The Reproductive System

Female Reproductive Anatomy

- Ovaries are the primary female reproductive organs
  - Make female gametes
  - Secrete female sex hormones (estrogen and progesterone)
- Accessory ducts include uterine tubes, uterus, and vagina
- Internal genitalia – ovaries and the internal ducts
- External genitalia – external sex organs

Female Reproductive Anatomy

Figure 28.11

The Ovaries

- Paired organs on each side of the uterus held in place by several ligaments
  - Ovarian – anchors the ovary medially to the uterus
  - Suspensory – anchors the ovary laterally to the pelvic wall
  - Mesovarium – suspends the ovary in between
- Broad ligament – contains the suspensory ligament and the mesovarium

The Ovaries

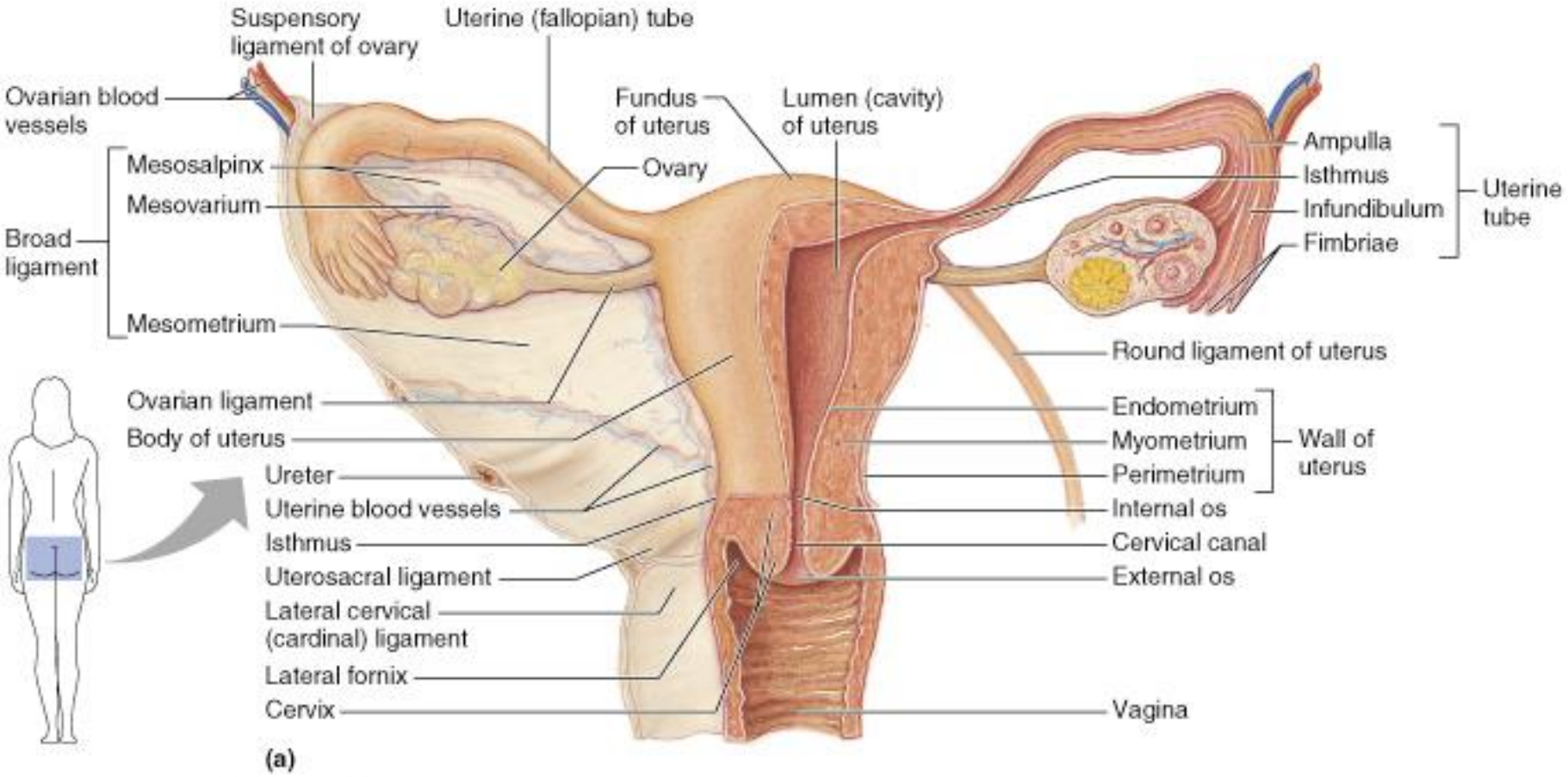


Figure 28.14a

Ovaries

- Blood supply – ovarian arteries and the ovarian branch of the uterine artery
- They are surrounded by a fibrous tunica albuginea, which is covered by a misnamed layer of epithelial cells called the germinal epithelium
- Embedded in the ovary cortex are ovarian follicles
- Each follicle consists of an immature egg called an oocyte
- Cells around the oocyte are called:
  - Follicle cells (one cell layer thick)
  - Granulosa cells (when more than one layer is present)

Ovaries

- Primordial follicle – one layer of squamous like follicle cells surrounds the oocyte
- Primary follicle – two or more layers of cuboidal granulosa cells enclose the oocyte
- Secondary follicle – has a fluid-filled space between granulosa cells that coalesces to form a central antrum
- Graafian follicle – secondary follicle at its most mature stage that bulges from the surface of the ovary
- Ovulation – ejection of the oocyte from the ripening follicle
- Corpus luteum – ruptured follicle after ovulation

Ovaries

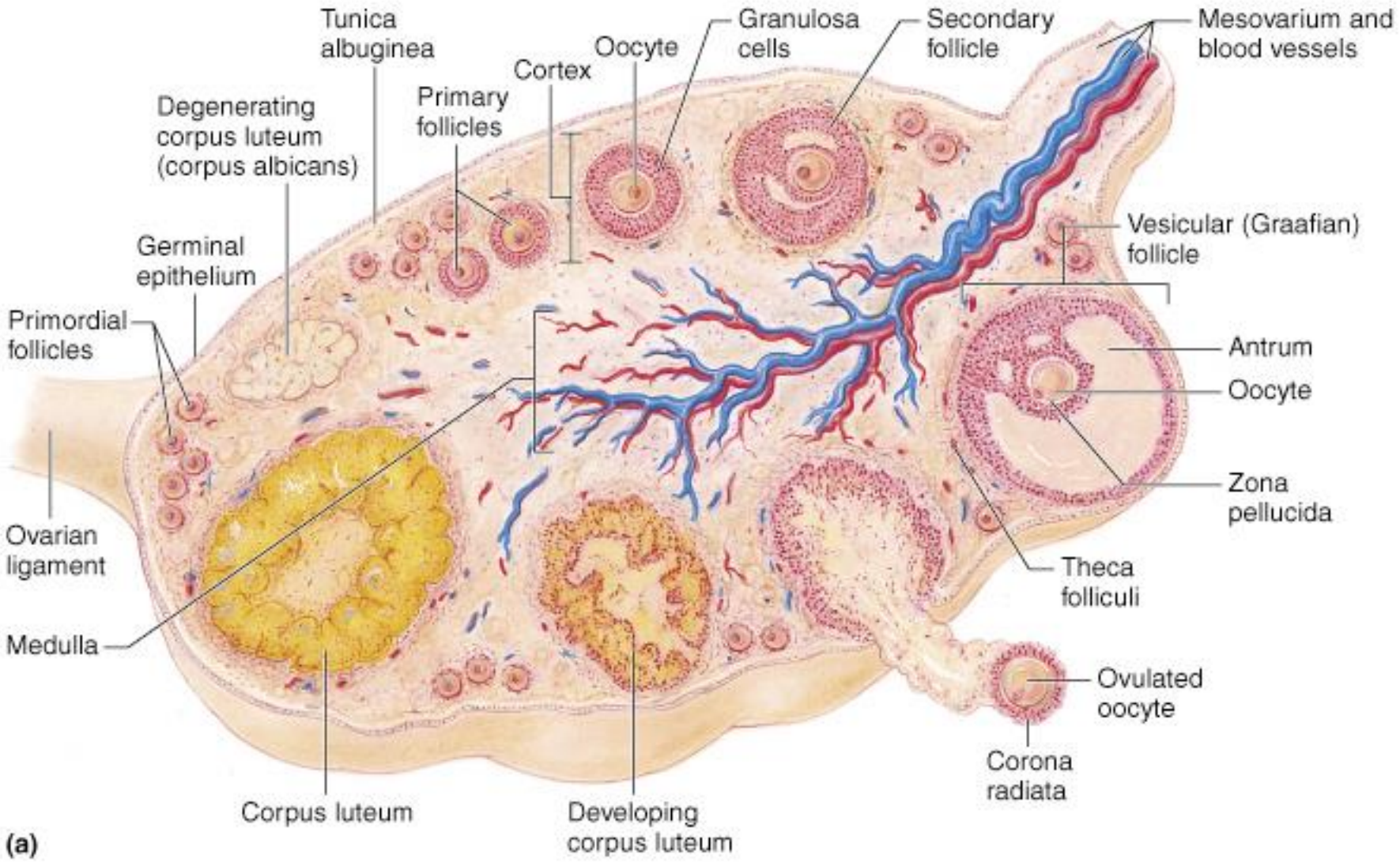


Figure 28.12a

Uterine Tubes (Fallopian Tubes) and Oviducts

- Receive the ovulated oocyte and provide a site for fertilization
- Empty into the superolateral region of the uterus via the isthmus
- Expand distally around the ovary forming the ampulla
- The ampulla ends in the funnel-shaped, ciliated infundibulum containing fingerlike projections called fimbriae

Uterine Tubes

- The uterine tubes have no contact with the ovaries and the ovulated oocyte is cast into the peritoneal cavity
- Beating cilia on the fimbriae create currents to carry the oocyte into the uterine tube
- The oocyte is carried toward the uterus by peristalsis and ciliary action
- Nonciliated cells keep the oocyte and the sperm nourished and moist
- Mesosalpinx – visceral peritoneum that support the uterine tubes

Uterus

- Hollow, thick-walled organ located in the pelvis anterior to the rectum and posterosuperior to the bladder
- Body – major portion of the uterus
- Fundus – rounded region superior to the entrance of the uterine tubes
- Isthmus – narrowed region between the body and cervix

Uterus

- Cervix – narrow neck which projects into the vagina inferiorly
- Cervical canal – cavity of the cervix that communicates with:
  - The vagina via the external os
  - The uterine body via the internal os
- Cervical glands secrete mucus that covers the external os and blocks sperm entry except during midcycle

Uterine Wall

- Composed of three layers
  - Perimetrium – outermost serous layer; the visceral peritoneum
  - Myometrium – middle layer; interlacing layers of smooth muscle
  - Endometrium – mucosal lining of the uterine cavity

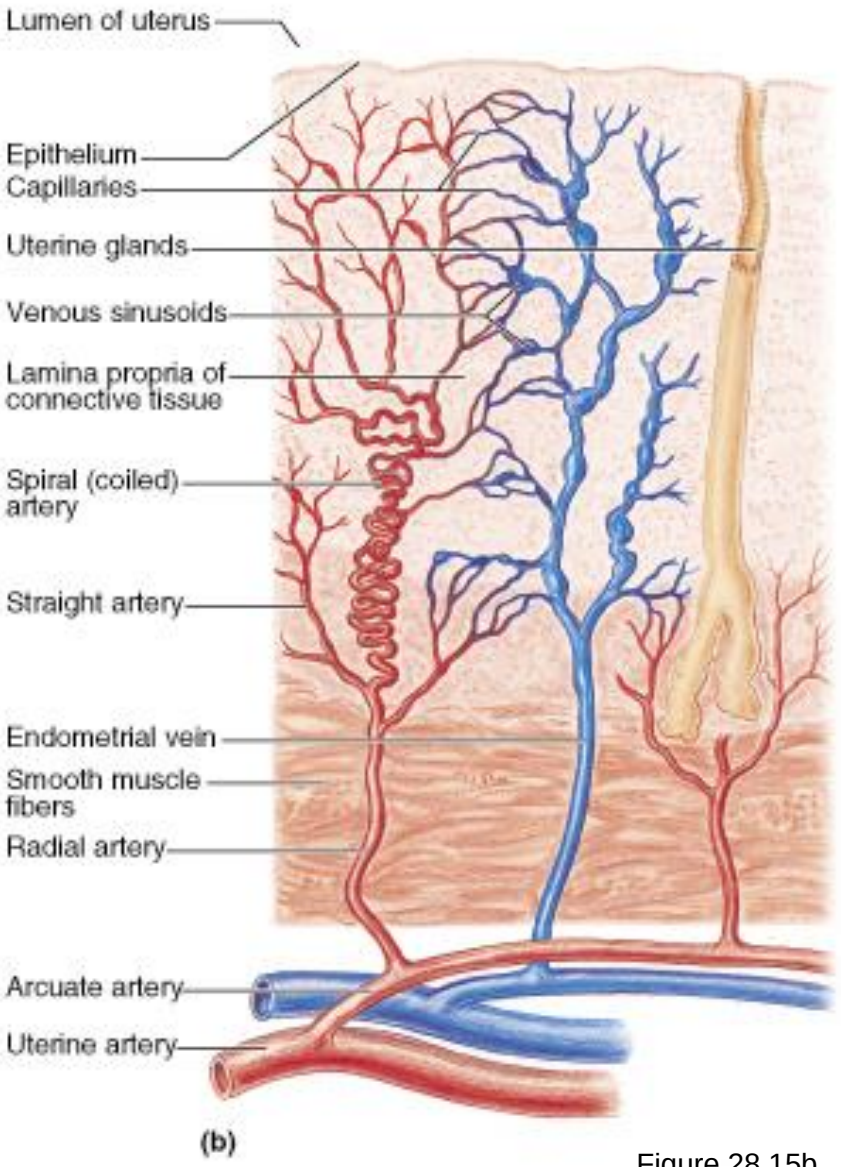


Figure 28.15b

Endometrium

- Has numerous uterine glands that change in length as the endometrial thickness changes
- Stratum functionalis:
  - Undergoes cyclic changes in response to ovarian hormones
  - Is shed during menstruation
- Stratum basalis:
  - Forms a new functionalis after menstruation ends
  - Does not respond to ovarian hormones

Uterine Vascular Supply

- Uterine arteries – arise from the internal iliacs, ascend the sides of the uterus and send branches into the uterine wall
- Arcuate arteries – branches of the uterine arteries in the myometrium that give rise to radial branches
- Radial branches – descend into the endometrium and give rise to:
  - Spiral arteries to the stratum functionalis
  - Straight arteries to the stratum basalis

Uterine Vascular Supply

- Degeneration and regeneration of spiral arteries causes the functionalis to shed during menstruation
- Veins of the endometrium are thin-walled with occasional sinusoidal enlargements

Vagina

- Thin-walled tube lying between the bladder and the rectum, extending from the cervix to the exterior of the body
- The urethra is embedded in the anterior wall
- Provides a passageway for birth, menstrual flow, and is the organ of copulation

External Genitalia: Vulva (Pudendum)

- Lies external to the vagina and includes the mons pubis, labia, clitoris, and vestibular structures
- Mons pubis – round, fatty area overlying the pubic symphysis
- Labia majora – elongated, hair-covered, fatty skin folds homologous to the male scrotum
- Labia minora – hair-free skin folds lying within the labia major: homologous to the ventral penis

Mammary Glands

- Modified sweat glands consisting of 15-25 lobes that radiate around and open at the nipple
- Areola – pigmented skin surrounding the nipple
- Suspensory ligaments attach the breast to underlying muscle fascia
- Lobes contain glandular alveoli that produce milk in lactating women
- Compound alveolar glands pass milk to lactiferous ducts, which open to the outside

Oogenesis

- Production of female sex cells by meiosis
- In the fetal period, oogonia (2*n* ovarian stem cells) multiply by mitosis and store nutrients
- Primordial follicles appear as oogonia are transformed into primary oocytes
- Primary oocytes begin meiosis but stall in prophase I

Oogenesis: Puberty

- At puberty, one activated primary oocyte produces two haploid cells
  - The first polar body
  - The secondary oocyte
- The secondary oocyte arrests in metaphase II and is ovulated
- If penetrated by sperm:
  - The second oocyte completes meiosis II, yielding:
    - One large ovum (the functional gamete)
    - A tiny second polar body

Oogenesis: Puberty

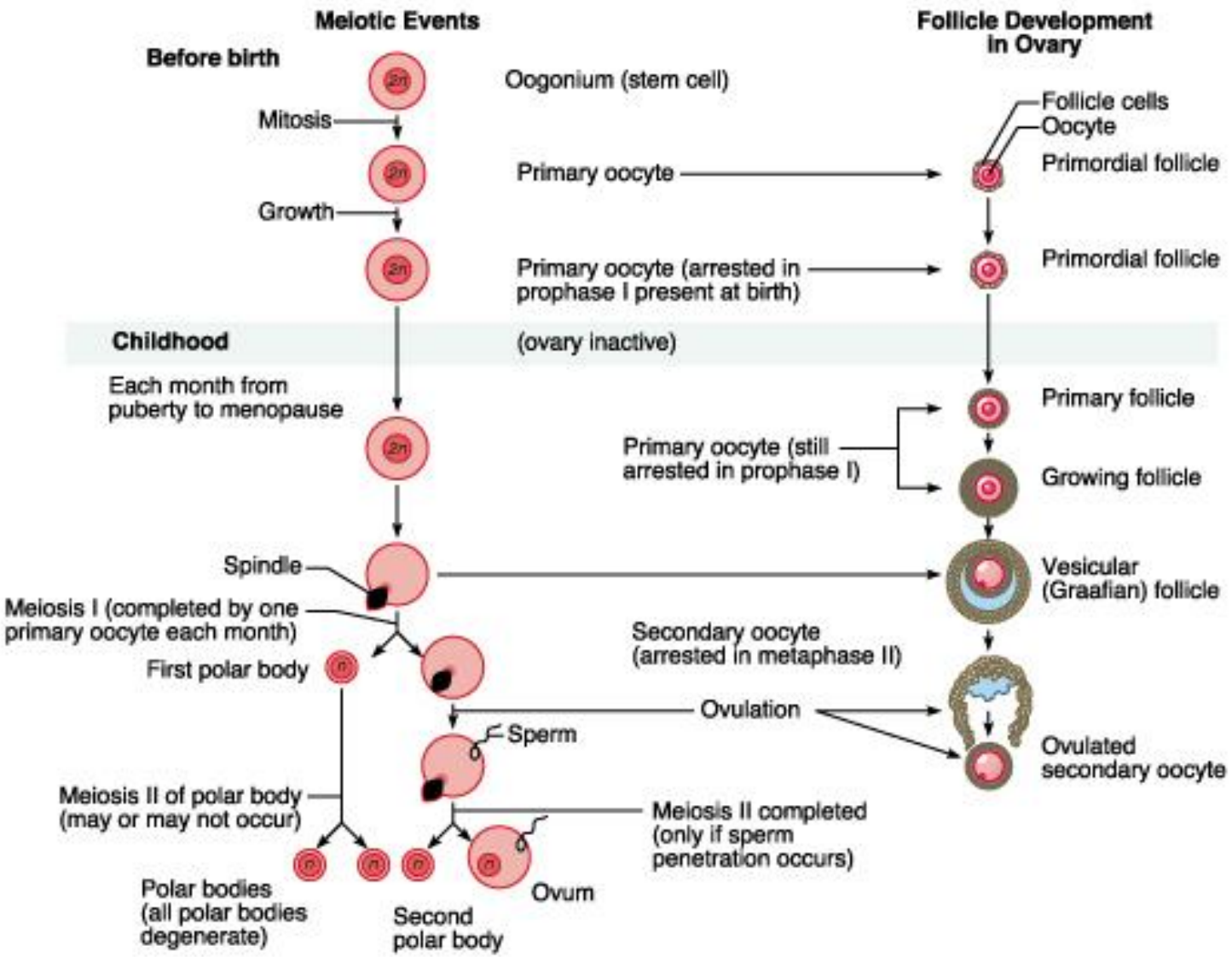


Figure 28.19

Major steps in the production of an ovum

Before birth

Oogonia

46 chromosomes

mitosis

6- 7million oogonia by the 5th month of pregnancy

Start first meiosis but it is suspended at prophase I

Primary oocyte surrounded by flattened follicle cells Primordial follicle

Birth

2 million at birth

Inactive

Puberty

Primordial follicles develop into primary follicles which consist of an enlarged oocyte surrounded by cuboidal granulosa cells

A portion of follicles begin developing into secondary follicles on a cyclical basis. Most follicles become atretic.

A secondary follicle develops with an antrum beginning. There are thecal cells surrounding granulosa cells. The follicle develops into a Graafian (pre-ovulatory) follicle which will ovulate

First polar body

Ovulation

The first meiotic division is completed just before ovulation. The second meiotic division commences but is suspended

23 chromosomes

Seconday oocyte

Fertilisation

The second meiotic division is completed with fertilisation resulting in a mature ovum

Second polar body

Ovarian Cycle

- Monthly series of events associated with the maturation of an egg
- Follicular phase – period of follicle growth (days 1–14)
- Luteal phase – period of corpus luteum activity (days 14–28)
- Ovulation occurs midcycle

Follicular Phase

- The primordial follicle becomes a primary follicle
- Primary follicle becomes a secondary follicle
  - The theca folliculi and granulosa cells cooperate to produce estrogens
  - The zona pellucida forms around the oocyte
  - The antrum is formed

Follicular Phase

- The secondary follicle becomes a vesicular follicle
  - The antrum expands and isolates the oocyte and the corona radiata
  - The full size follicle (vesicular follicle) bulges from the external surface of the ovary
  - The primary oocyte completes meiosis I, and the stage is set for ovulation

Follicular Phase

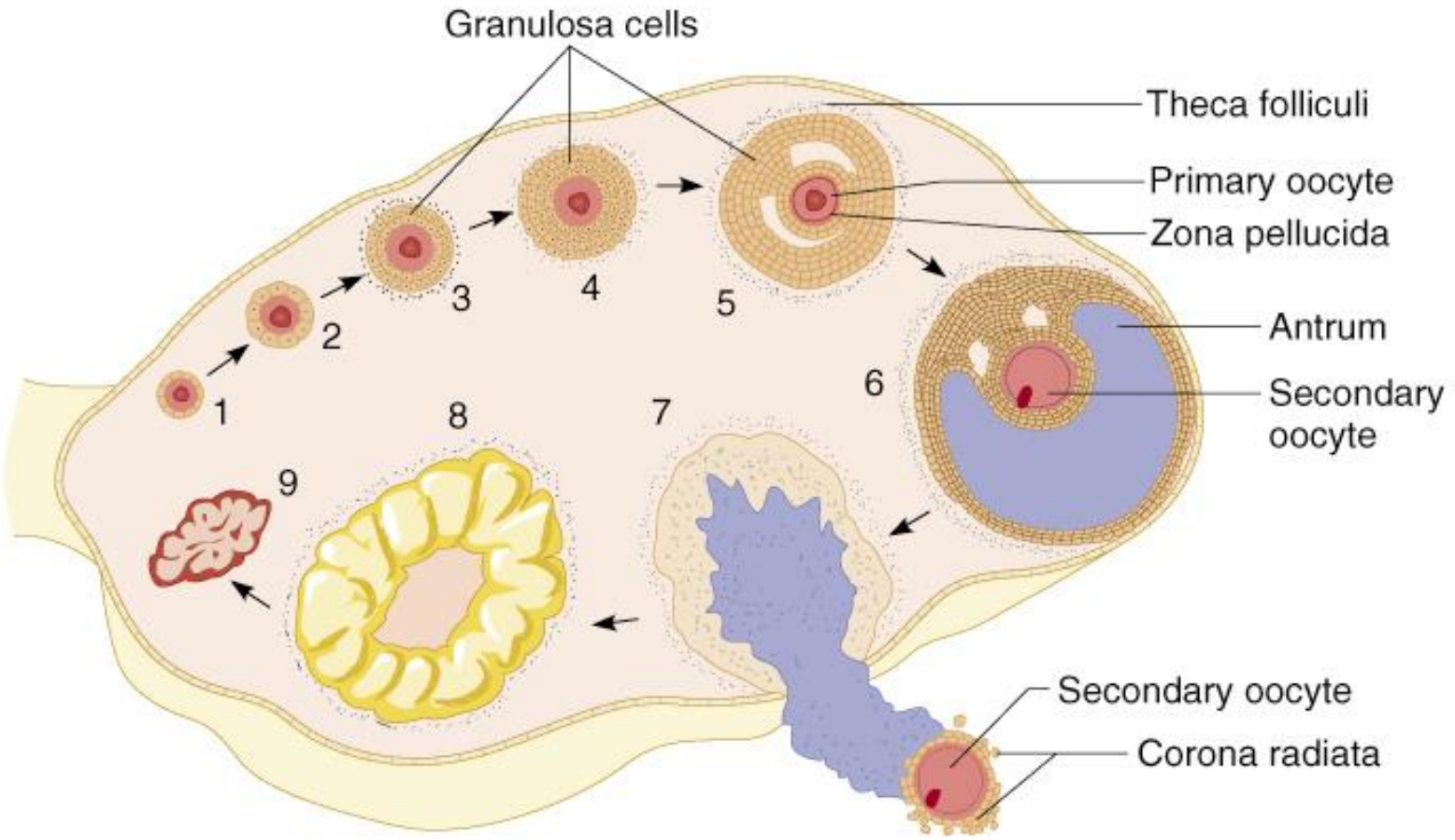
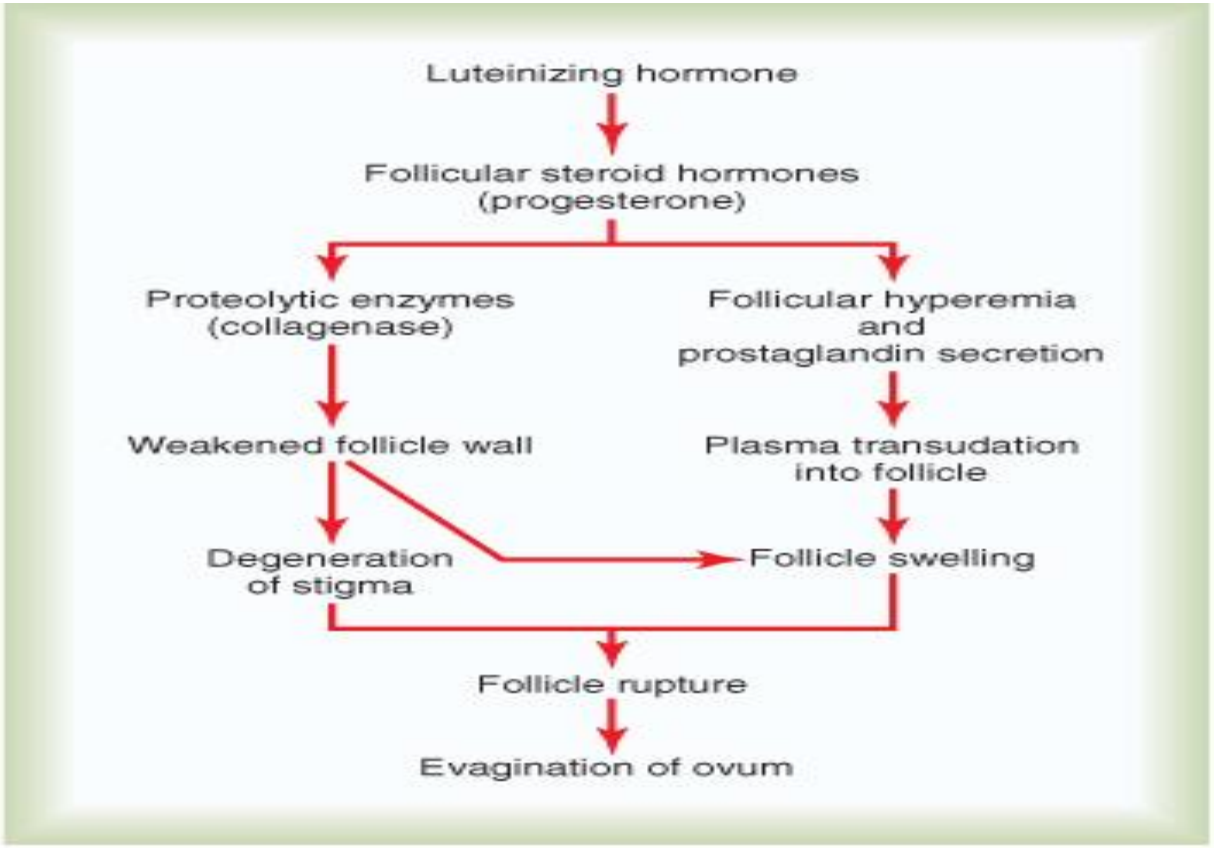


Figure 28.20

Ovulation

- Ovulation occurs when the ovary wall ruptures and expels the secondary oocyte
- Mittelschmerz – a tinge of pain sometimes felt at ovulation
- 1-2% of ovulations release more than one secondary oocyte, which if fertilized, results in fraternal twins

Initiation of Ovulation



Luteal Phase

- After ovulation, the ruptured follicle collapses, granulosa cells enlarge, and along with internal thecal cells, form the corpus luteum
- The corpus luteum secretes progesterone and estrogen
- If pregnancy does not occur, the corpus luteum degenerates in 10 days, leaving a scar (corpus albicans)
- If pregnancy does occur, the corpus luteum produces hormones until the placenta takes over that role (at about 3 months)

Establishing the Ovarian Cycle

- During childhood, ovaries grow and secrete small amounts of estrogens that inhibit the hypothalamic release of GnRH
- As puberty nears, GnRH is released; FSH and LH are released by the pituitary, which act on the ovaries
- These events continue until an adult cyclic pattern is achieved and menarche occurs

Hormonal Interactions During the Ovarian Cycle

- Day 1 – GnRH stimulates the release of FSH and LH
- FSH and LH stimulate follicle growth and maturation, and low-level estrogen release
- Rising estrogen levels:
  - Inhibit the release of FSH and LH
  - Prod the pituitary to synthesize and accumulate these gonadotropins
- Estrogen levels increase and high estrogen levels have a positive feedback effect on the pituitary, causing a sudden surge of LH

Hormonal Interactions During the Ovarian Cycle

- The LH spike simulates the primary oocyte to complete meiosis I, and the secondary oocyte continues on to metaphase II
- Day 14 – LH triggers ovulation
- LH transforms the ruptured follicle into a corpus luteum, which produces inhibin, progesterone, and estrogen

Hormonal Interactions During the Ovarian Cycle

- These hormones shut off FSH and LH release and declining LH ends luteal activity
- Days 26-28 – decline of the ovarian hormones
  - Ends the blockade of FSH and LH
  - The cycle starts anew

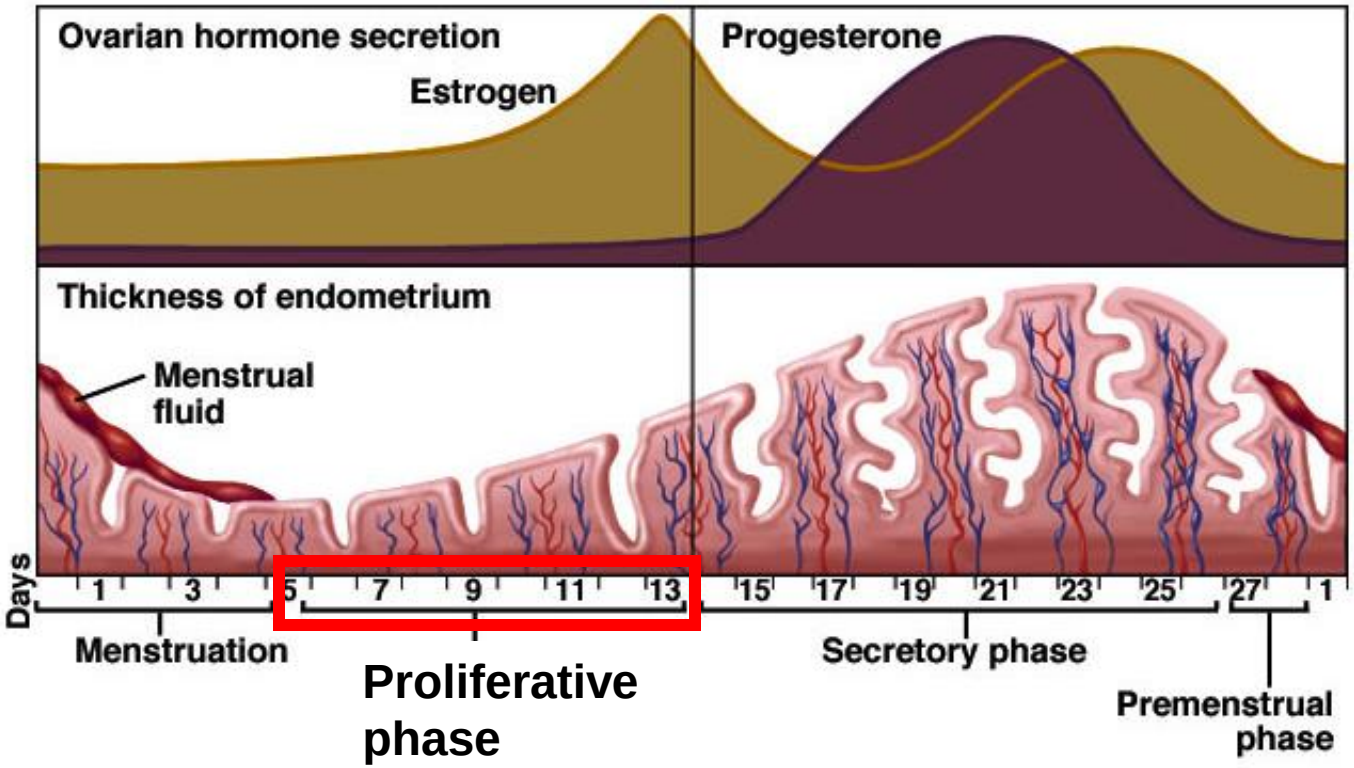
Summary

- About every 28 days, gonadotropic hormones from the anterior pituitary gland cause about 8 to 12 new follicles to begin to grow in the ovaries. One of these follicles finally becomes "mature" and ovulates on the 14th day of the cycle. During growth of the follicles, mainly estrogen is secreted.
- After ovulation, the secretory cells of the ovulating follicle develop into a corpus luteum that secretes large quantities of both the major female hormones, progesterone and estrogen. After another 2 weeks, the corpus luteum degenerates, whereupon the ovarian hormones estrogen and progesterone decrease greatly, and menstruation begins. A new ovarian cycle then follows.

Uterine (Menstrual) Cycle

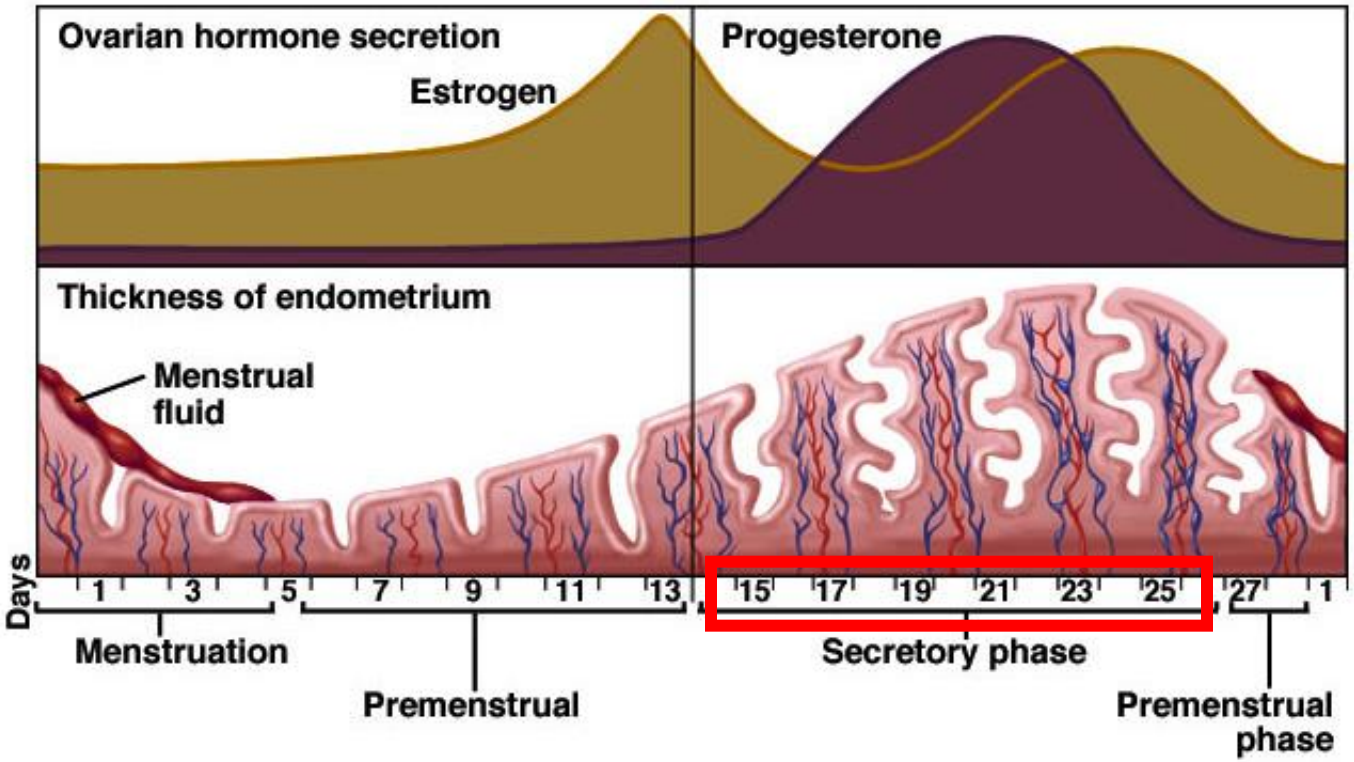
- Series of cyclic changes that the uterine endometrium goes through each month in response to ovarian hormones in the blood
- Days 1-5: Menstrual phase – uterus sheds all but the deepest part of the endometrium
- Days 6-14: Proliferative phase – endometrium rebuilds itself
- Days 15-28: Secretory phase – Endometrium prepares for implantation of the embryo

Menstrual Cycle -- Proliferative Phase



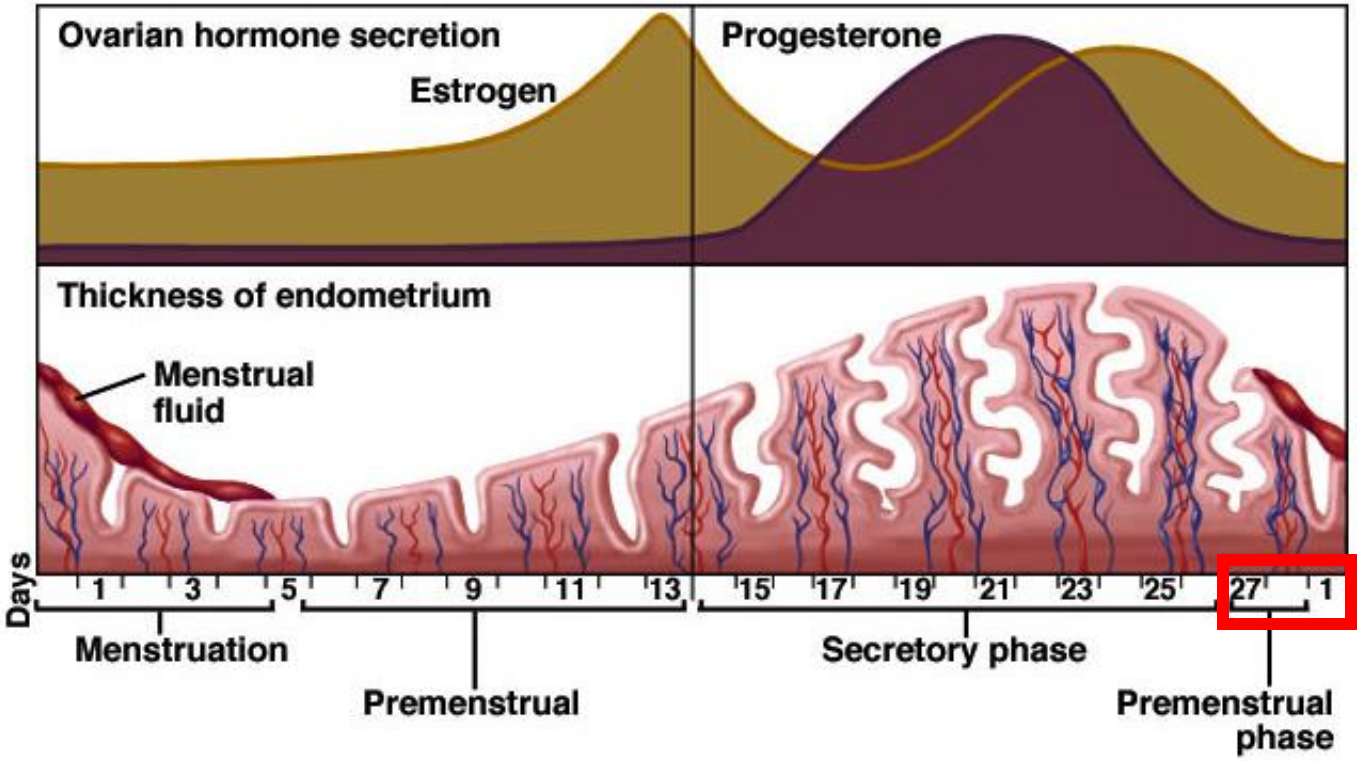
- **Time of rebuilding of endometrial tissue lost at last menstruation -- mitosis occurs in stratum basalis (day 6 to 14)**
- **Result of estrogen from developing follicles**
- **Estrogen also stimulate endometrium to produce progesterone receptors**
- **Endometrium reaches 2-3 mm in thickness**

Menstrual Cycle -- Secretory Phase



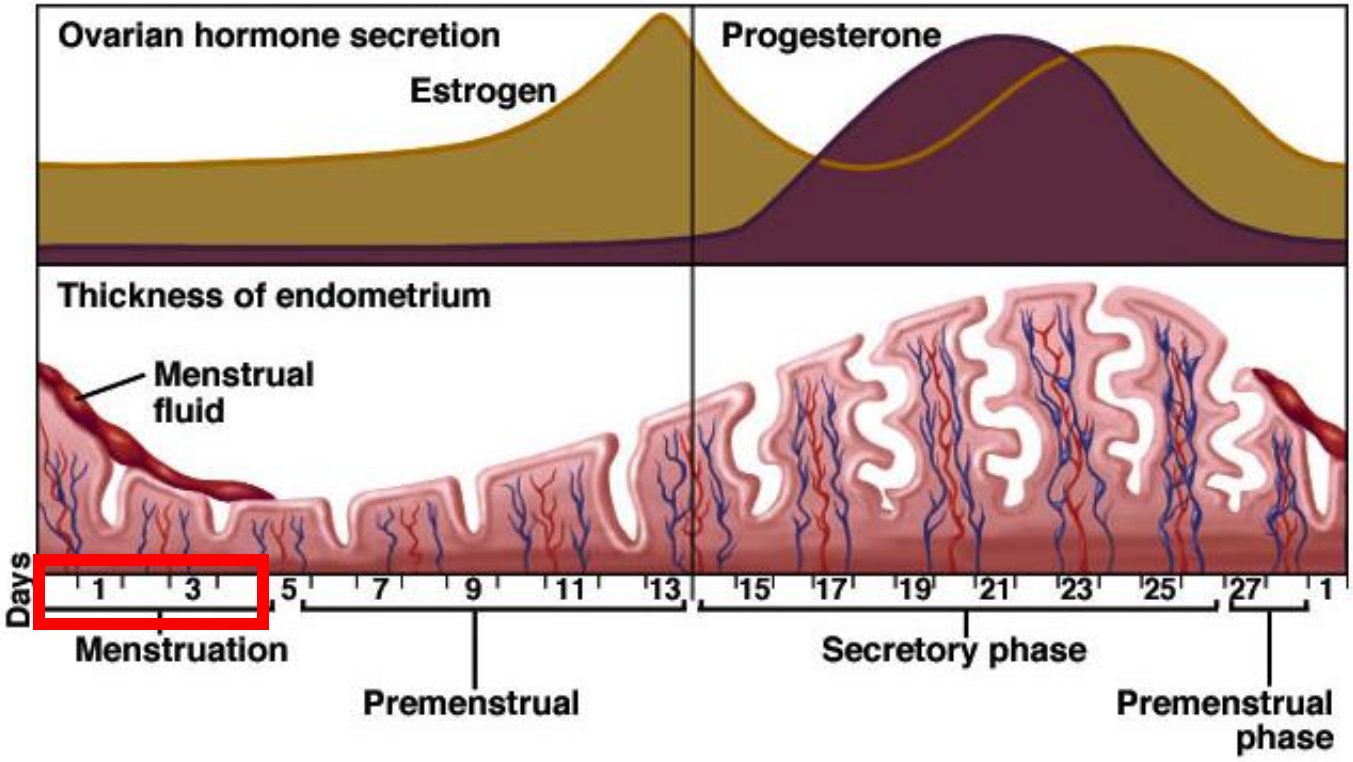
- Further thickening of endometrium due to secretion & fluid accumulation -- not mitosis (day 15 to 26)
- Due to progesterone stimulation of glands
- Reaches 5-6 mm in thickness

Menstrual Cycle -- Premenstrual Phase

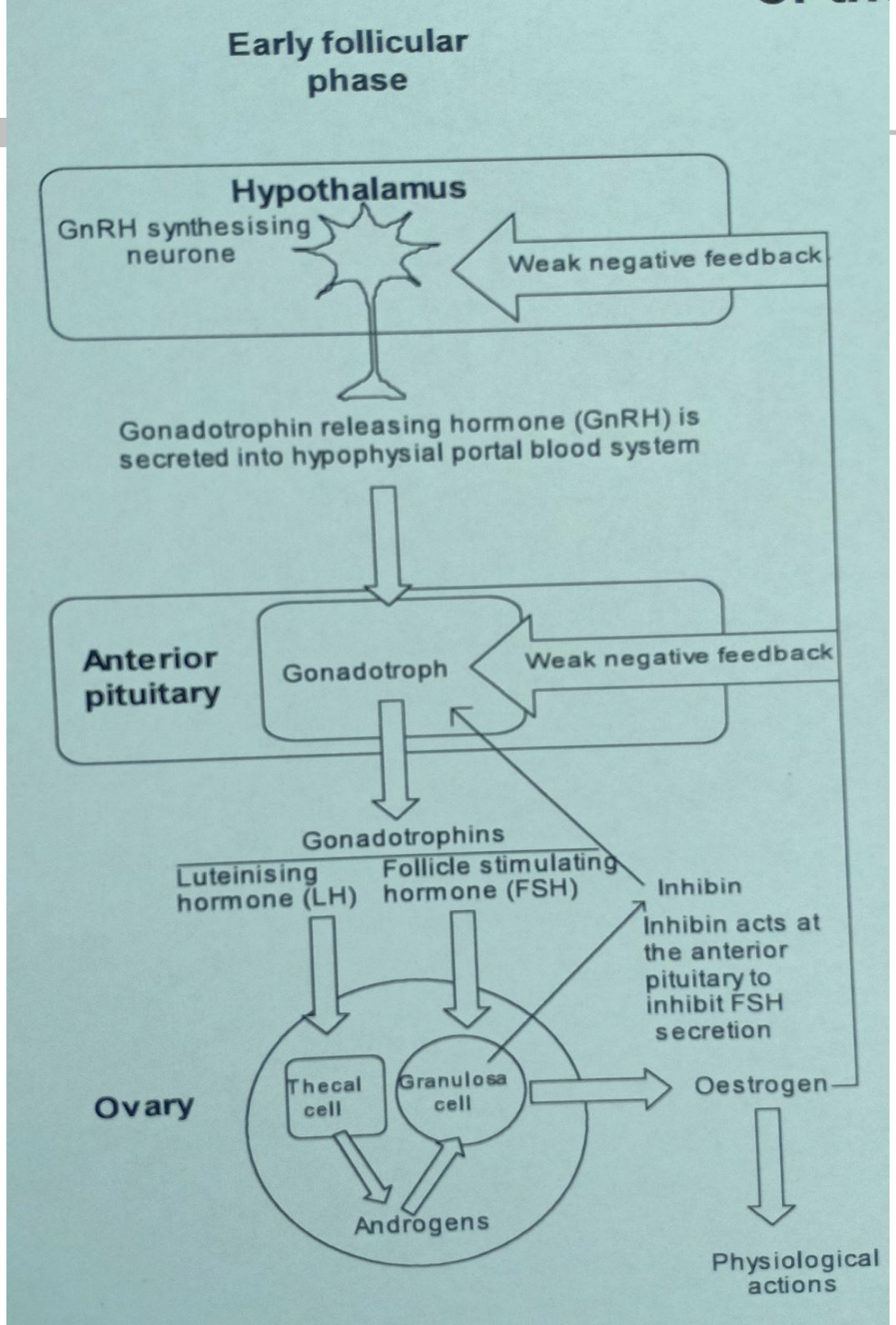


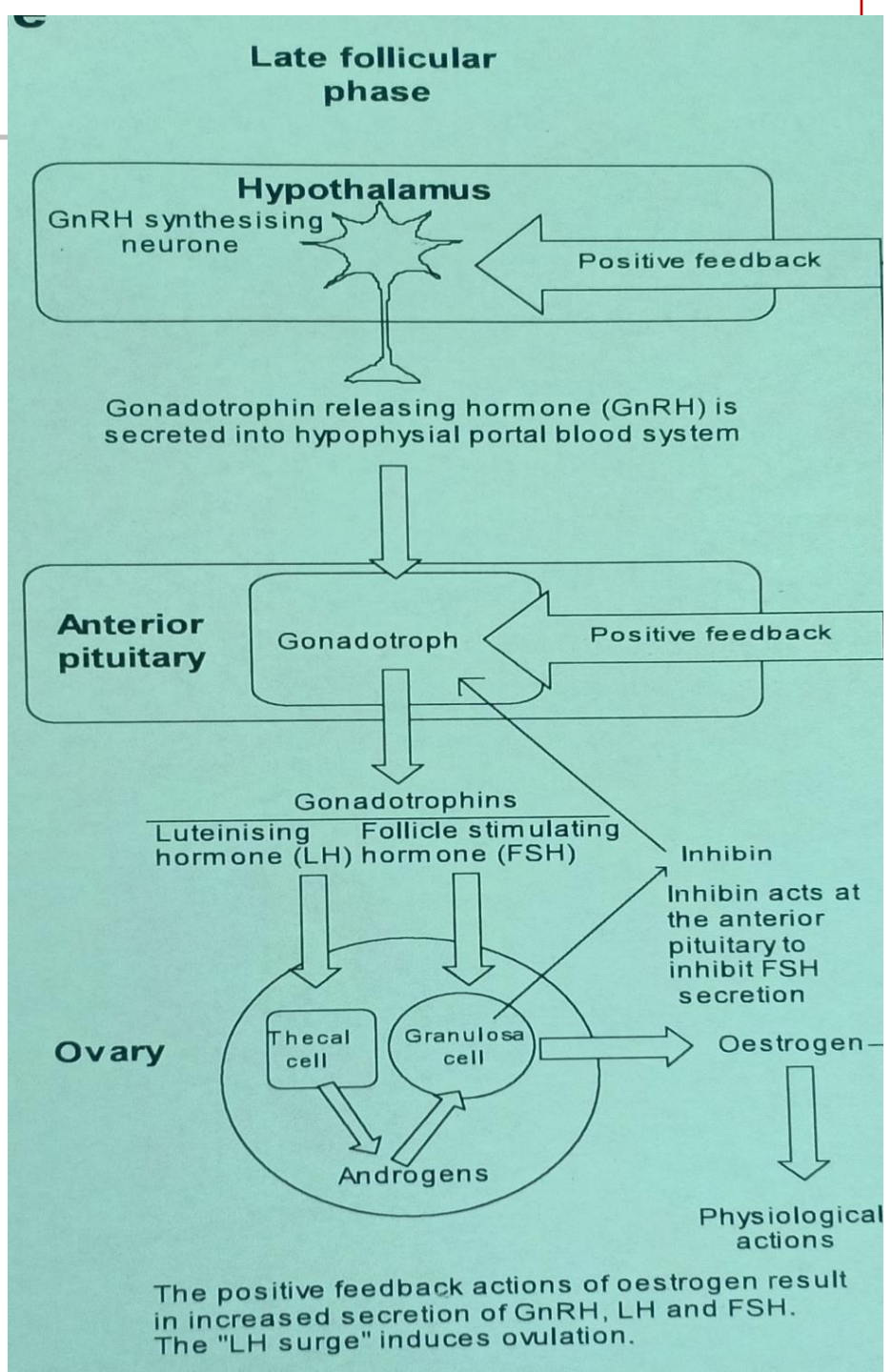
- Endometrial degeneration (last 2 days of menstrual cycle)
- Progesterone level falls due to atrophy of corpus luteum
- Spiral arteries constrict causing endometrial ischemia
- Pools of blood accumulate in stratum functionalis

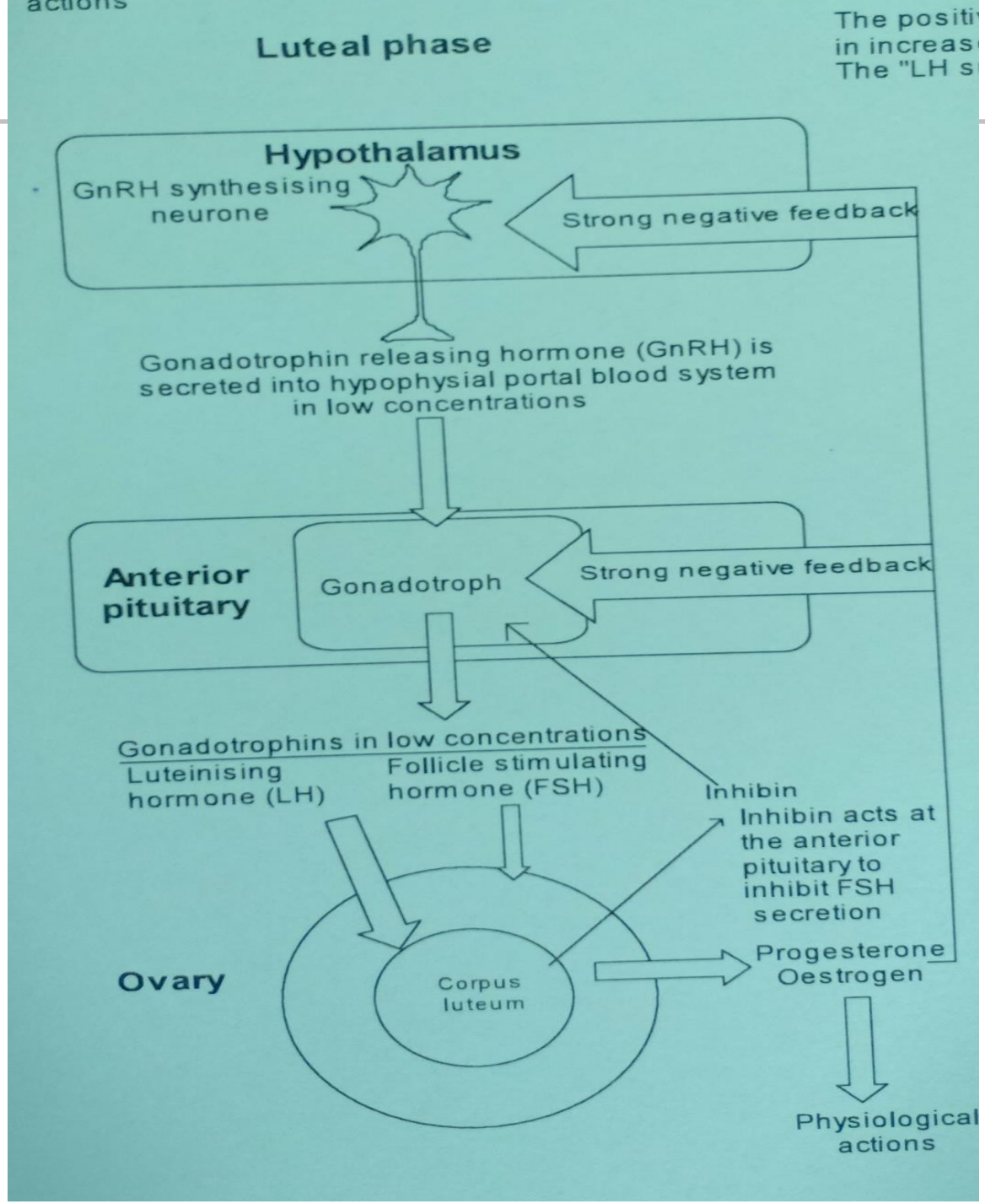
Menstrual Cycle -- Menstrual Phase



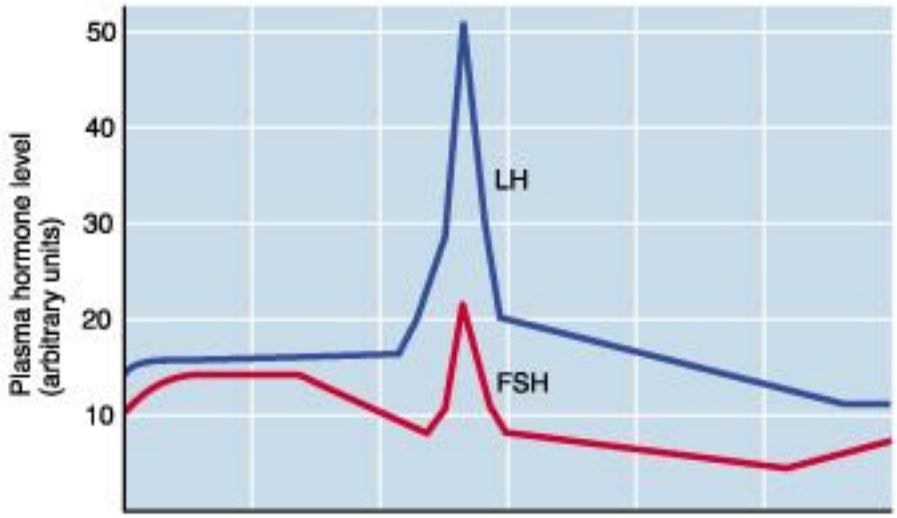
- Blood, serous fluid and endometrial tissue are discharged (day 1 to 5)
- Average woman loses 40 mL of blood & 35 mL of serous fluid --- contains fibrinolysin so it does not clot


Early follicular phase
Hypothalamus
GnRH synthesising neurone
Weak negative feedback
Gonadotrophin releasing hormone (GnRH) is secreted into hypophysial portal blood system
Anterior pituitary
Gonadotroph
Weak negative feedback
Gonadotrophins
Luteinising hormone (LH)
Follicle stimulating hormone (FSH)
Inhibin
Inhibin acts at the anterior pituitary to inhibit FSH secretion
Ovary
Thecal cell
Granulosa cell
Androgens
Oestrogen
Physiological actions

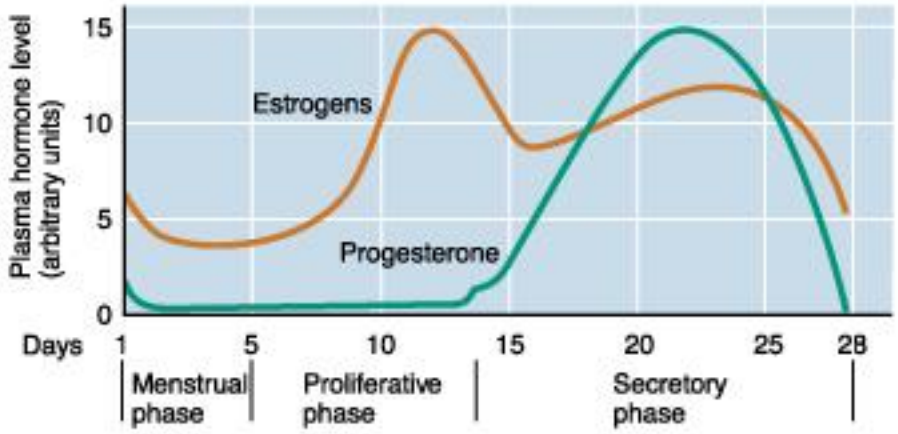

Late follicular phase
Hypothalamus
GnRH synthesising neurone
Positive feedback
Gonadotrophin releasing hormone (GnRH) is secreted into hypophysial portal blood system
Anterior pituitary
Gonadotroph
Positive feedback
Gonadotrophins
Luteinising hormone (LH)
Follicle stimulating hormone (FSH)
Inhibin
Inhibin acts at the anterior pituitary to inhibit FSH secretion
Ovary
Thecal cell
Granulosa cell
Androgens
Oestrogen
Physiological actions
The positive feedback actions of oestrogen result in increased secretion of GnRH, LH and FSH. The "LH surge" induces ovulation.


actions
Luteal phase
The positi
in increas
The "LH s
Hypothalamus
GnRH synthesising neurone
Strong negative feedback
Gonadotrophin releasing hormone (GnRH) is secreted into hypophysial portal blood system in low concentrations
Anterior pituitary
Gonadotroph
Strong negative feedback
Gonadotrophins in low concentrations
Luteinising hormone (LH)
Follicle stimulating hormone (FSH)
Inhibin
Inhibin acts at the anterior pituitary to inhibit FSH secretion
Ovary
Corpus luteum
Progesterone
Oestrogen
Physiological actions

Gonadotropins, Hormones, and the Ovarian and Uterine Cycles



(a) Fluctuation of gonadotropin levels



(b) Fluctuation of ovarian hormone levels

Figure 28.22a, b

Gonadotropins, Hormones, and the Ovarian and Uterine Cycles

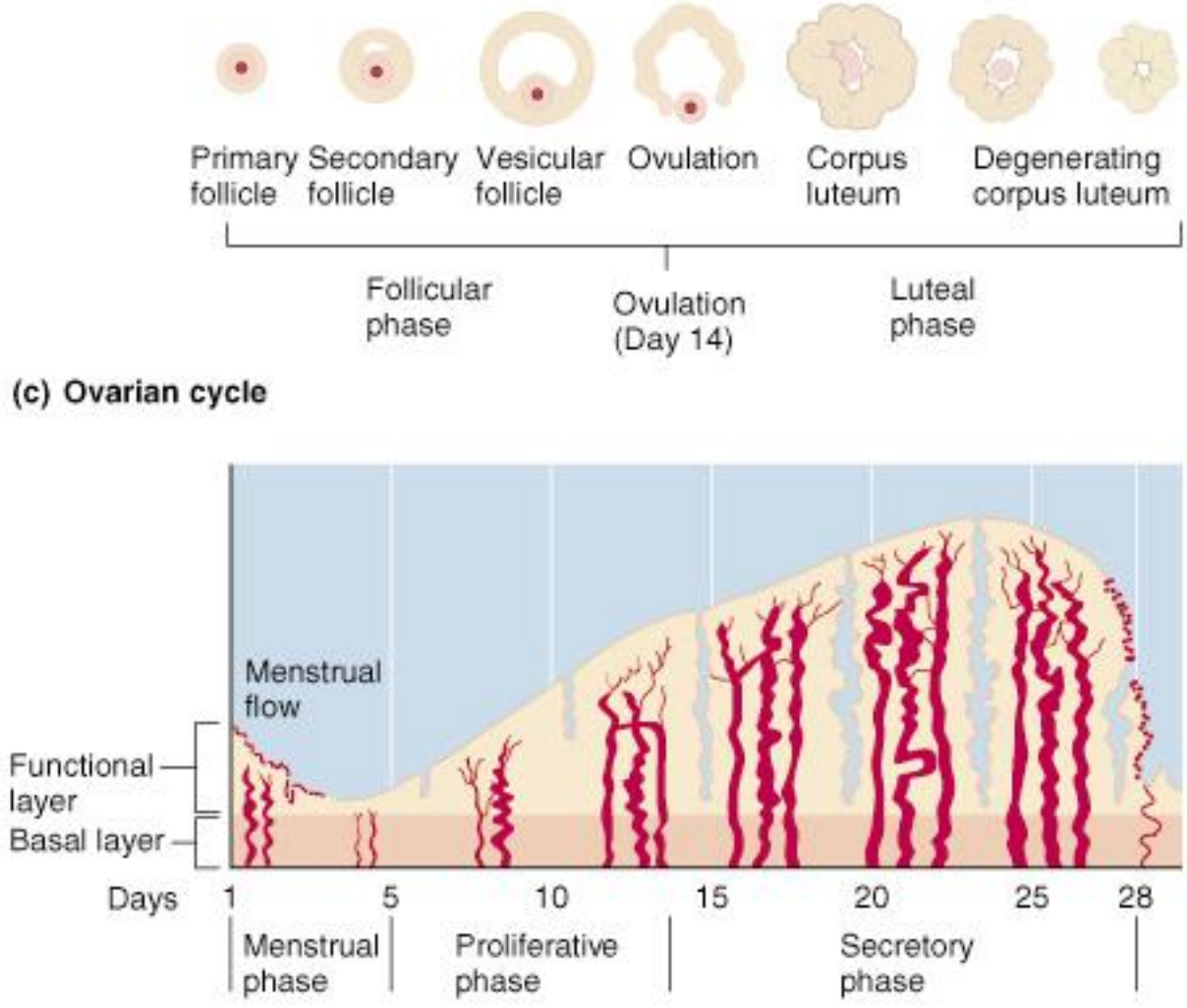
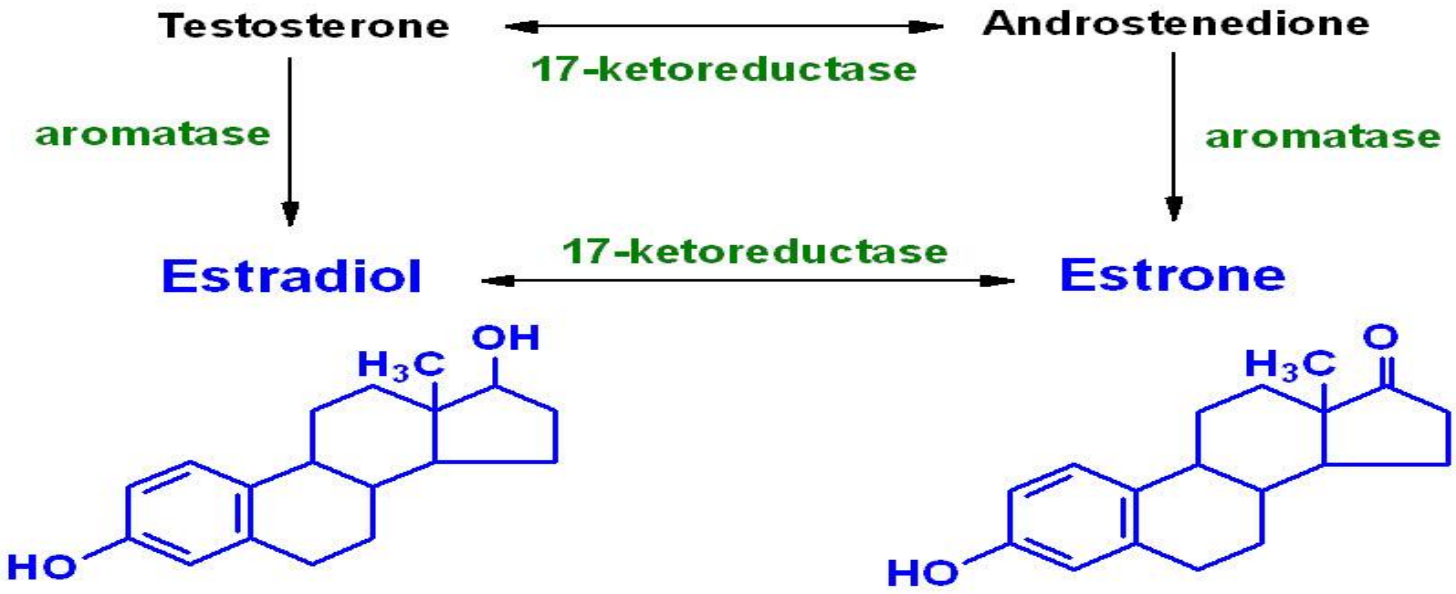


Figure 28.22c ,d

Synthesis of the major female sex hormones in the ovary



Effects of Estrogen

- Estrogen levels rise during puberty
  - Promote oogenesis and follicle growth in the ovary
  - Exert anabolic effects on the female reproductive tract
    - Uterine tubes, uterus, and vagina grow larger and become functional
    - Uterine tubes and uterus exhibit enhanced motility
    - Vaginal mucosa thickens and external genitalia mature

Estrogen-Induced Secondary Sex Characteristics

- Growth of the breasts
- Increased deposition of subcutaneous fat, especially in the hips and breasts
- Widening and lightening of the pelvis
- Growth of axillary and pubic hair

Other actions –Hormonal

Hormonal

*Stimulates secretion of GnRH, LH and FSH during the follicular phase and inhibits the secretion of the same during the luteal phase .

*Decreases sensitivity of peripheral tissues to insulin

* Increases the circulating levels of renin and angiotensin II

Metabolic

* Protects against bone loss

Actions of progesterone

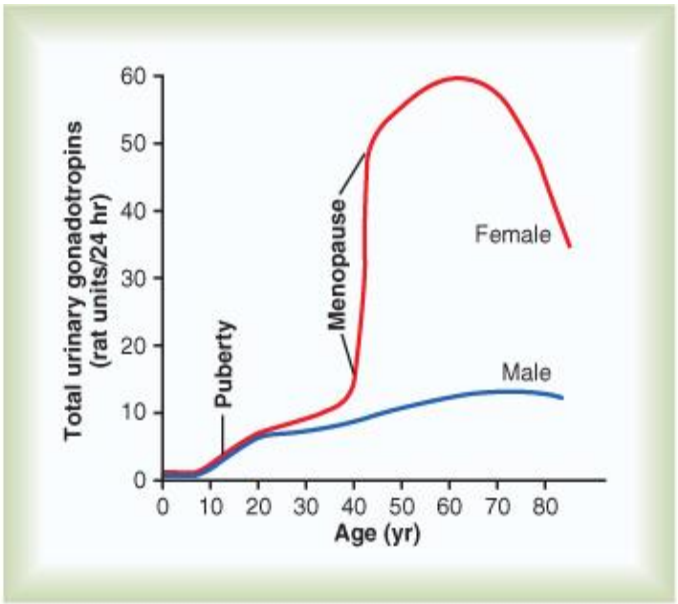
1.Converts the estrogen primed endometrium to an actively secreting tissue for implantation of the embryo.
2.Induces thick, sticky cervical mucus.
3.Decreases contraction of the uterine tubes and myometrium .
4.Decreases proliferation of vaginal epithelial cells
5.Stimulates breast growth ,particularly glandular cells
6.Inhibits ,milk inducing effects of prolactin.
7.Increases body temperature .

Female Sexual Response

- The clitoris, vaginal mucosa, and breasts engorge with blood
- Vestibular glands lubricate the vestibule and facilitates entry of the penis
- Orgasm – accompanied by muscle tension, increase in pulse rate and blood pressure, and rhythmical contractions of the uterus
- Females do not have a refractory period after orgasm and can experience multiple orgasms in a single sexual experience
- Orgasm is not essential for conception

Puberty and Menarche

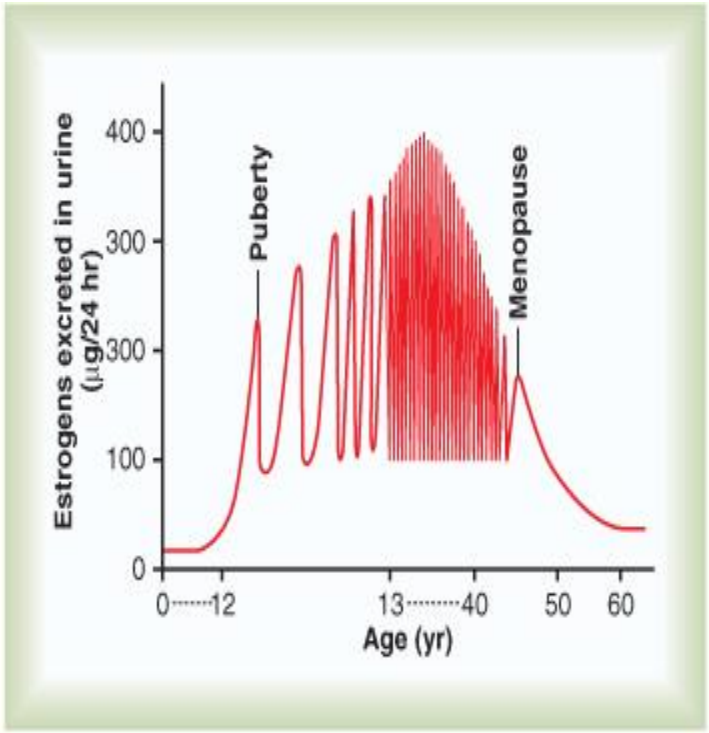
- *Puberty* means the onset of adult sexual life, and *menarche* means the beginning of the cycle of menstruation. The period of puberty is caused by a gradual increase in gonadotropic hormone secretion by the pituitary, beginning in about the eighth year of life, and usually culminating in the onset of puberty and menstruation between ages 11 and 16 years in girls (average, 13 years)



- Total rates of secretion of gonadotropic hormones throughout the sexual lives of female and male human beings, showing an especially abrupt increase in gonadotropic hormones at menopause in the female.

Menopause

- At age 40 to 50 years, the sexual cycle usually becomes irregular, and ovulation often fails to occur. After a few months to a few years, the cycle ceases altogether. The period during which the cycle ceases and the female sex hormones diminish to almost none is called *menopause*



Estrogen secretion throughout the sexual life of the female human being.