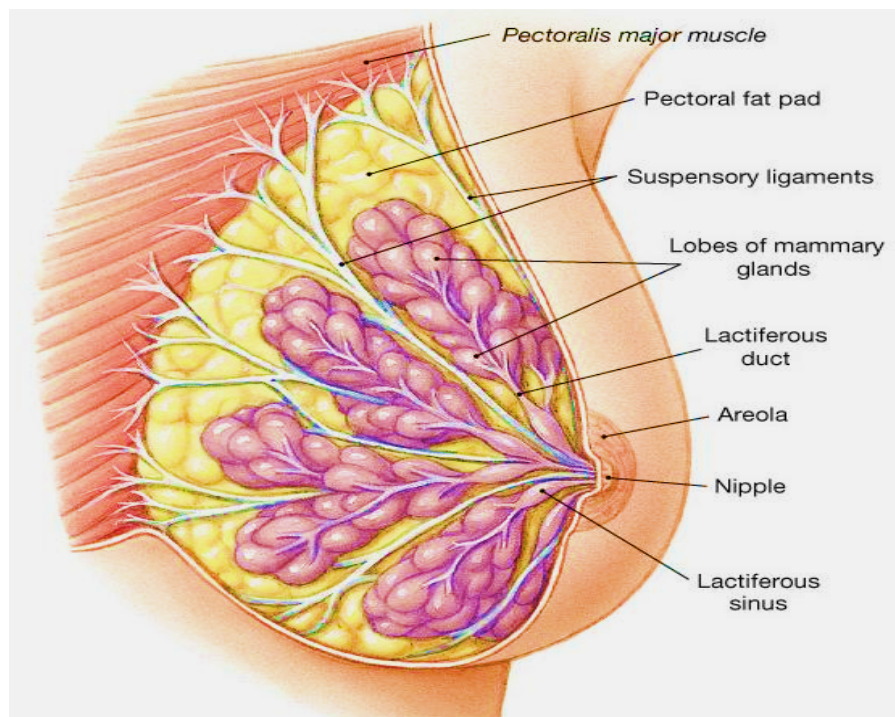
The basic components of the mammary gland are the **alveoli** (hollow cavities, a few millimeters large) lined with milk-secreting epithelial cells and surrounded by myoepithelial cells. These alveoli join up to form groups known as **lobules**, and each lobule has a **lactiferous duct** that drains into openings in the nipple.

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The development of mammary glands is controlled by hormones. The mammary glands exist in both sexes, but they are rudimentary until puberty when - in response to ovarian hormones - they begin to develop in the female. Estrogen promotes formation, while testosterone inhibits it.

At the time of birth, the baby has lactiferous ducts but no alveoli. Little branching occurs before puberty when ovarian estrogens stimulate branching differentiation of the ducts into spherical masses of cells that will become alveoli. True secretory alveoli only develop in pregnancy, where rising levels of estrogen and progesterone cause further branching and differentiation of the duct cells, together with an increase in adipose tissue and a richer blood flow.

Colostrum is secreted in late pregnancy and for the first few days after giving birth. True milk secretion (lactation) begins a few days later due to a reduction in circulating progesterone and the presence of the hormone prolactin.



The cells of mammary glands can easily be induced to grow and multiply by hormones. If this growth runs out of control, cancer results. Almost all instances of breast cancer originate in the lobules or ducts of the mammary glands.



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## 4. Oogenesis

### Key Points

- Oogenesis starts with the process of developing oogonia via the transformation of primordial follicles into primary oocytes, a process called oocytogenesis.
- Oocytogenesis is complete either before or shortly after birth in humans. During the menstrual cycle primary oocytes complete maturation through further meiotic divisions.
- The first meiotic division is coordinated by hormones: follicle stimulating hormone (FSH), estrogen, luteinizing hormone (LH), and progesterone.
- The oocyte is arrested in cell division prior to the second meiotic division, which only occurs after fertilization.

### The Process

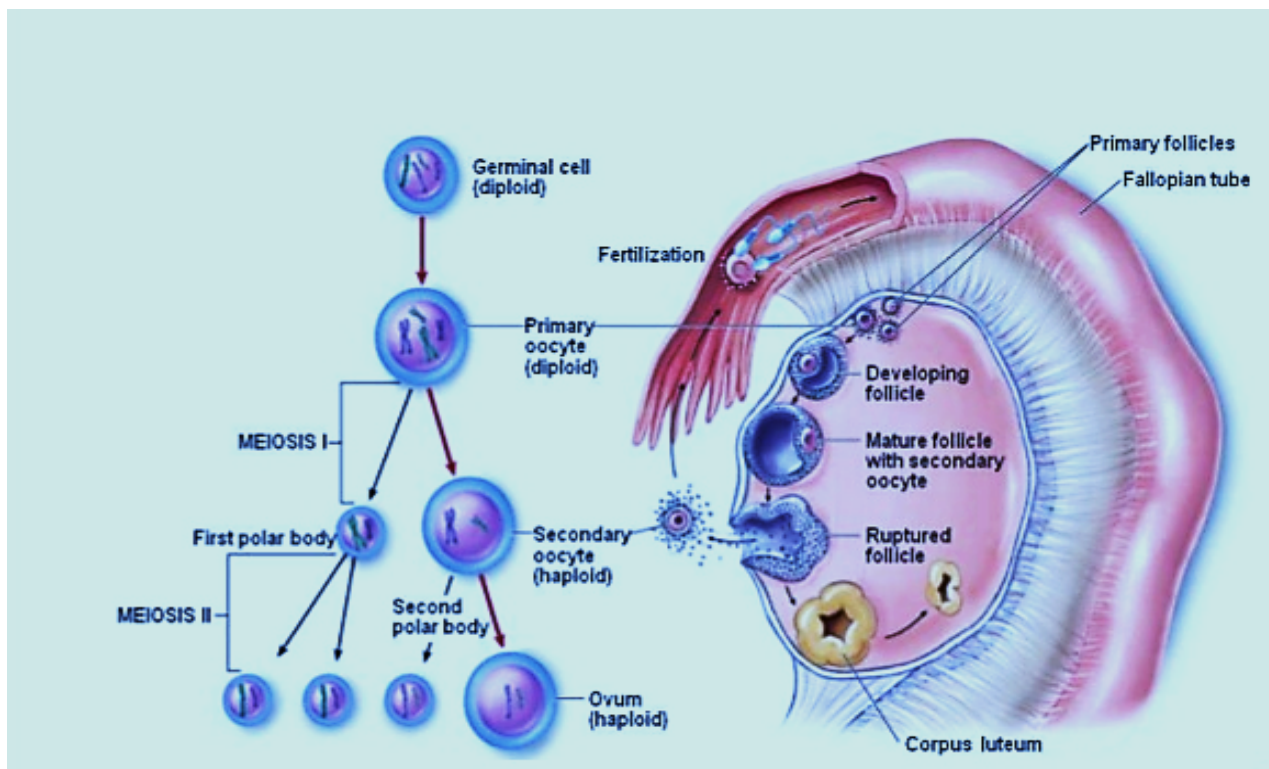
Oogenesis is initiated during the embryonic development stage when a couple of million gamete mother cells (oogonia) are formed within each fetal ovary; no more oogonia are formed and added after birth. These cells start division and enter into prophase-I of the meiotic division and get temporarily arrested at that stage, called primary oocytes. Each primary oocyte then gets surrounded by a layer of granulosa cells and is called the primary follicle. A large number of these follicles degenerate during the phase from birth to puberty. Therefore, at puberty only 60,000-80,000 primary follicles are left in each ovary.

The primary follicles get surrounded by more layers of granulosa cells and a new theca and are called secondary follicles. The secondary follicle soon transforms into a tertiary follicle which is characterized by a fluid filled cavity called antrum. The theca layer is organised into an inner theca interna and an outer theca externa.

It is important to draw your attention that it is at this stage that the primary oocyte within the tertiary follicle grows in size and completes its first meiotic division. 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 bulk of the nutrient rich cytoplasm of the primary oocyte.

Can you think of any advantage for this? Does the first polar body born out of first meiotic division divide further or degenerate? (At present we are not very certain about this).

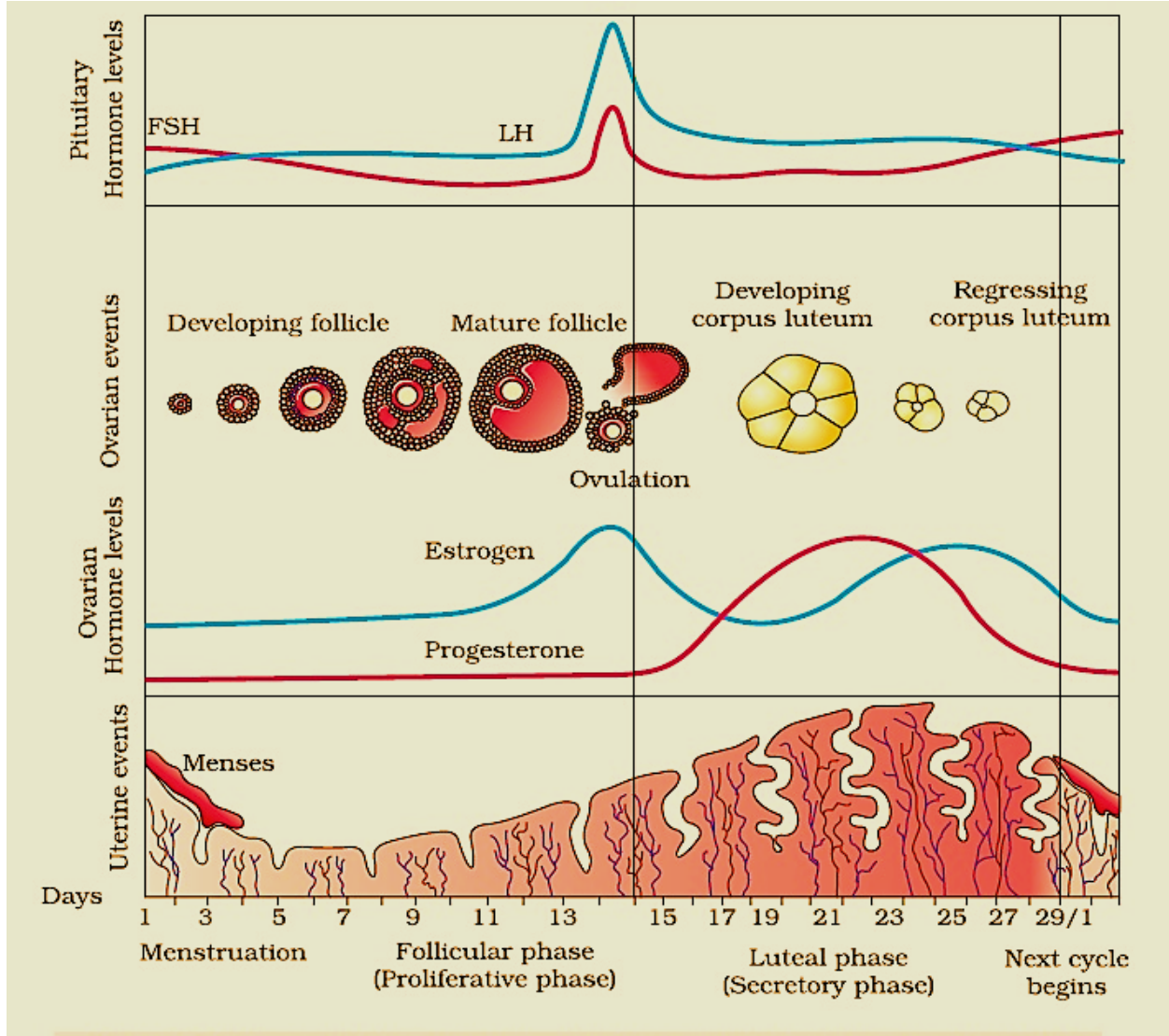
The tertiary follicle further changes into the mature follicle or Graafian follicle .The secondary oocyte forms a new membrane called zona pellucida surrounding it. The Graafian follicle now ruptures to release the secondary oocyte (ovum) from the ovary by the process called ovulation.



## Menstrual Cycle

The menstrual cycle can be described by the **ovarian or uterine cycle**. The ovarian cycle describes changes that occur in the follicles of the ovary whereas the uterine cycle describes changes in the endometrial lining of the uterus. Both cycles can be divided into three phases.

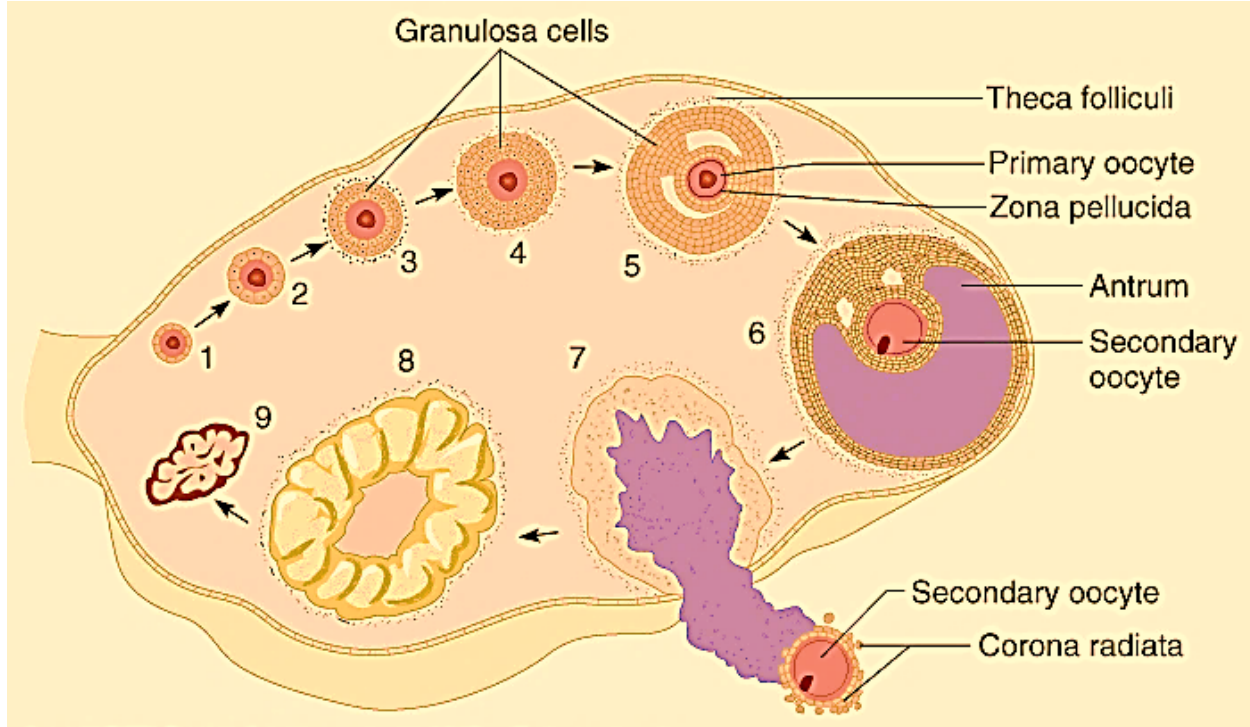
**The ovarian cycle consists of the follicular phase, ovulation, and the luteal phase whereas the uterine cycle consists of menstruation, proliferative phase, and secretory phase.**



## Ovarian cycle

### Follicular phase

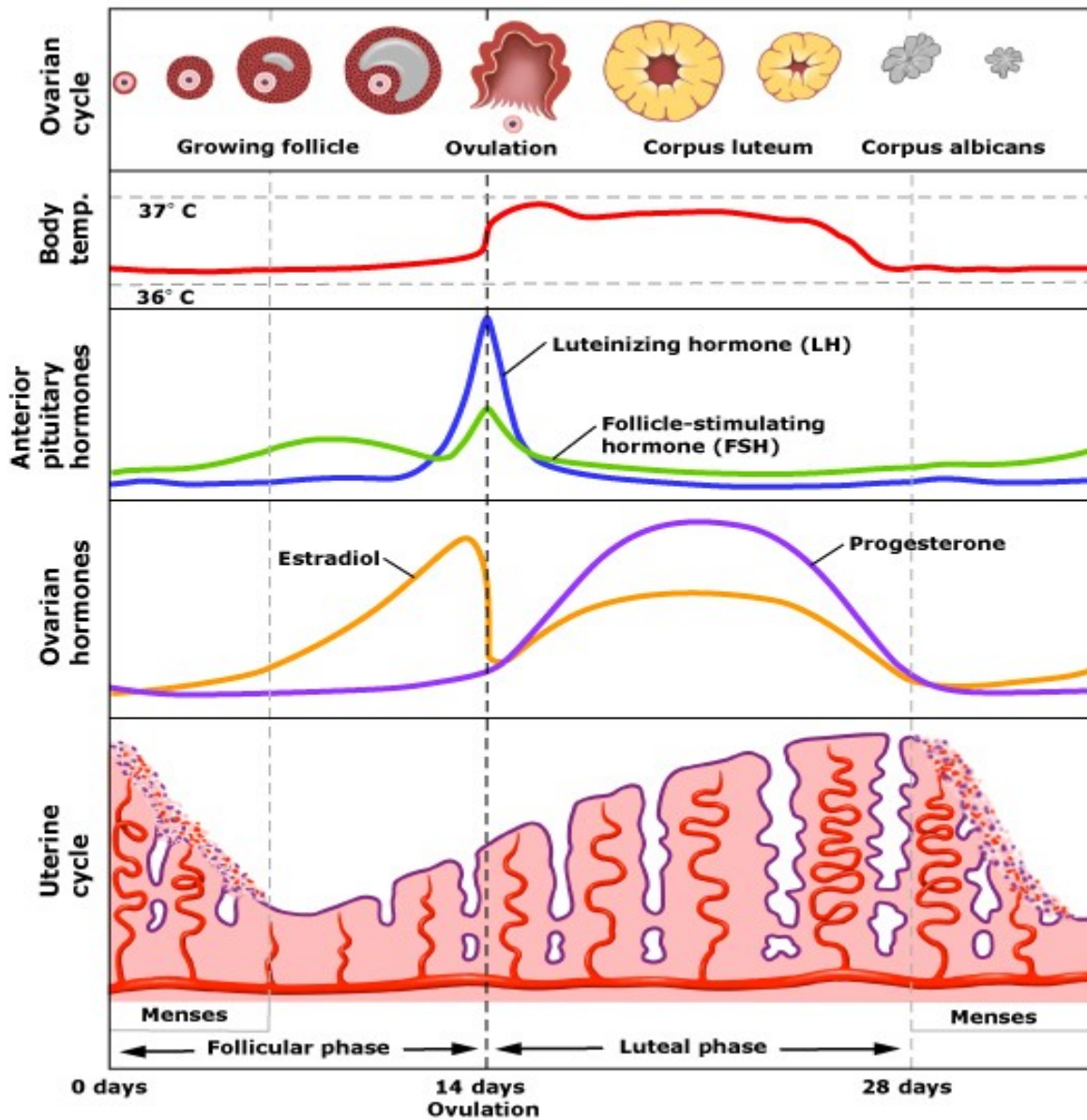
The follicular phase is the first part of the ovarian cycle. During this phase, the ovarian follicles mature and get ready to release an egg. The latter part of this phase overlaps with the proliferative phase of the uterine cycle.



Through the influence of a rise in follicle stimulating hormone (FSH) during the first days of the cycle, a few ovarian follicles are stimulated. These follicles, which were present at birth and have been developing for the better part of a year in a process known as folliculogenesis, compete with each other for dominance. Under the influence of several hormones, all but one of these follicles will stop growing, while one dominant follicle in the ovary will continue to maturity. The follicle that reaches maturity is called a tertiary, or Graafian, follicle, and it contains the ovum.

### Ovulation

Ovulation is the second phase of the ovarian cycle in which a mature egg is released from the ovarian follicles into the oviduct. During the follicular phase, estradiol suppresses production of luteinizing hormone (LH) from the anterior pituitary gland. When the egg has nearly matured, levels of estradiol reach a threshold above which this effect is reversed and estrogen stimulates the production of a large amount of LH. This process, known as the LH surge, starts around day 12 of the average cycle and may last 48 hours.



The release of LH matures the egg and weakens the wall of the follicle in the ovary, causing the fully developed follicle to release its secondary oocyte. The secondary oocyte promptly matures into an ootid and then becomes a mature ovum. The mature ovum has a diameter of about 0.2 mm.

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Which of the two ovaries—left or right—ovulates appears essentially random; no known left and right co-ordination exists. Occasionally, both ovaries will release an egg; if both eggs are fertilized, the result is fraternal twins.

After being released from the ovary, the egg is swept into the fallopian tube by the fimbria, which is a fringe of tissue at the end of each fallopian tube. After about a day, an unfertilized egg will disintegrate or dissolve in the fallopian tube.

### **Luteal phase**

The luteal phase is the final phase of the ovarian cycle and it corresponds to the secretory phase of the uterine cycle. During the luteal phase, the pituitary hormones FSH and LH cause the remaining parts of the dominant follicle to transform into the corpus luteum, which produces progesterone. The increased progesterone in the adrenals starts to induce the production of estrogen. The hormones produced by the corpus luteum also suppress production of the FSH and LH that the corpus luteum needs to maintain itself. Consequently, the level of FSH and LH fall quickly over time, and the corpus luteum subsequently atrophies. Falling levels of progesterone trigger menstruation and the beginning of the next cycle. From the time of ovulation until progesterone withdrawal has caused menstruation to begin, the process typically takes about two weeks, with 14 days considered normal. For an individual woman, the follicular phase often varies in length from cycle to cycle; by contrast, the length of her luteal phase will be fairly consistent from cycle to cycle.

The loss of the corpus luteum is prevented by fertilization of the egg. The outer layer of the resulting embryo-containing structure (the blastocyst) and later also becomes the outer layer of the placenta, produces human chorionic gonadotropin (hCG), which is very similar to LH and which preserves the corpus luteum. The corpus luteum can then continue to secrete progesterone to maintain the new pregnancy.

### **Uterine cycle**

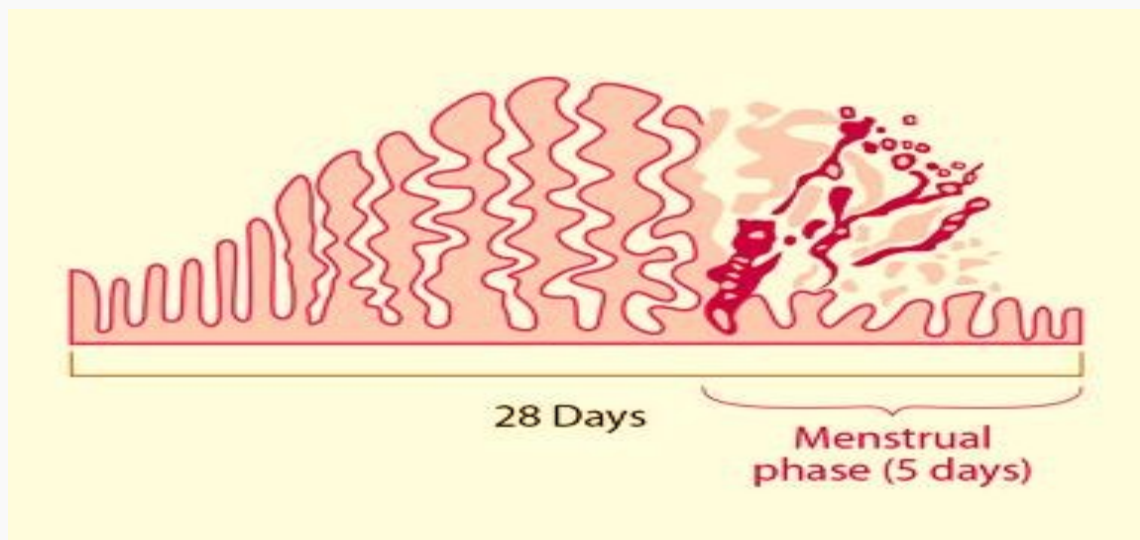
The uterine cycle has three phases.

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## Menstruation

Menstruation (also called menstrual bleeding, menses, or a period) is the first phase of the uterine cycle. The flow of menses normally serves as a sign that a woman has not become pregnant. (However, this cannot be taken as certainty, as a number of factors can cause bleeding during pregnancy; some factors are specific to early pregnancy, and some can cause heavy flow.)

Levels of estradiol (the main estrogen), progesterone, luteinizing hormone, and follicle-stimulating hormone during the menstrual cycle, taking inter-cycle and inter-woman variability into account.



*Eumenorrhea* denotes normal, regular menstruation that lasts for a few days (usually 3 to 5 days, but anywhere from 2 to 7 days is considered normal). The average blood loss during menstruation is 35 milliliters with 10–80 ml considered normal.

Painful cramping in the abdomen, back, or upper thighs is common during the first few days of menstruation. Severe uterine pain during menstruation is most common among adolescents and younger women (affecting about 67.2% of adolescent females).

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## **Proliferative phase**

The proliferative phase is the second phase of the uterine cycle when estrogen causes the lining of the uterus to grow, or proliferate, during this time. As they mature, the ovarian follicles secrete increasing amounts of estradiol, and estrogen. The estrogens initiate the formation of a new layer of endometrium in the uterus, histologically identified as the proliferative endometrium.

## **Secretory phase**

The secretory phase is the final phase of the uterine cycle and it corresponds to the luteal phase of the ovarian cycle. During the secretory phase, the corpus luteum produces progesterone, which plays a vital role in making the endometrium receptive to implantation of the blastocyst and supportive of the early pregnancy, by increasing blood flow and uterine secretions and reducing the contractility of the smooth muscle in the uterus; it also has the side effect of raising the woman's basal body temperature.

## **5. The Role of Hormones**

### **Follicle stimulating hormone**

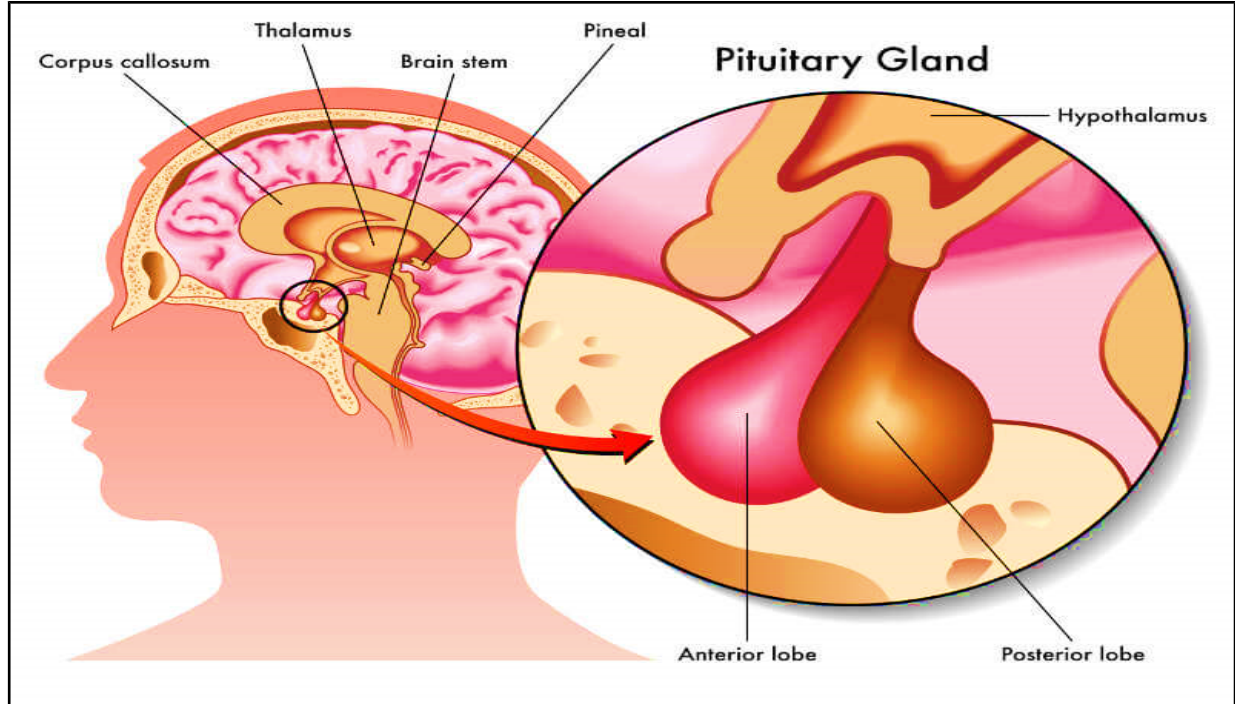
A gonadotropic glycoprotein hormone, secreted in part of the pituitary gland that stimulates the growth of ovarian follicles in female mammals .

### **Lutenizing hormone**

A hormone produced by the anterior pituitary gland. In females, an acute rise of LH triggers ovulation and development of the corpus luteum.

- Hormones control the menstrual cycle. During each cycle, brain's hypothalamus and pituitary gland send hormone signals back and forth with ovaries. These signals get the ovaries and uterus ready for a pregnancy.





- The hormones **estrogen** and **progesterone** play the biggest roles in how the uterus changes during each cycle.
- **Estrogen** builds up the lining of the uterus.
- **Progesterone** increases after an ovary releases an egg (ovulation) at the middle of the cycle. This helps the estrogen keep the lining thick and ready for a fertilized egg.
- A drop in progesterone (along with estrogen) causes the lining to break down. This is when the period starts.
- A change in hormone levels can affect the cycle or fertility. For example, teens tend to have low or changing progesterone levels. This is also true for women close to menopause. That is why teens and women in their 40s may have heavy menstrual bleeding and cycles that change in length.

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## 6. Summary

The female reproductive system consists of a pair of ovaries, a pair of oviducts, a uterus, a vagina, external genitalia, and a pair of mammary glands. The ovaries produce the female gamete (ovum) and some steroid hormones (ovarian hormones). Ovarian follicles in different stages of development are embedded in the stroma. The oviducts, uterus and vagina are female accessory ducts. The uterus has three layers namely perimetrium, myometrium and endometrium. The female external genitalia includes mons pubis, labia majora, labia minora, hymen and clitoris. The mammary glands are one of the female secondary sexual characteristics. The process of formation of mature female gametes is called oogenesis. The reproductive cycle of female primates is called menstrual cycle. Menstrual cycle starts only after attaining sexual maturation (puberty). During ovulation only one ovum is released per menstrual cycle. The cyclical changes in the ovary and the uterus during menstrual cycle are induced by changes in the levels of pituitary and ovarian hormones.