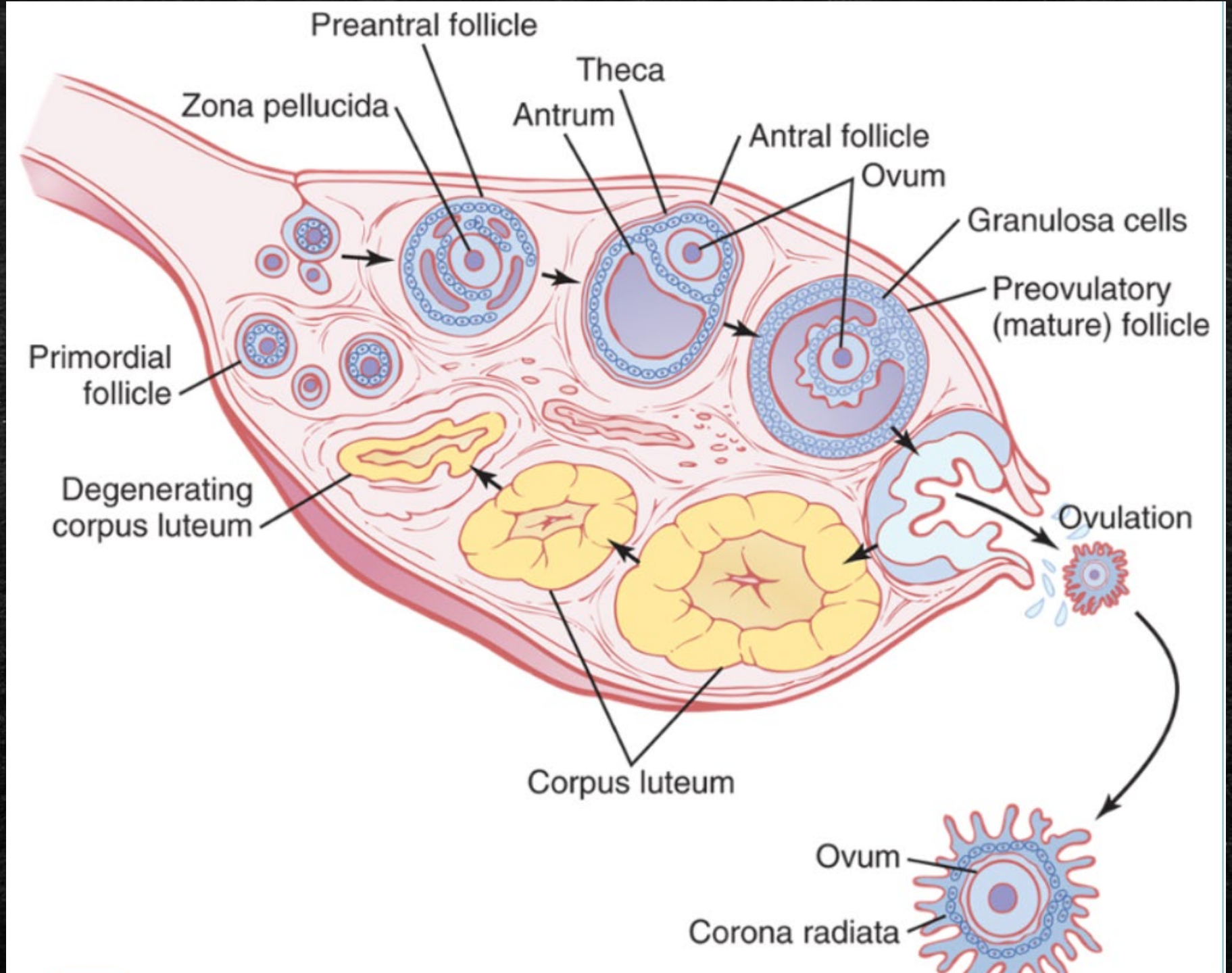
Reproductive Physiology

Female Physiology Before Pregnancy and Female Hormones Female reproductive functions

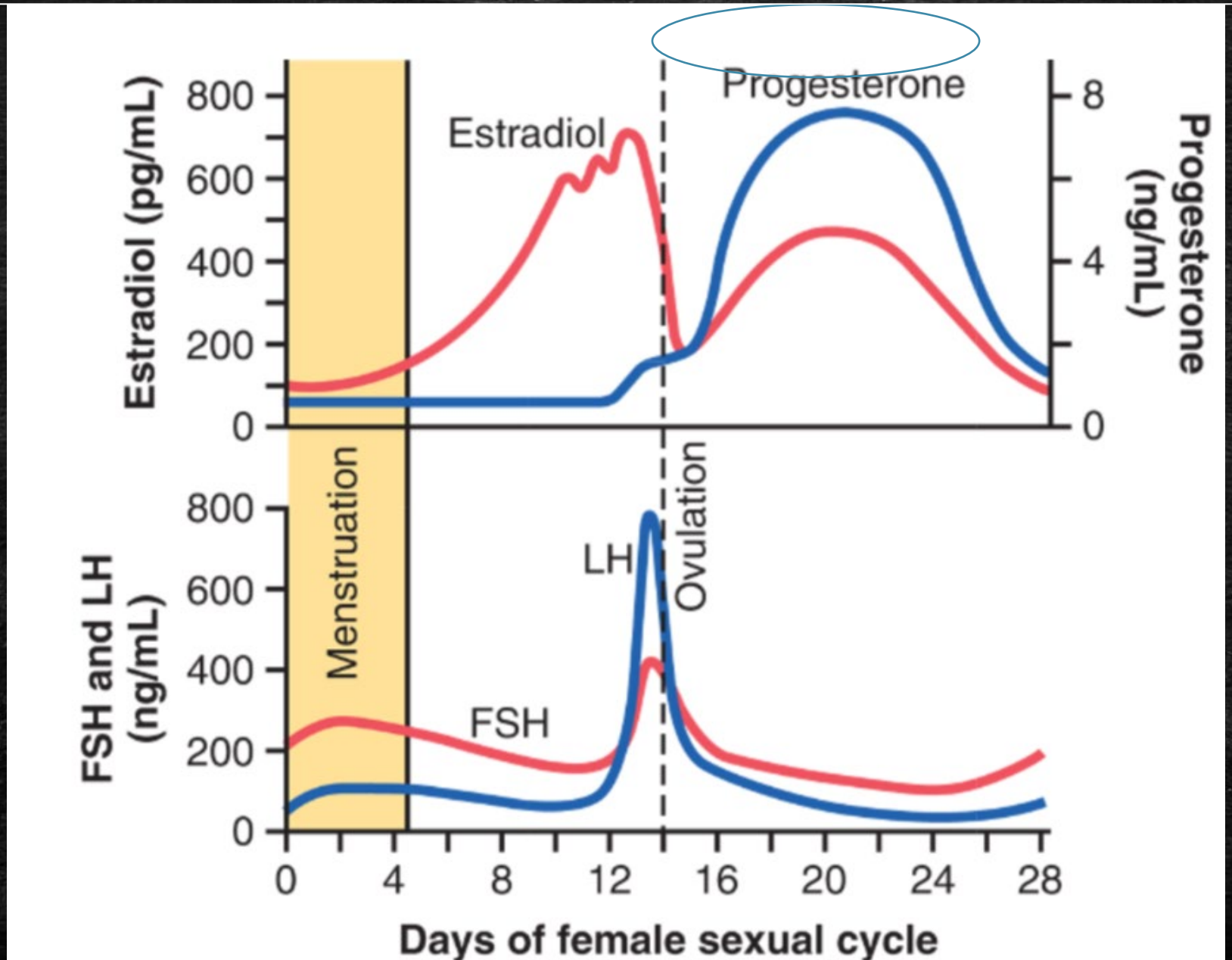
Chapter 82

The Luteal Phase


Preantral follicle
Theca
Zona pellucida
Antrum
Antral follicle
Ovum
Granulosa cells
Preovulatory (mature) follicle
Primordial follicle
Degenerating corpus luteum
Ovulation
Corpus luteum
Ovum
Corona radiata

NOTES

** During the **luteal phase** of the cycle, far too much progesterone is formed for all of it to be converted, which accounts for the large secretion of progesterone into the circulating blood at this time.

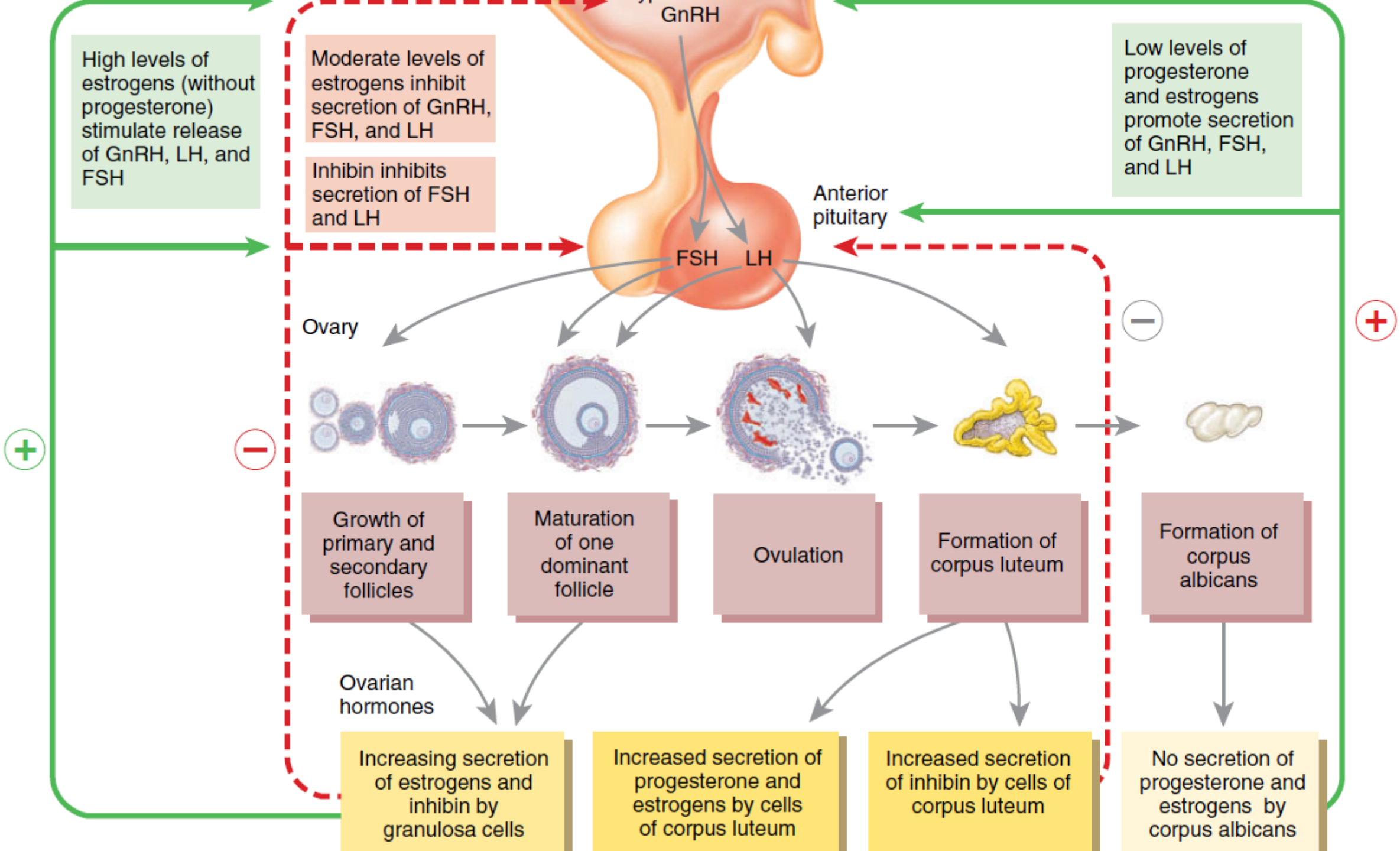


Corpus Luteum

- During the first few hours after expulsion of the ovum from the follicle, the **remaining granulosa and theca interna** cells change rapidly into **lutein cells.**
- They **enlarge** in diameter two or more times and become filled with **lipid inclusions** that give them a **yellowish appearance**.
- 12 days after ovulation → the corpus luteum begins to **involute** and eventually **loses its secretory function** and its **yellowish, lipid characteristic** about, becoming the corpus albicans; during the ensuing few weeks, the corpus albicans is **replaced by connective tissue** and over months is **absorbed.**

NOTES

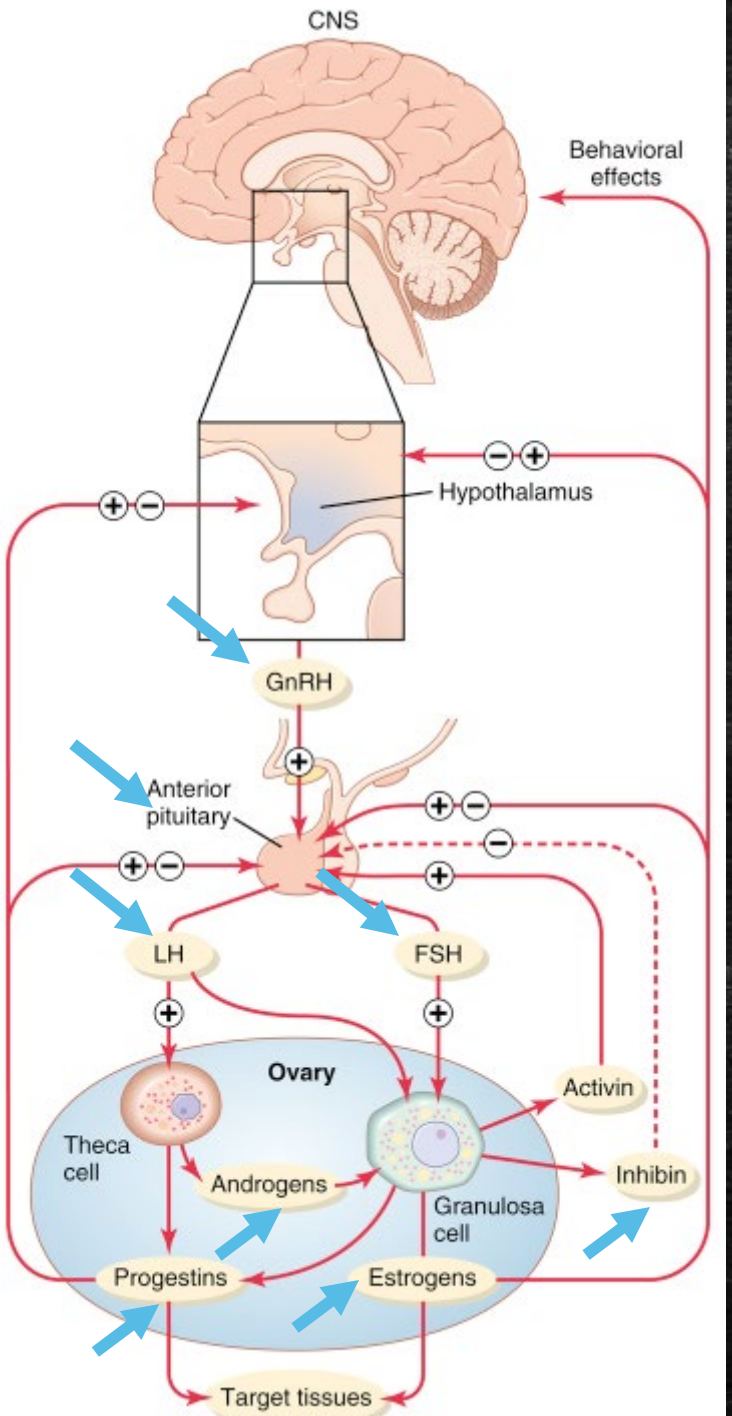
** Another hormone with almost exactly the same properties as LH, chorionic gonadotropin, which is secreted by the placenta, can act on the corpus luteum to prolong its life—usually maintaining it for at least the first 2 to 4 months of pregnancy.


GnRH
High levels of estrogens (without progesterone) stimulate release of GnRH, LH, and FSH
Moderate levels of estrogens inhibit secretion of GnRH, FSH, and LH
Inhibin inhibits secretion of FSH and LH
Low levels of progesterone and estrogens promote secretion of GnRH, FSH, and LH
Anterior pituitary
FSH
LH
Ovary
Growth of primary and secondary follicles
Maturation of one dominant follicle
Ovulation
Formation of corpus luteum
Formation of corpus albicans
Ovarian hormones
Increasing secretion of estrogens and inhibin by granulosa cells
Increased secretion of progesterone and estrogens by cells of corpus luteum
Increased secretion of inhibin by cells of corpus luteum
No secretion of progesterone and estrogens by corpus albicans

Summary

Gonadotropic Hormones and Their Effects on the Ovaries

- The ovarian changes that occur during the sexual cycle depend completely on the gonadotropic hormones FSH and LH.
- In the absence of these hormones, the ovaries remain inactive, which is the case throughout childhood, when almost no pituitary gonadotropic hormones are secreted.
- At age 9 to 12 years, the pituitary begins to secrete progressively more FSH and LH, which leads to onset of normal monthly sexual cycles beginning between the ages of 11 and 15 years.
- This period of change is called *puberty*, and the time of the first menstrual cycle is called *menarche*.


CNS
Behavioral effects
Hypothalamus
GnRH
Anterior pituitary
LH
FSH
Ovary
Activin
Theca cell
Androgens
Inhibin
Granulosa cell
Progestins
Estrogens
Target tissues

Summary (Female hormones)

- The amount of GnRH released from the hypothalamus increases and decreases much less drastically during the monthly sexual cycle. It is secreted in short pulses averaging once every 90 minutes.
- During the first few days of each monthly female sexual cycle, the concentrations of FSH and LH increase slightly to moderately, with the increase in FSH slightly greater than that of LH and preceding it by a few days.
- FSH, cause accelerated growth of 6 to 12 primary follicles each month.
- During growth of the follicles, estrogen is mainly secreted.

Summary (Female hormones)

- 2 days before ovulation there is a surge of LH, initiation of secretion of progesterone, and diminished estrogen secretion.
- Estrogen in particular and progesterone to a lesser extent, secreted by the corpus luteum during the luteal phase, have strong negative feedback effects on FSH and LH.
- In addition, the lutein cells secrete inhibin. This hormone inhibits FSH secretion.
- Low blood concentrations of FSH and LH result in corpus luteum involution.

Monthly Endometrial Cycle and Menstruation

Female sexual cycle: Menstrual cycle

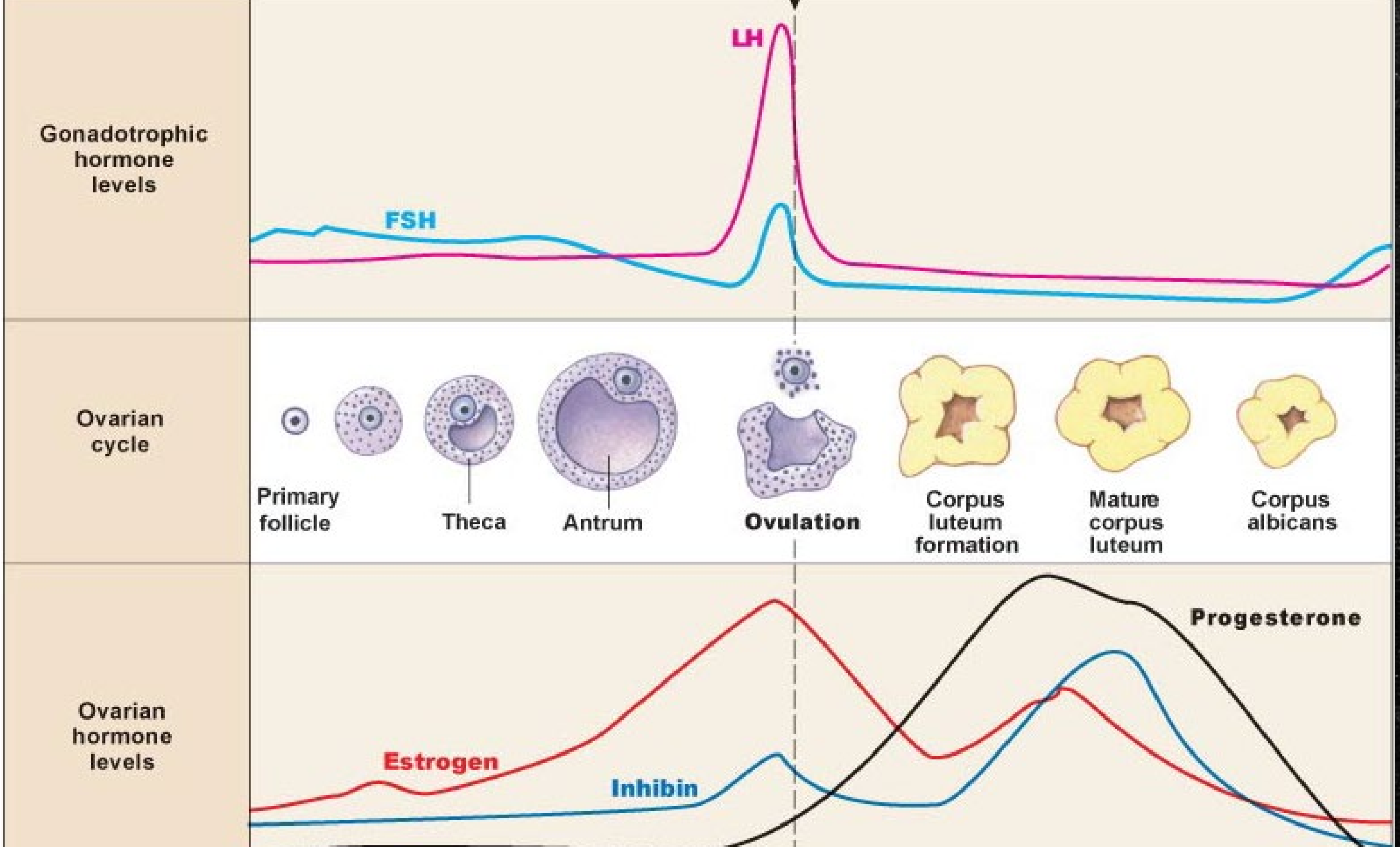
The normal reproductive years of the female are characterized by monthly (28d) rhythmical changes in the rates of secretion of the female hormones and corresponding physical changes in the ovaries and other sexual organs.

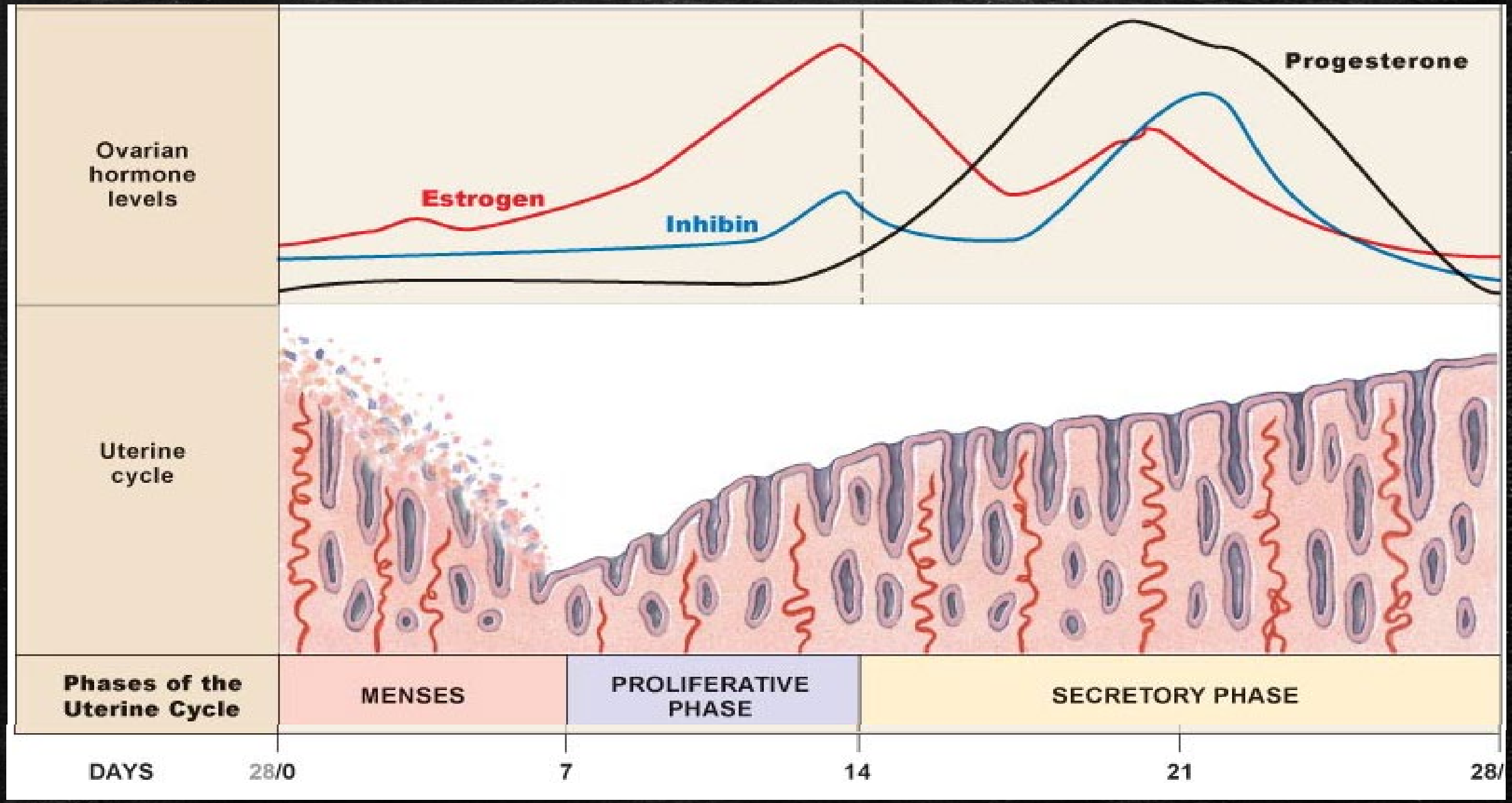
Ovarian Cycle

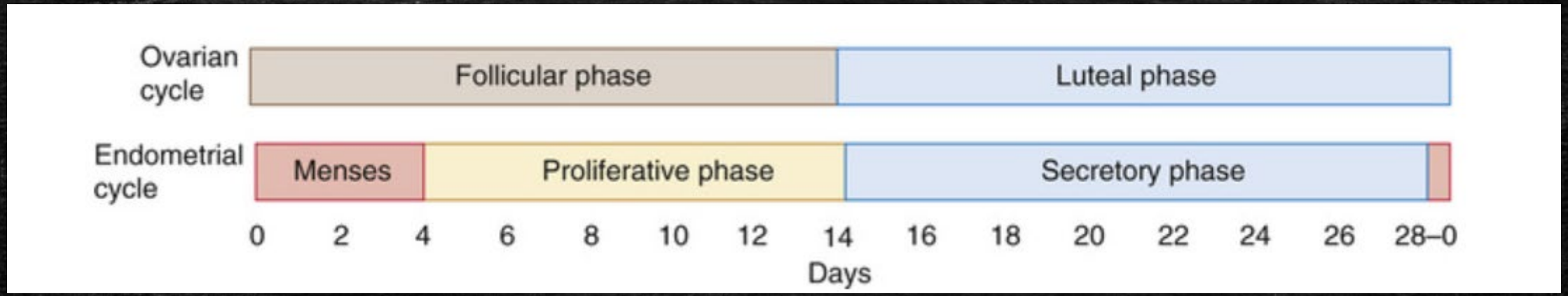
Follicular phase
Ovulatory phase
Luteal phase

Endometrial Cycle

Menstruation
Proliferative phase
Secretory phases


Gonadotrophic hormone levels
LH
FSH
Ovarian cycle
Primary follicle
Theca
Antrum
Ovulation
Corpus luteum formation
Mature corpus luteum
Corpus albicans
Ovarian hormone levels
Progesterone
Estrogen
Inhibin


Ovarian hormone levels
Estrogen
Inhibin
Progesterone
Uterine cycle
Phases of the Uterine Cycle
MENSES
PROLIFERATIVE PHASE
SECRETORY PHASE
DAYS
28/0
7
14
21
28/


Ovarian cycle
Follicular phase
Luteal phase
Endometrial cycle
Menses
Proliferative phase
Secretory phase
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28–0
Days

Menstruation

- If the ovum is not fertilized, about 2 days before the end of the monthly cycle, the corpus luteum in the ovary suddenly involutes, ovarian hormones (estrogens and progesterone) decrease to low levels of secretion.
- 24 hours preceding the onset of menstruation, vasospasm (increase release of prostaglandins), decrease in nutrients to the endometrium, and the loss of hormonal stimulation initiate necrosis in the endometrium.

NOTES

Menstruation is caused by the reduction of estrogens and progesterone, **especially progesterone, at the end of the monthly ovarian cycle.

**During normal menstruation, approximately 40 milliliters of blood and an additional 35 milliliters of serous fluid are lost. The menstrual fluid is normally nonclotting because a fibrinolysin is released along with the necrotic endometrial material.

**If heavy bleeding occurs from the uterine surface (first 2d), the quantity of fibrinolysin may be insufficient to prevent clotting, resulting in the passage of blood clots.

Menstruation

- Hormonal stimulation initiate necrosis in the endometrium.
- Hemorrhagic areas → superficial layers of the endometrium have desquamated →uterine contractions to expel the uterine contents (prostaglandins).
- Menstrual flow from the uterus consists of 50–150 mL of blood, tissue fluid, mucus, and epithelial cells shed from the endometrium.
- Tremendous numbers of leukocytes are released along with the necrotic material and blood (resistant to infection).

Proliferative Phase (Estrogen Phase)

- Under the influence of estrogens, the stromal cells and the epithelial cells proliferate rapidly.
- The endometrial surface is re-epithelialized within 4 to 7 days after the beginning of menstruation.
- During the next week and a half, the endometrium increases greatly in thickness, owing to **increasing numbers of stromal cells** and to progressive growth of the **endometrial glands** and **new blood vessels** into the endometrium.
- At the time of ovulation, the endometrium is 3 to 5 mm thick.

NOTES

**At the beginning of each monthly cycle, most of the endometrium has been desquamated by menstruation.
**After menstruation, only a thin layer of endometrial stroma remains and the only epithelial cells that are left are those located in the remaining deeper portions of the glands and crypts of the endometrium.

Secretory Phase (Progestational Phase)

- The estrogens cause slight additional cellular proliferation in the endometrium during this phase of the cycle.
- **Progesterone** causes marked swelling and secretory development of the endometrium.
- The glands increase in tortuosity; an excess of secretory substances accumulates in the glandular epithelial cells.
- lipid and glycogen deposits increase greatly in the stromal cells.
- Further Increase blood supply to the endometrium

NOTES

**At the peak of the secretory phase, about 1 week after ovulation, the endometrium has a thickness of 5 to 6 millimeters.

Secretory Phase (Progestational Phase)

- From the time of fertilization until the time implantation, the uterine secretions, called "uterine milk," provide nutrition for the early dividing ovum.
- Then, once the ovum implants in the endometrium, the trophoblastic cells on the surface of the implanting ovum (in the blastocyst stage) begin to digest the endometrium and absorb the endometrial stored substances, thus making great quantities of nutrients available to the early implanting embryo.

NOTES

****The whole purpose of all these endometrial changes is to produce a highly secretory endometrium that contains large amounts of stored nutrients to provide appropriate conditions for implantation of a *fertilized* ovum during the latter half of the monthly cycle.

Function of sex hormones

Ovarian sex hormones

- Estrogens and the progestins.
- The most important of the estrogens → estradiol.
- The most important progestin → progesterone.
- The estrogens → mainly **promote proliferation** and **growth** of specific cells in the body that are responsible for development of most **secondary sexual characteristics** of females.
- The progestins → function mainly to **prepare the uterus for pregnancy** and the **breasts for lactation**.

Functions of Estrogens

- Effect of Estrogens on the Uterus and External Female Sex Organs
- Transform the female sex organs from those of a child → an adult.
- The ovaries, fallopian tubes, uterus, and vagina all increase several times in size.
- Deposition of fat and enlargement of external genitalia.
- Change the vaginal epithelium from a cuboidal into a stratified type, which is considerably more resistant to trauma and infection.
- Estrogens cause marked proliferation of the endometrial stroma and greatly increased development of the endometrial glands, which will later aid in providing nutrition to the implanted ovum.

Functions of Estrogens

- Effect of Estrogens on the Breast
- Development of the stromal tissues of the breasts.
- Growth of an extensive ductile system..
- Deposition of fat in the breasts.

NOTES

**→ estrogens initiate growth of the breasts and of the milk-producing apparatus. They are also responsible for the characteristic growth and external appearance of the mature female breast. However, they do not complete the job of converting the breasts into milk-producing organs.

Functions of Estrogens

- Effect of Estrogens on the Skeleton
- Estrogens inhibit osteoclastic activity in the bones and therefore stimulate bone growth.
- They cause uniting of the epiphyses with the shafts of the long bones.
- After menopause → increased osteoclastic activity, decreased bone matrix, and decreased deposition of bone calcium and phosphate →osteoporosis → fracture

NOTES

**This effect of estrogen (uniting epiphyses)in the female is much stronger than the similar effect of testosterone in the male. As a result, growth of the female usually ceases several years earlier than growth of the male.

Functions of Estrogens

- Effect of Estrogens on metabolism
- Estrogens **Slightly** Increase Protein Deposition.
- Estrogens increase the whole-body metabolic rate **slightly.**
- Increased deposition of fat in the subcutaneous tissues, breasts, buttocks and thighs.

NOTES

** increase protein deposition → This effect mainly results from the growth-promoting effect of estrogen on the sexual organs, the bones, and a few other tissues of the body.

Functions of Progesterone

- Progesterone promotes **secretory changes** in the uterus.
- Progesterone decreases the frequency and intensity of uterine contractions, thereby helping to prevent expulsion of the implanted ovum.
- Progesterone promotes development of the lobules and alveoli of the breasts, causing the alveolar cells to proliferate, enlarge, and become secretory in nature.

NOTES

**progesterone does not cause the alveoli to secrete milk; milk is secreted only after the prepared breast is further stimulated by *prolactin* from the anterior pituitary gland.
**Progesterone also causes the breasts to swell. Part of this swelling is due to the secretory development in the lobules and alveoli, but part also results from increased fluid in the tissue.