

# **HORMONES AND REPRODUCTIVE MATURITY**

The background of the slide is a gradient of blue and purple. It features abstract, flowing white lines that create a sense of movement and depth. In the lower right quadrant, there is a grid-like pattern of white lines that appears to be receding into the distance, adding a three-dimensional effect to the design.

**The sex hormones, together with the hypothalamus and the pituitary gland, form a complex regulatory system that influences sexual activity and the maturation and maintenance of the reproductive organs. The secretion of the various sex hormones, particularly testosterone, and estrogen, increases significantly during adolescence. These changes give rise to puberty, a stage of rapid growth and sexual development. The cycle of physical changes that ensue ultimately culminates in reproductive maturity.**

## **SEX HORMONES**

**Sex hormones are those produced by the testes and ovaries.**

### **ANDROGENS**

**Androgens are hormones that primarily influence the growth and development of the male reproductive system. The predominant and most active androgen is testosterone, which is produced by the male testes. The other androgens, which support the functions of testosterone, are produced mainly by the adrenal cortex—the outer portion of the adrenal glands—and only in relatively small quantities. The adrenal production of androgens is of importance to several physiological processes. Certain adrenal androgens—  
androstenedione, dehydroepiandrosterone (DHEA), and dehydroepiandrosterone sulfate (DHEA sulfate)—can be converted to testosterone in other tissues.**

**Only a small amount of androgen is secreted before puberty. In both girls and boys, puberty is associated with an increase in adrenal androgen production. This “adrenarche” contributes to pubertal maturation, particularly growth of axillary and pubic hair. Androgens also are needed for the development of the male reproductive system. Males that have been castrated prior to adolescence and sexual maturity require injections of testosterone to develop functioning adult reproductive organs.**

**Androgens given to normal males tend to increase the size of the reproductive organs. In contrast, castration performed on males that have already reached maturity causes the organs to shrink and to stop functioning. Androgens also are necessary for the formation of sperm cells and for the maintenance of sexual interest and behavior.**



**Other effects of androgens on the male body are diversified. The growth of pubic hair and facial and chest hair and the regression of scalp hair, or baldness, is influenced by androgens. During adolescence, androgens lengthen and thicken the male vocal cords, causing voice deepening, and they enhance bone growth and increase the number and thickness of muscle fibers in the male body. Other growth patterns that androgens stimulate are kidney weight and size, the increase of protein in bone tissue, the regeneration of red blood(erythrocytes), the presence of pigments in the skin, and the increased activity of sweat and sebaceous (oil-producing) glands.**

**Testosterone is the major hormone responsible for the development of the male sex organs and masculine characteristics. It was first isolated from testicular extracts in 1935. Its discovery followed that of an androgen called androsterone, which was isolated from urine in 1931. However, testosterone proved to be more potent than androsterone, which was later shown to be a biochemical product (a metabolite) of testosterone.**

**A healthy man produces about  $1.8 \times 10^{-4}$  ounces (5 mg) of testosterone daily. Testosterone serves as a circulating prohormone for a more active androgen called dihydrotestosterone. Testosterone is converted to dihydrotestosterone in most tissues that are sensitive to androgens, including the testes, prostate gland, hair follicles, and muscles.**



**Dihydrotestosterone is responsible for sperm maturation during spermatogenesis, for the formation of the prostate gland and external genitalia, and for sexual maturation at puberty. The production of testosterone by the testes is stimulated by luteinizing hormone (LH), which is produced by the anterior pituitary and acts via receptors on the surface of the Leydig cell.**

**The secretion of LH is stimulated by gonadotropin-releasing hormone (GnRH), which is released from the hypothalamus. Testosterone, in turn, provides negative feedback inhibition on the secretion of GnRH and LH. These three hormones constitute the hypothalamic-pituitary-testes axis. When serum testosterone concentrations decrease, the secretion of GnRH and LH increases. In contrast, when serum testosterone concentrations increase, the secretion of GnRH and LH decrease.**

**Testosterone can be manufactured by chemical and microbiological modification of inexpensive steroids, such as diosgenin. It is used clinically to treat testicular insufficiency, suppress lactation (milk production), and treat certain types of breast cancer. Androgens are essential precursors of estrogens, and no estrogens can be produced without them.**

**Mild androgen excess in women results in excess hair growth (hirsutism) that occurs all over the body but is most often noted on the face. With increasing androgen excess, menstrual periods become irregular (oligomenorrhea) and eventually cease (amenorrhea), and women are virilized. The manifestations of virilism include frontal balding, deepening of the voice, acne, clitoral enlargement, and increased muscle mass**

**In women, excess production of androgen can occur as a result of adrenal disorders, ovarian disorders, ingestion or injection of androgens, and perhaps disorders of fat or other nonendocrine tissues. The adrenal causes of excess production of androgens are Cushing syndrome, congenital adrenal hyperplasia, and adrenal tumors. Tumors (including cancers) of the interstitial cells and other cells of the ovary are a rare cause of androgen excess in women. A far more common cause of excess production of androgens in women is polycystic ovary syndrome (PCOS; also called Stein-Leventhal syndrome). This syndrome is characterized by excess androgens and the presence of a menstrual disorder.**

## **ESTROGENS**

**Estrogens are hormones that primarily influence the female reproductive tract in its development, maturation, and function. There are three major hormones—estradiol, estrone, and estriol—among the estrogens, and estradiol is the predominant one of the three.**

**The major sources of estrogens are the ovaries and the placenta (the temporary organ that serves to nourish the fetus and remove its wastes). Additional small amounts of estrogens are secreted by the adrenal glands and by the male testes. It is believed that the egg follicle and interstitial cells in the ovaries are the actual production sites of estrogens in the female. Estrogen levels in the bloodstream seem to be highest during the egg-releasing period (ovulation) and after menstruation, when tissue called the corpus luteum replaces the empty egg follicle.**



**Cholesterol is the parent molecule from which all ovarian steroid hormones are formed. Cholesterol is converted to pregnenolone, and pregnenolone is converted to progesterone. The steps in the conversion of progesterone to the main estrogens—estradiol and estrone—include the intermediate formation of several androgens: dehydroepiandrosterone, androstenedione, and testosterone.**

**Androgens are converted to estrogens through the action of an enzyme known as aromatase. Although the ovaries are the richest source of aromatase, some aromatase is present in adipose tissue, which is also an important source of estrogen in postmenopausal women. Estradiol, the most potent estrogen, is synthesized from testosterone. Estrone can be formed from estradiol, but its major precursor is androstenedione. Estriol, the weakest of the estrogens, is formed from both estrone and estradiol.**

**Once secreted into the blood, estrogens bind reversibly to sex hormone-binding globulin. In females, estrogen affects the ovaries, vagina, fallopian tubes, uterus, and mammary glands. In the ovaries, estrogens help to stimulate the growth of the egg**

**Estrogens also build and maintain the endometrium, the mucous membrane that lines the uterus. They increase the endometrium's size and weight, cell number, cell types, blood flow, protein content, and enzyme activity. Estrogens also stimulate the muscles in the uterus to develop and contract, contractions having a crucial role in helping the wall to slough off dead tissue during menstruation and during the delivery of a child and placenta.**

**The cervix secretes mucus that enhances sperm transport, and estrogens are thought to regulate the flow and thickness of these mucous secretions. The growth of the vagina to its adult size, the thickening of the vaginal wall, and the increase in vaginal acidity that reduces bacterial infections are also correlated to estrogen activities.**

**However, estrogens are responsible for the growth of the breasts during adolescence, pigmentation of the nipples, and the eventual cessation of the flow of milk. Actions of estrogens related to bone development and bone maintenance include the stimulation of bone formation and the closure of bone epiphyses, which causes linear growth to cease at the end of puberty, and the maintenance of bone throughout the reproductive years, which limits bone resorption and preserves bone strength.**

- ❖ **Estrogens tend to decrease serum cholesterol concentrations and increase serum triglyceride concentrations.**
- ❖ **Estrogens influence the structural differences between the male and female bodies.**
- ❖ **The voice box is smaller and the vocal cords shorter, giving a higher-pitched voice than in males. In addition, estrogens suppress the activity of sebaceous (oil-producing) glands and thereby reduce the likelihood of acne in the female.**



# **PROGESTERONE**

**Progesterone is a hormone secreted by the female reproductive system that functions mainly to regulate the condition of the inner lining (endometrium) of the uterus. Progesterone is produced by the ovaries, placenta, and adrenal glands. The released egg, if fertilized by the male sperm cell, becomes implanted in the uterus, and a placenta forms. The placenta then produces progesterone during the period of pregnancy**

**If the egg is unfertilized, progesterone is secreted by the ovaries until a few days before menstruation, at which time the level of progesterone drops sufficiently to stop the growth of the uterine wall and to cause it to start to break down, and menstruation ensues. Progesterone prepares the wall of the uterus so the lining is able to accept a fertilized egg and the egg can be implanted and developed.**

**In the ovaries, progesterone and estrogens are responsible for the release of an egg during ovulation. If the egg is fertilized, these hormones are influential in the prevention of further egg release until the pregnancy has terminated.**

## **GONADOTROPINS**

**Gonadotropins are hormones secreted from the anterior pituitary gland that act on the ovaries and the testes. Secretion of LH and FSH is low in both males and females prior to puberty. The start of this stage of development is marked by the onset of nocturnal pulses of gonadotropin-releasing hormone (GnRH; also known as luteinizing hormone-releasing hormone). GnRH is a neurohormone consisting of 10 amino acids that is produced in the arcuate nuclei of the hypothalamus. Its primary function is to stimulate the synthesis and secretion of LH and FSH from the anterior pituitary gland.**

**Another type of gonadotropin found in women is human chorionic gonadotropin (HCG), which is produced by the placenta during pregnancy. The detection of HCG forms the basis of pregnancy tests. Hypogonadism, in which the functional activity of the gonads is decreased and sexual development is inhibited, can be caused by a congenital deficiency of GnRH. Patients with this type of hypogonadism typically respond to pulsatile treatment with the hormone.**

**Many of these patients also have deficiencies of other hypothalamic-releasing hormones. A subset of patients with hypogonadism have isolated GnRH deficiency and loss of the sense of smell (anosmia), a disorder called Kallmann syndrome that is usually caused by a mutation in a gene that directs the formation of the olfactory (sense of smell) system and the formation of parts of the hypothalamus. Abnormalities in the pulsatile secretion of GnRH result in subnormal fertility and abnormal or absent menstruation.**

## **PUBERTY**

**Puberty is the stage or period of life when a child transforms into an adult normally capable of procreation.**

**In girls, the interval from the first indication of puberty to complete maturity may vary from 18 months to 6 years. In boys, a similar variation occurs, with male genitalia taking anywhere between 2 and 5 years to attain full development. In puberty both girls and boys experience a swift increase in body size, a change in shape and composition of the body, and a rapid development of the reproductive organs and other characteristics marking sexual maturity. Nocturnal pulses of GnRH play a major role in the development of the reproductive organs during this stage of life.**



**These pulses are initiated at least in part by increasing body size, which may cause an increase in the secretion of leptin (from the Greek leptos, meaning “thin”; a protein hormone important for regulation of reproduction, metabolism, and body weight), which in turn stimulates the secretion of GnRH. Numerous factors may delay maturation or prevent normal growth, including hormonal disorders, metabolic defects, hereditary conditions, and inadequate nutrition.**

# **REPRODUCTIVE ORGANS AND SECONDARY SEX CHARACTERISTICS**

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**The acceleration of penis growth begins on average at about age 12 ½ years but sometimes as early as 10 ½ and sometimes as late as 14 ½. The completion of penis development usually occurs at about age 14 ½ but in some boys is at 12 ½ and in others at 16 ½.**

**The first sign of puberty in the boy is usually an acceleration of the growth of the testes and scrotum with reddening and wrinkling of the scrotal skin. Slight growth of pubic hair may begin about the same time but is usually a trifle later. Axillary (armpit) hair appears on average some two years after the beginning of pubic hair growth.**

**Breaking of the voice occurs relatively late in adolescence. The change in pitch accompanies the enlargement of the larynx and lengthening of the vocal cords, caused by the action of testosterone on the laryngeal cartilages. This is caused by the enlargement of the resonating spaces above the larynx, as a result, of the rapid growth of the mouth, nose, and maxilla (upper jaw).**



**In the skin, particularly of the armpits and the genital and anal regions, the sebaceous and apocrine sweat glands develop rapidly during puberty and give rise to a characteristic odor. The changes occur in both sexes but are more marked in the male. Enlargement of the pores at the root of the nose and the appearance of comedones (blackheads) and acne, while likely to occur in either sex, are considerably more common in adolescent boys than girls because the underlying skin changes are the result of androgenic activity**

**During adolescence, the male breast undergoes changes, some temporary and some permanent. The diameter of the areola, which is equal in both sexes before puberty, increases considerably, though less than it does in girls. In some boys (between a fifth and a third of most groups studied) there is a distinct enlargement of the breast (sometimes unilaterally) about midway through adolescence. This usually regresses again after about one year**



**In girls, the start of breast enlargement—the appearance of the “breast bud”—is as a rule the first sign of puberty, but the appearance of pubic hair precedes it in about one-third. The uterus and vagina develop simultaneously with the breast. The labia and clitoris also enlarge. Menarche, the first menstrual period, is a late event in the sequence.**

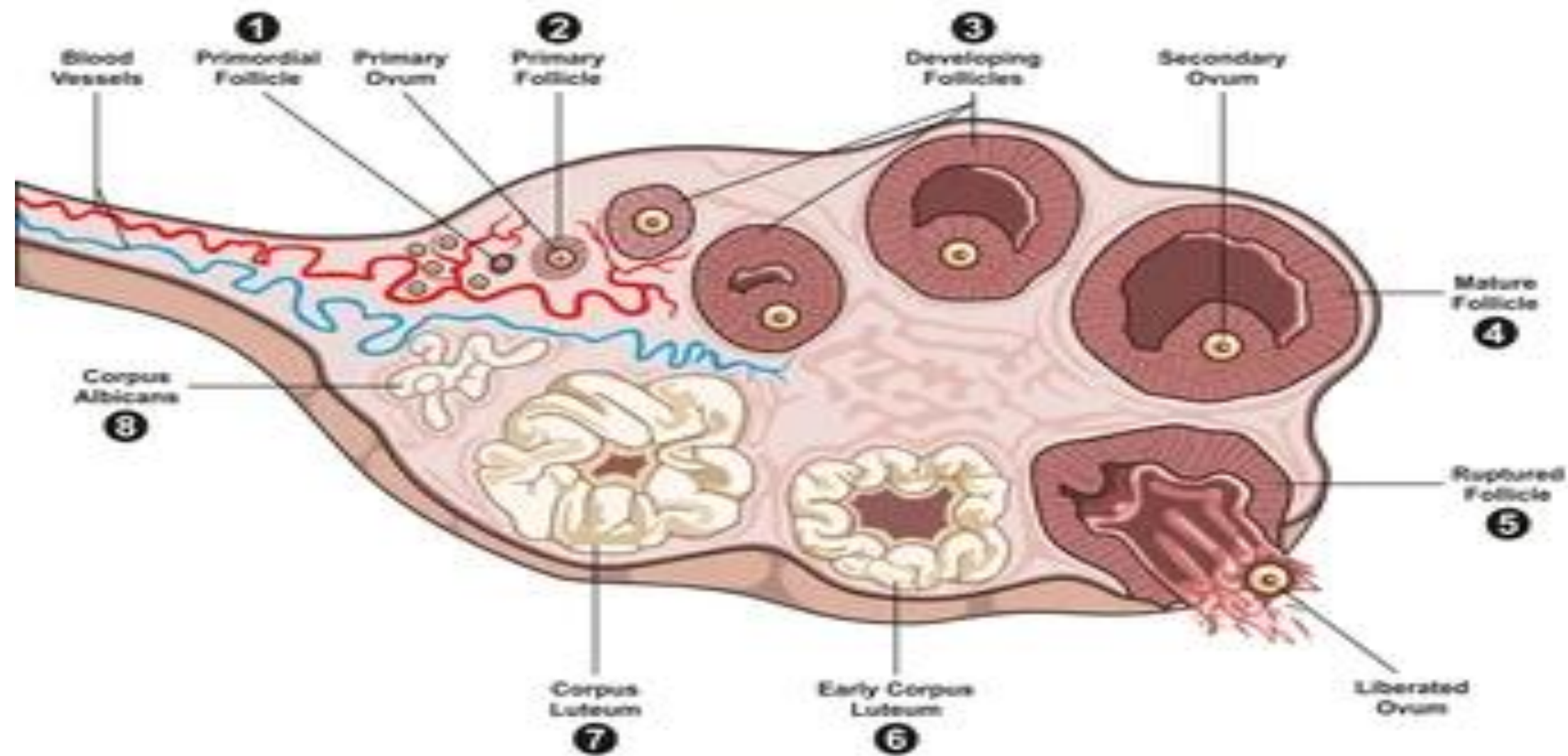
## **MENSTRUATION**

**Menstruation is the periodic discharge from the vagina of blood, secretions, and disintegrating mucous membrane that had lined the uterus.**

## **PHASES OF THE MENSTRUAL CYCLE**

**The normal menstrual cycle is typically divided into a follicular phase of about 14 days, during which the endometrium proliferates, and a luteal phase of about 14 days, which culminates with the endometrial lining being sloughed off**

## Ovulation



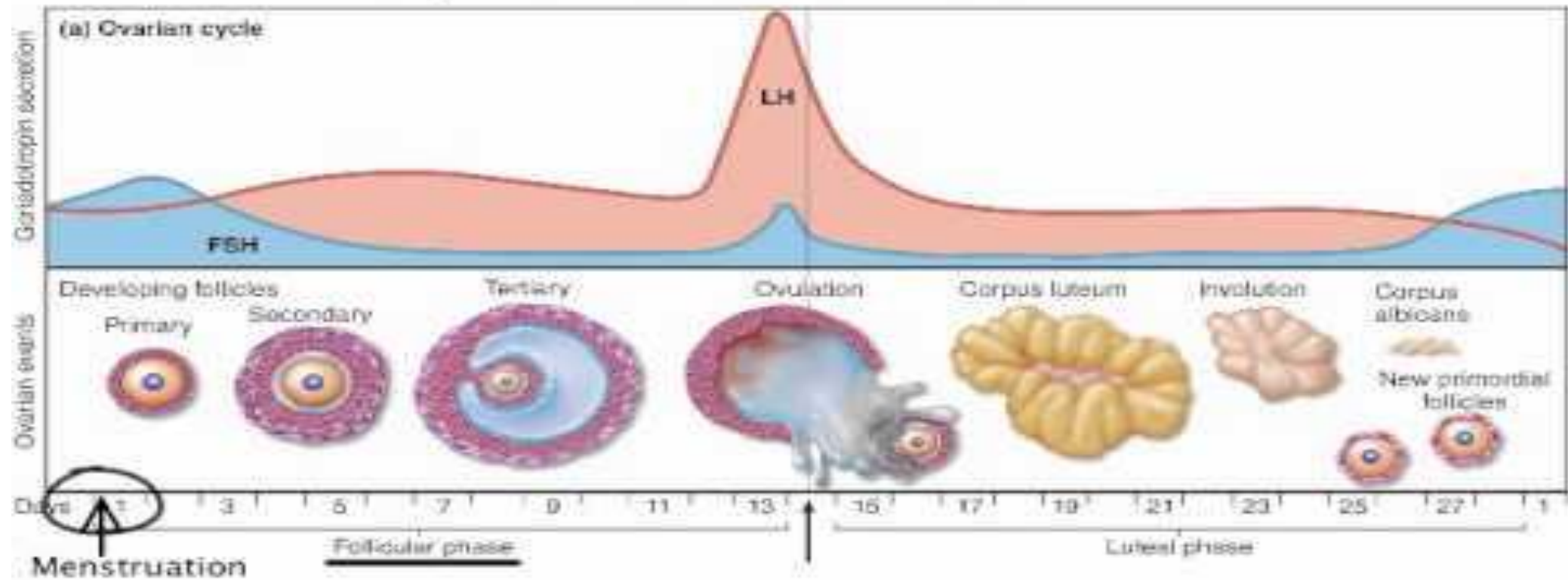
**In puberty, the onset of menarche is marked by the maturation of the hypothalamus, pituitary, and ovaries, at which point the cyclic hypothalamic-pituitary-ovarian activity characteristic of adult women begins. During the first days of the menstrual cycle, secretion of FSH increases, causing the maturation of follicles. As follicles mature, they secrete more estradiol, which is paralleled by an increase in the secretion of LH. Increased secretion of LH stimulates the secretion of more estradiol and a small amount of progesterone that then triggers a transient surge in LH secretion and to a lesser extent FSH secretion, causing rupture of the mature Graafian follicles.**

**The Graafian follicle contains the ovum, which is a cell about 0.006 inches (0.14 mm) in diameter, surrounded by group of smaller cells, called granulosa cells. The granulosa cells multiply, with the ovum situated in the wall of the rounded structure that they form, and secrete estradiol. This hormone causes proliferative changes in the endometrium so that the glands become taller and the whole endometrium becomes thicker and more vascular.**

**The follicular phase of the cycle ends at the time of ovulation. Serum LH, FSH, and estradiol concentrations then decrease considerably, and the corpus luteum begins to produce some estrogen and large quantities of progesterone. This is known as the luteal phase of the menstrual cycle.**

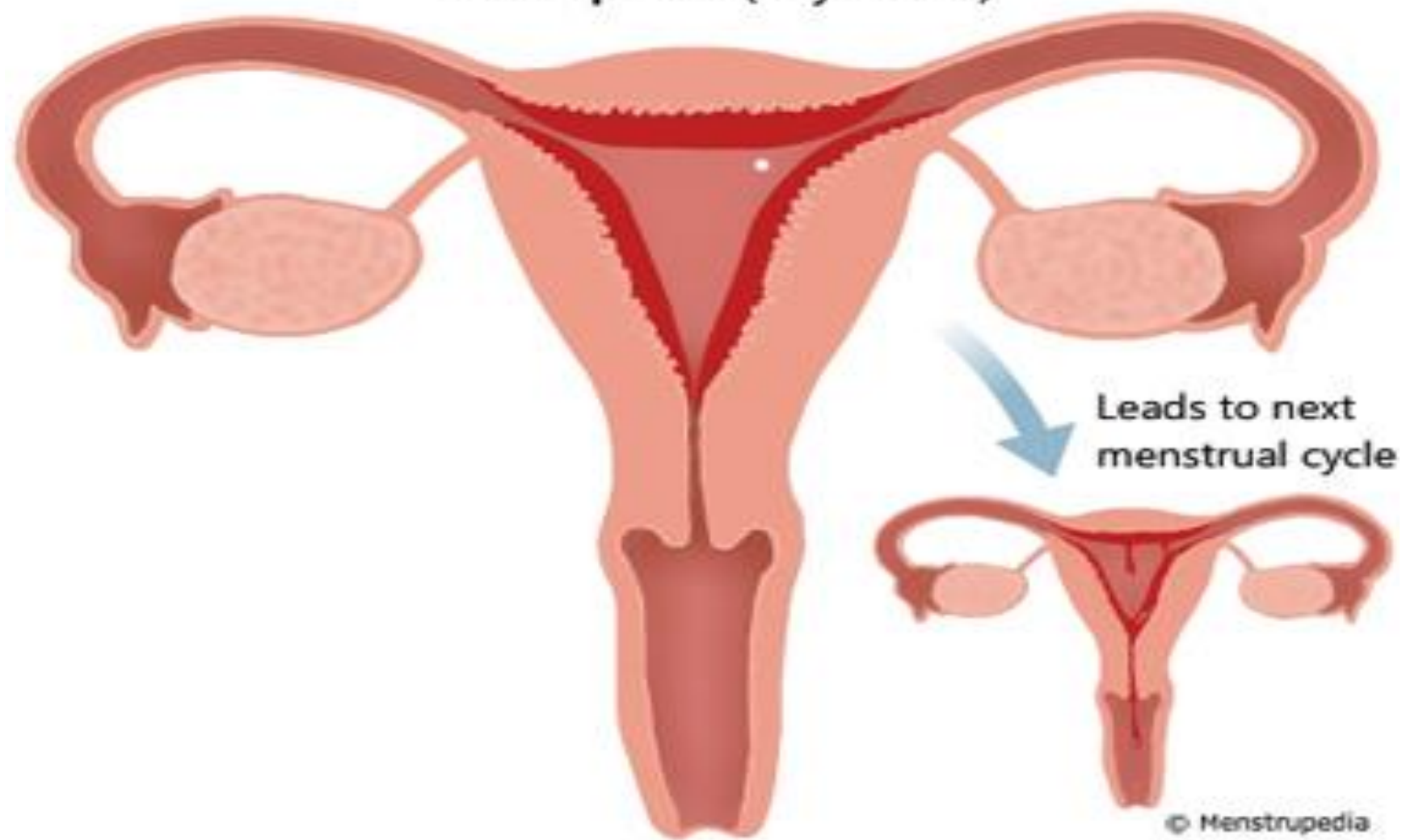
# Ovarian Cycle

## Step 1: Follicular Phase

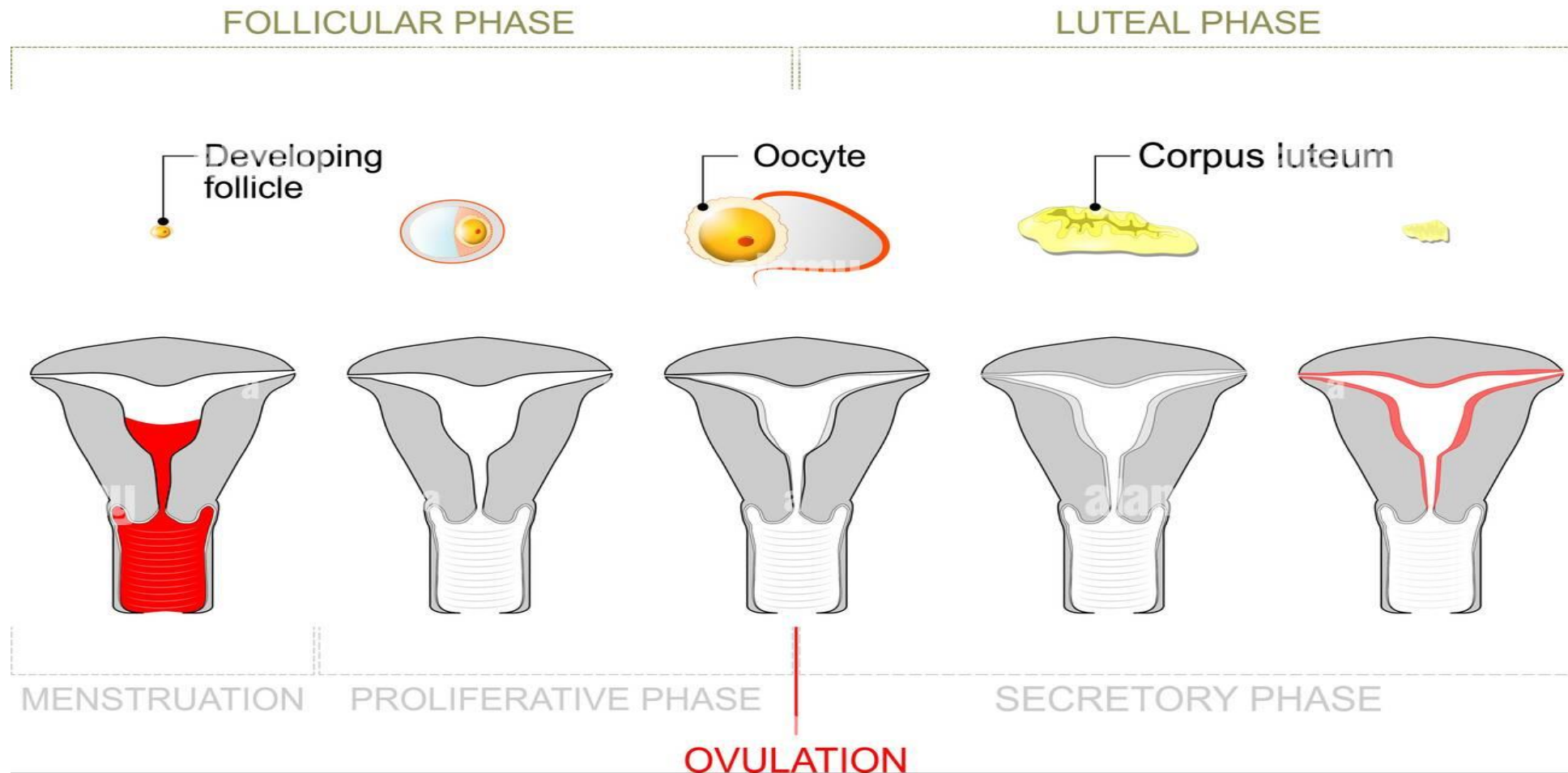


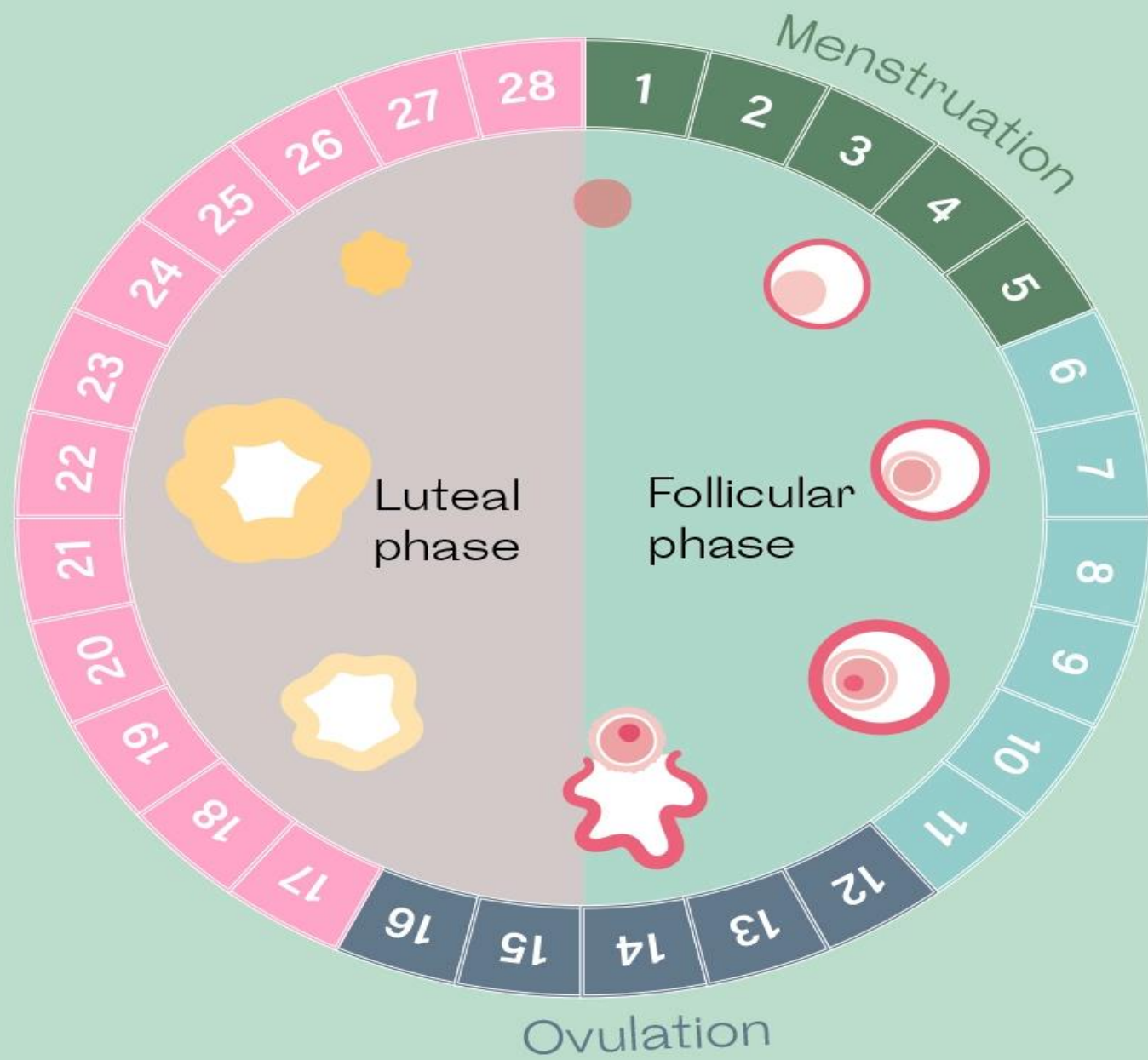


**Luteal phase (day 15-28)**

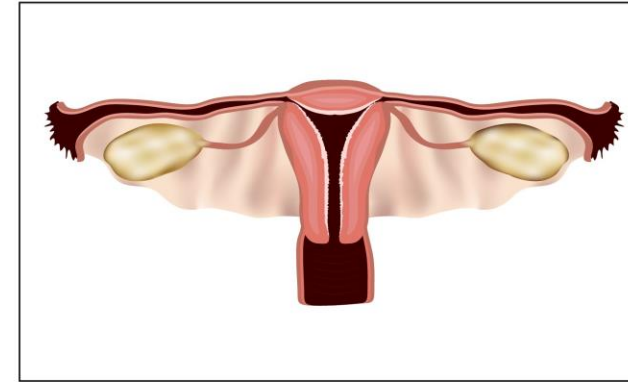
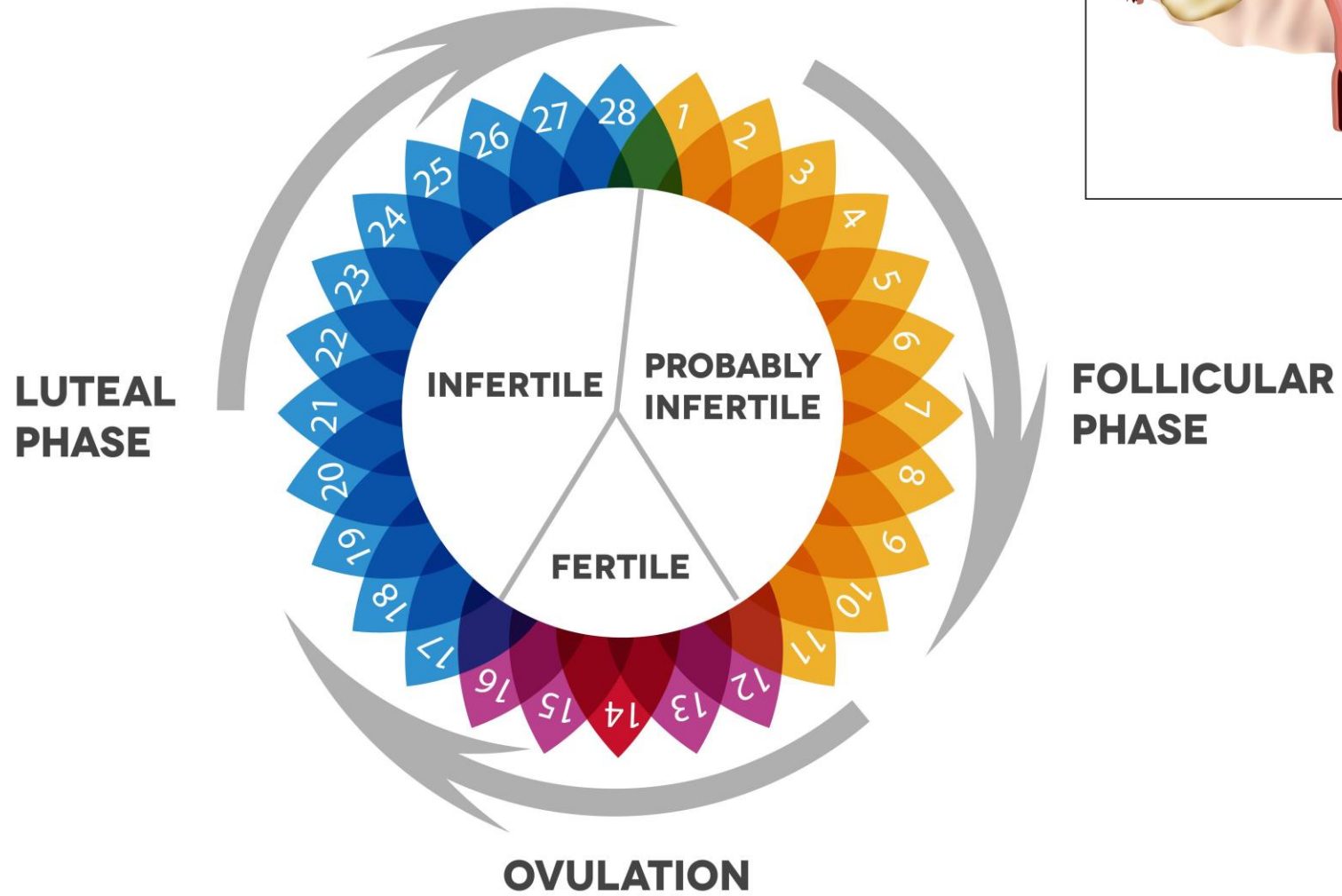


# Menstrual cycle





## MENSTRUAL CYCLE WHEEL



## **HORMONAL CONTROL OF THE MENSTRUAL CYCLE**

**The ovarian hormones circulate in the blood and are excreted in modified forms in the urine. The pituitary gland stimulates the ovary to produce estrogens and progesterone, but there is a “negative feedback” by which the estrogens inhibit the output of FSH from the pituitary gland (and probably stimulate the output of LH). In addition, progesterone is believed to inhibit the further output of LH.**

**The anterior lobe secretes many important hormones, including those that control the activity of the adrenal and thyroid glands and the release of growth hormones and gonadotropic hormones. From the hypothalamus, substances are carried in the veins in the pituitary stalk that cause the release of hormones from the pituitary, including FSH and LH, but also a factor that inhibits the release of LTH**

**Ovulation and the Fertile Phase** The release of a mature egg from the ovary during ovulation enables the egg to be fertilized by the male sperm cells. The egg erupts from the ovary on the 14th to 16th day of the approximately 28-day menstrual cycle. An unfertilized egg is passed from the reproductive tract during menstrual bleeding, which starts about two weeks after ovulation. Prior to an eruption from the ovary, an egg first must grow and mature.

**The egg cell is surrounded by a capsule of cells that form the follicle. The follicular wall serves as a protective casing around the egg and provides a suitable environment for egg development. As the follicle ripens, the cell wall thickens and a fluid is secreted to surround the egg. The follicle migrates from within the ovary's deeper tissue to the outer wall.**



## **MENARCHE**

**The first menstruation, or menarche, usually occurs between 11 and 13 years of age, but in a few otherwise. Normal children's menstruation may begin sooner or may be delayed. If the menstrual periods have not started by age 16, a gynecological investigation is indicated. Menarche is preceded by other signs of estrogenic activity, such as enlargement of the breasts and the uterus and growth of pubic hair.**

## **MENOPAUSE**

**Menopause is the permanent cessation of menstruation that results from the loss of ovarian function and therefore represents the end of a woman's reproductive life. the time of menopause, the ovaries contain few follicles; have decreased in size; and consist mostly of atretic (shrunken) follicles, some interstitial cells, and fibrous tissue. Estrogen production decreases by 80 percent or more, and this along with the loss of follicles results in marked increases in the secretion of luteinizing hormone (LH) and follicle-stimulating hormone (FSH).**

**Menopause occurs in most women between 45 and 55 years of age, but it may begin as early as age 40 or be delayed to the late 50s. The age of onset is probably determined by the hereditary background of the individual, however, good nutrition and health habits tend to postpone the onset**

**Another important consequence of menopause is an increased risk of heart disease. Increased risk of cardiovascular diseases such as atherosclerosis, a chronic condition affecting the arteries, is attributed to decreased levels of estrogen that lead to increased serum cholesterol and triglyceride concentrations and changes in vascular function and the production of blood clotting factors**

**Estrogen is also effective for increasing libido. In addition, estrogen increases bone density, thereby decreasing the risk of fracture**



**THANK YOU FOR LISTENING**

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