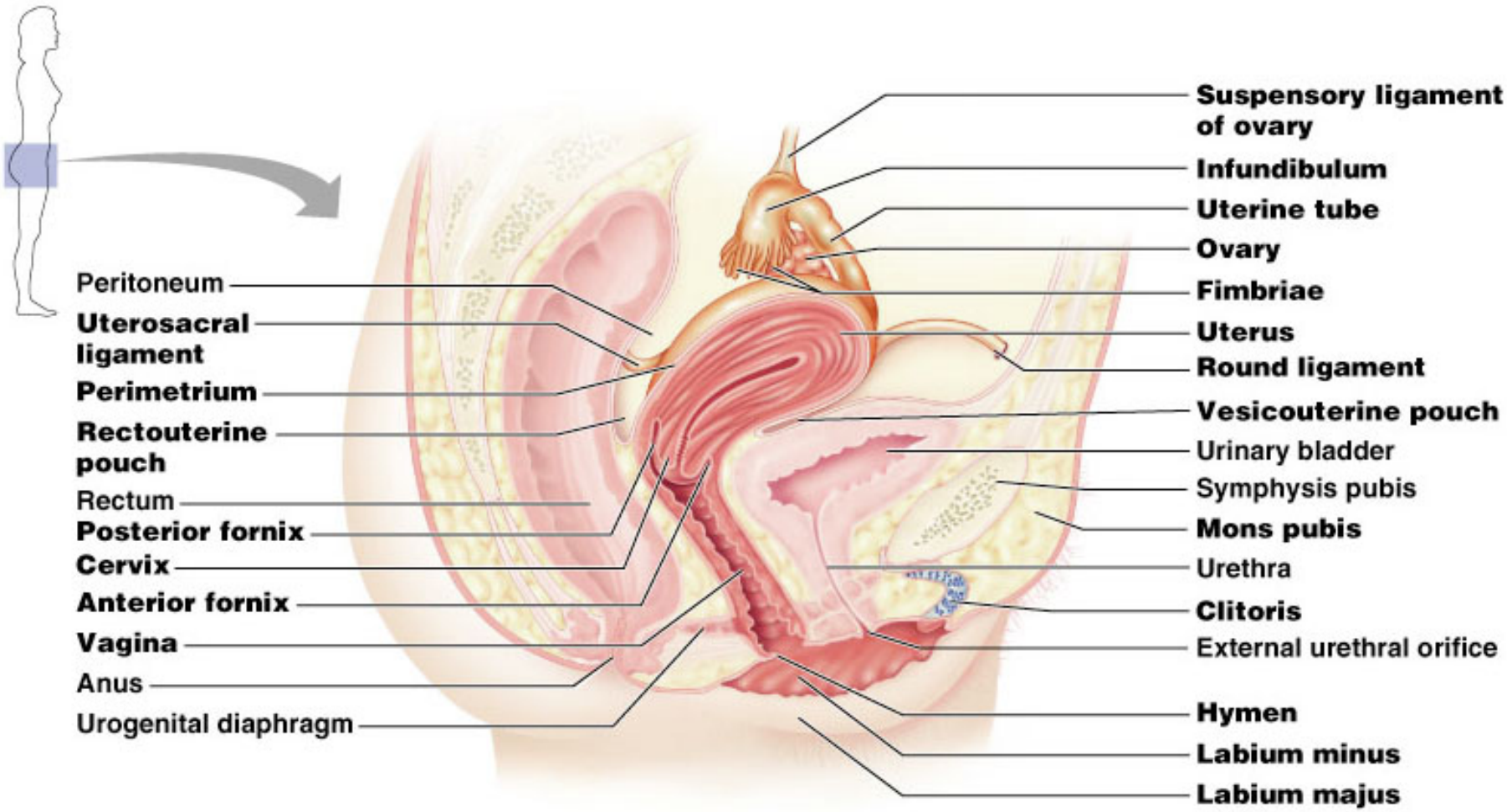
Reproductive Physiology

The Female Reproductive System

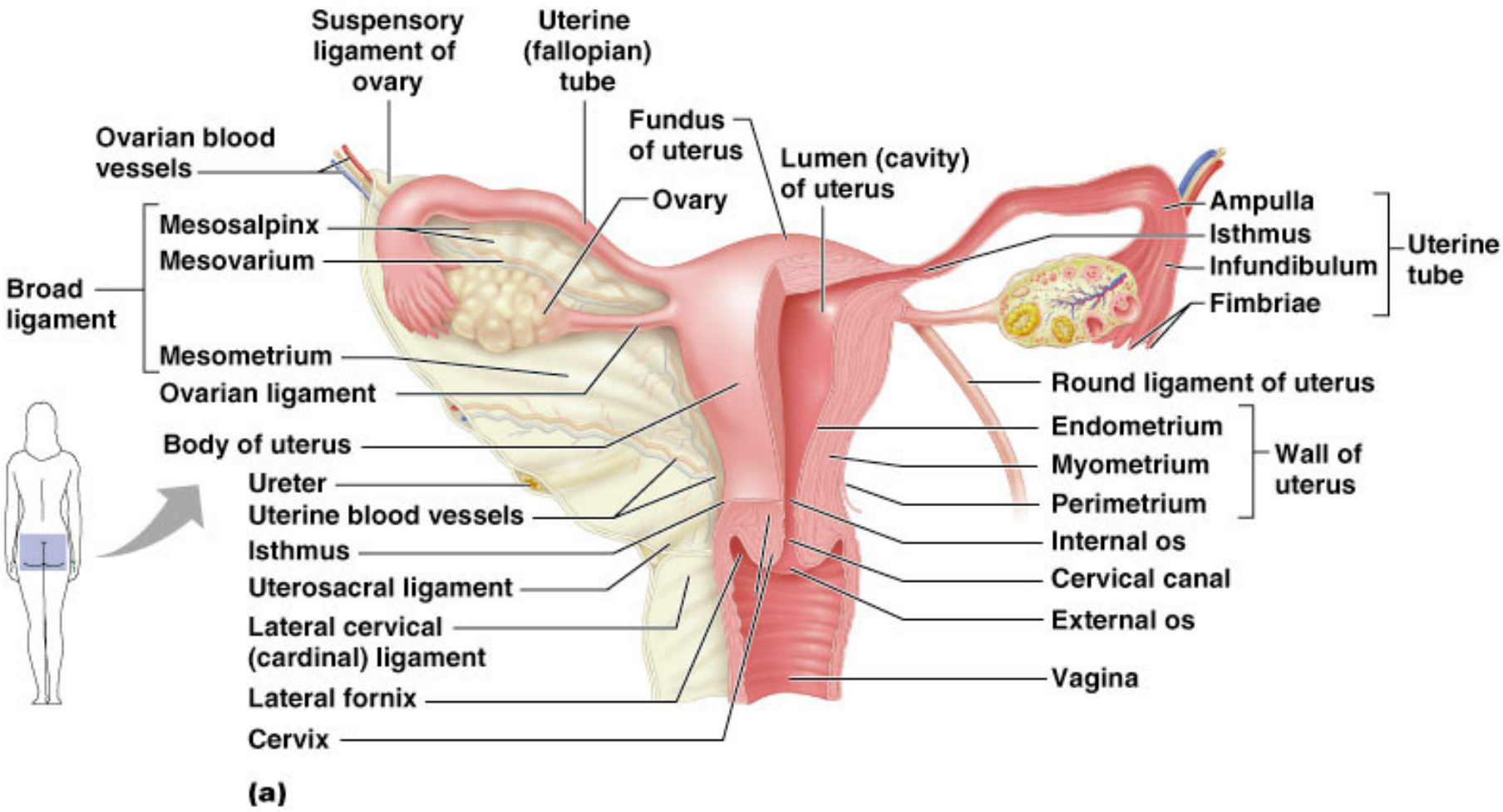
Female Reproductive Anatomy

- Ovaries are the primary female reproductive organs
  - Make female gametes (ova)
  - 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

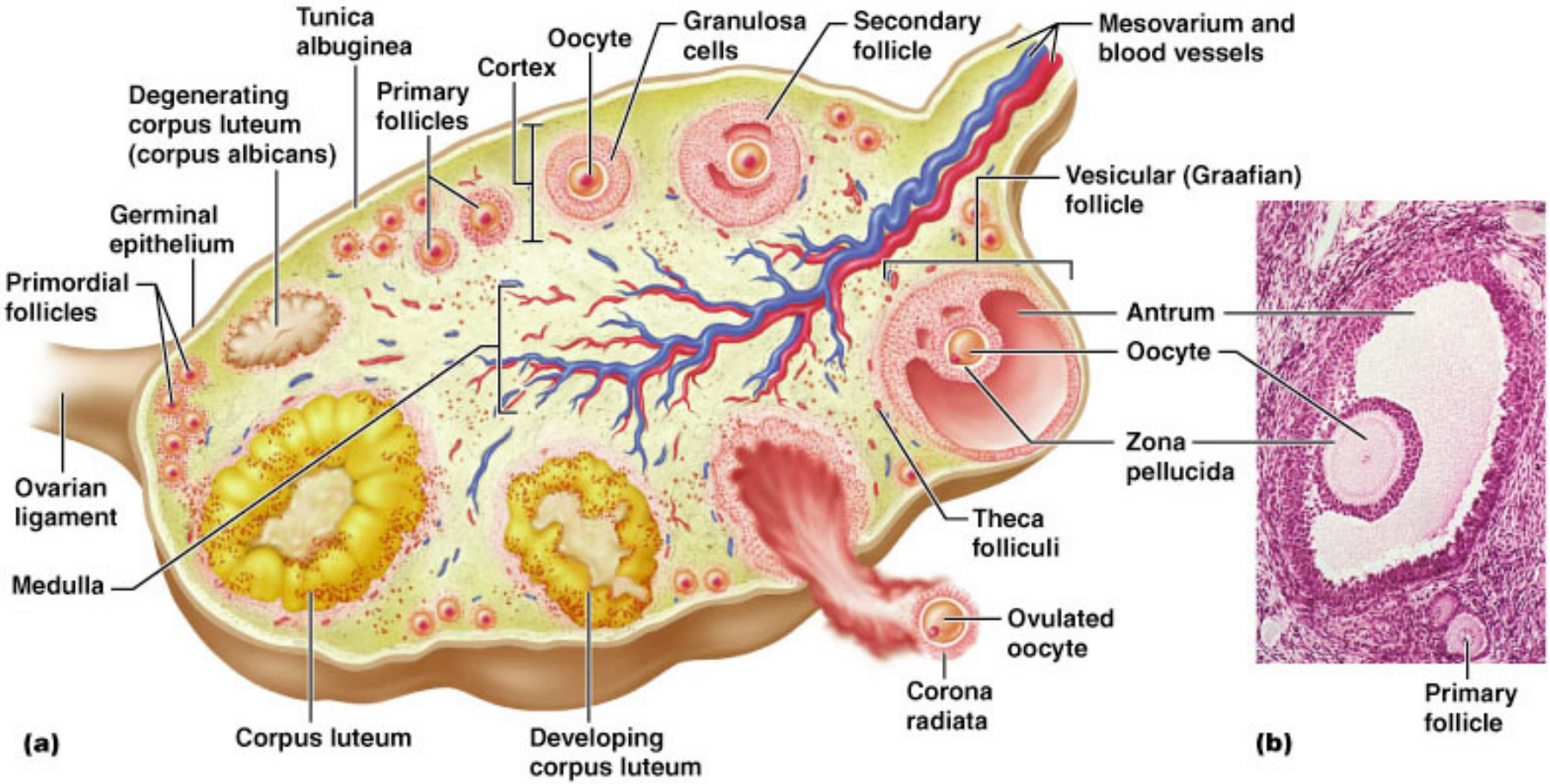
Female Reproductive Anatomy



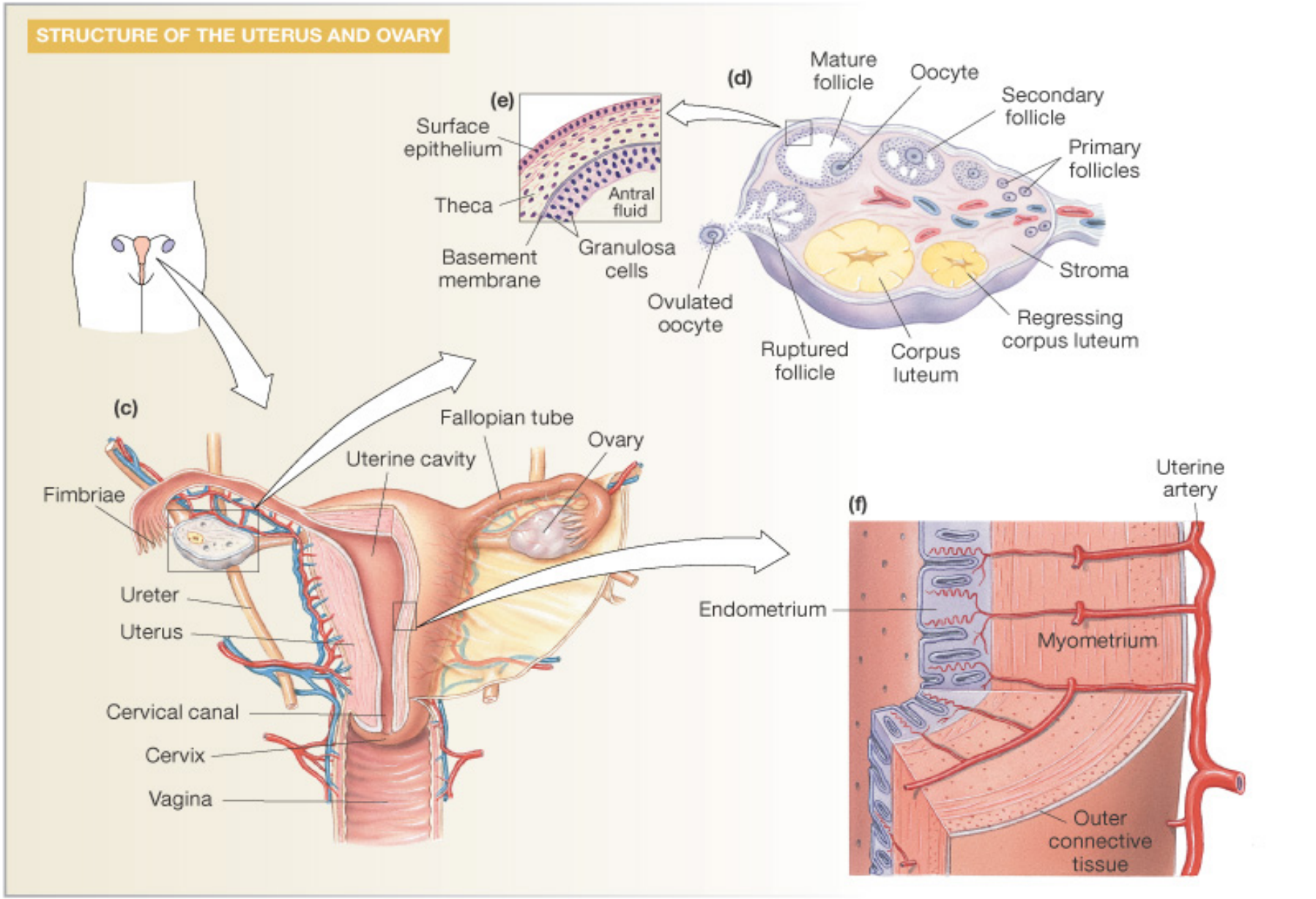
The Ovaries


Suspensory ligament of ovary
Uterine (fallopian) tube
Ovarian blood vessels
Fundus of uterus
Lumen (cavity) of uterus
Ovary
Broad ligament
Mesosalpinx
Mesovarium
Mesometrium
Ovarian ligament
Ampulla
Isthmus
Infundibulum
Fimbriae
Uterine tube
Round ligament of uterus
Endometrium
Myometrium
Perimetrium
Wall of uterus
Body of uterus
Ureter
Uterine blood vessels
Isthmus
Uterosacral ligament
Lateral cervical (cardinal) ligament
Lateral fornix
Cervix
Internal os
Cervical canal
External os
Vagina
(a)

Ovaries


Tunica albuginea
Oocyte
Granulosa cells
Secondary follicle
Mesovarium and blood vessels
Cortex
Primary follicles
Degenerating corpus luteum (corpus albicans)
Vesicular (Graafian) follicle
Germinal epithelium
Primordial follicles
Antrum
Oocyte
Zona pellucida
Ovarian ligament
Theca folliculi
Medulla
Ovulated oocyte
Corona radiata
Primary follicle
(a)
Corpus luteum
Developing corpus luteum
(b)

Ovary: histology



Ovarian Cycle

- Monthly series of events associated with the maturation of an egg
- Starts at puberty (beginning of the menstrual cycles is termed menarche
- Average duration 28 days (20-45 days)
- Phases of ovarian cycle:
  - Follicular phase – period of follicle growth (days 1–14)
  - Luteal phase – period of corpus luteum activity (days 14–28)
  - Ovulation occurs midcycle (day 14)

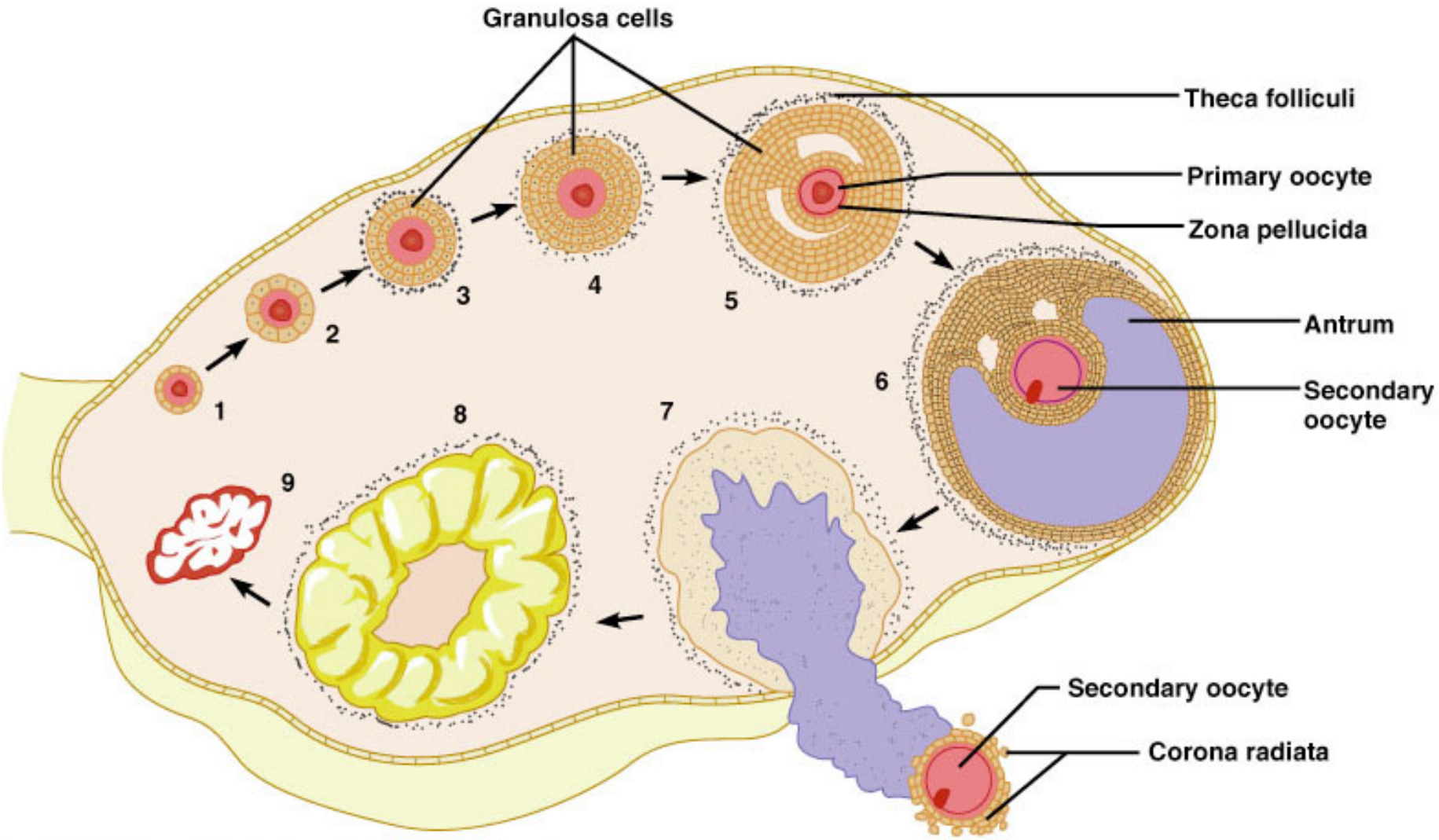
Follicular Phase

- Upon FSH stimulation, (6-12) primordial follicles becomes a primary follicle (one layer of cells)
- Primary follicle then becomes a secondary follicle
  - The theca and granulosa cells cooperate to produce estrogens
  - The antrum is formed
- Before ovulation, only one follicle grows and the rest (5-11) becomes atretic

Follicular Phase (hormonal regulation)

- GnRH rises in response to a decline in inhibin and sex steroids
- GnRH stimulates rise in pituitary FSH & LH secretion.
- FSH stimulates new follicle growth
- LH induces thecal cell growth, vascularization & androgen synthesis
- FSH stimulates granulosa cell production of E2 & LH receptor

Ovarian Cycle



Ovulation

- Rapidly rising estrogen levels stimulate LH surge (positive feedback-GnRH sensitization) about 2 days before ovulation
- LH surge triggers ovulation
- Ovulation occurs when the ovary wall ruptures and expels the secondary oocyte
- Mittelschmerz – a twinge of pain sometimes felt at ovulation

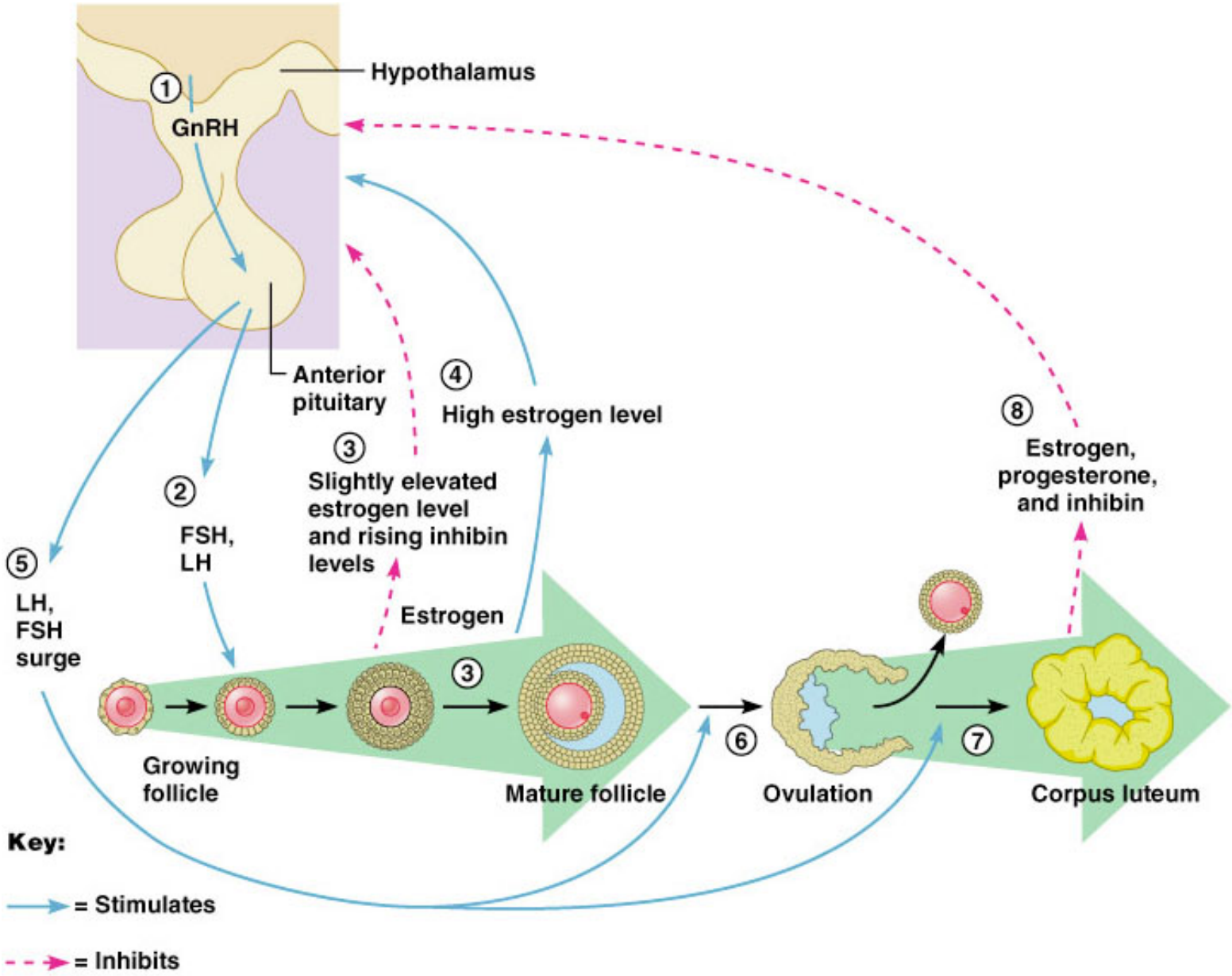
Luteal Phase

- After ovulation, the ruptured follicle collapses, granulosa cells enlarge, and along with internal thecal cells, form the corpus luteum (LH action)
- The corpus luteum secretes progesterone and estrogen
- If pregnancy does not occur, the corpus luteum degenerates in 12 days after ovulation, 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)

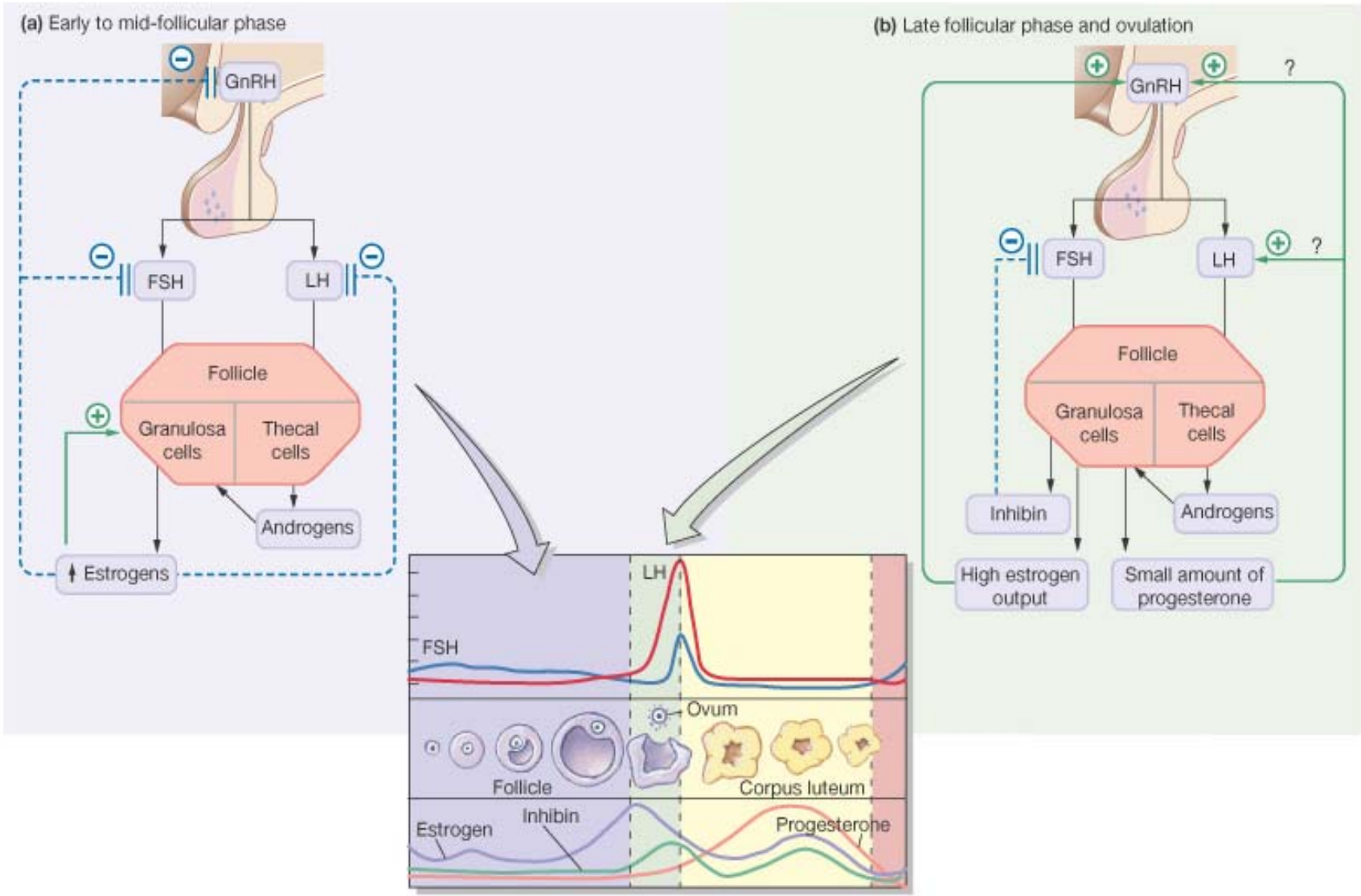
Luteal Phase (cont.)

- Estrogens and progesterones shut off FSH and LH release
- Days 26-28 – decline of the ovarian hormones
  - Ends the blockade of FSH and LH
  - The cycle starts anew

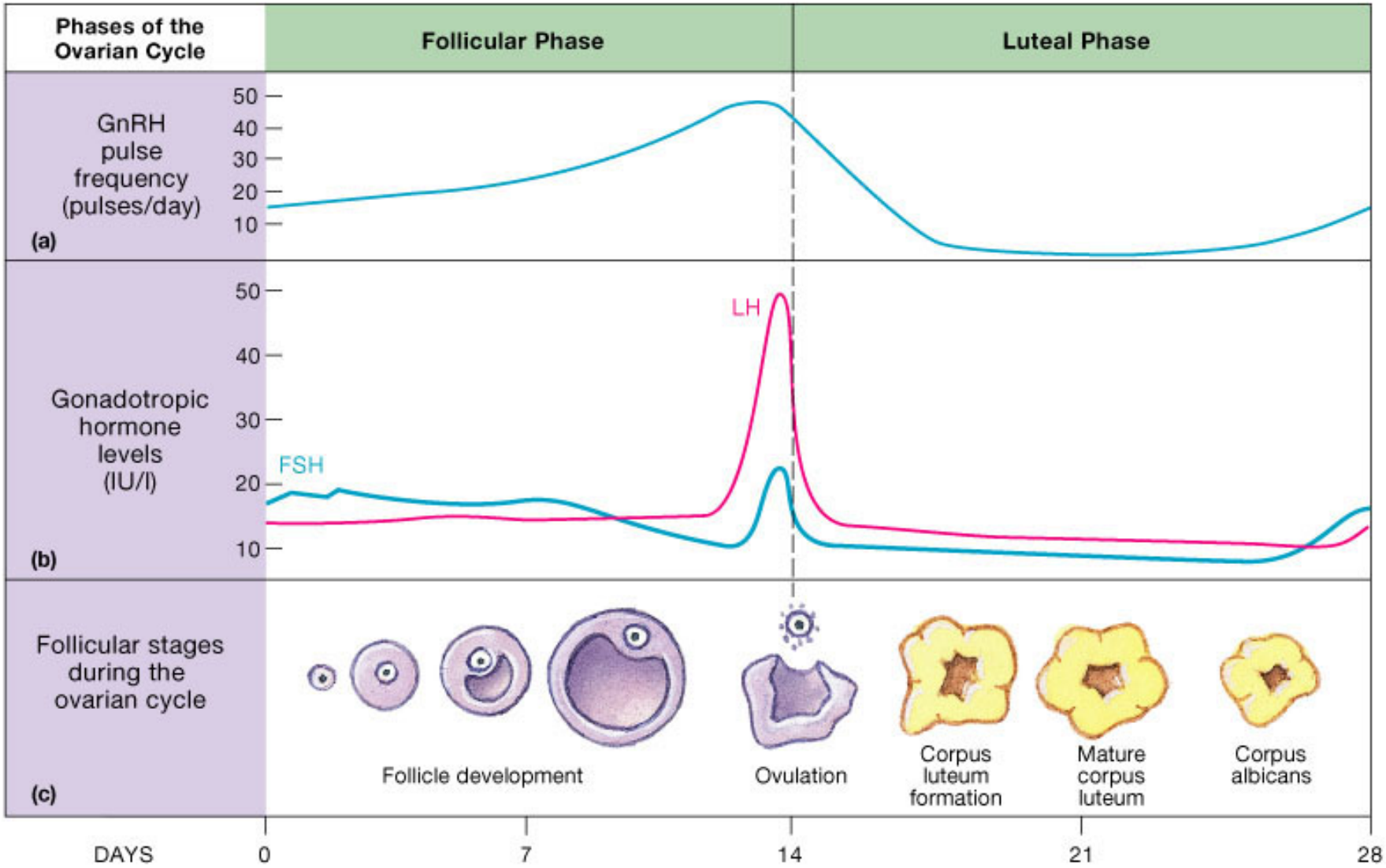
Feedback Mechanisms in Ovarian Function



Hormonal Interactions During the Ovarian Cycle



The Hormonal Regulation of the Female Reproductive Cycle



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 (preovulatory) phase – endometrium rebuilds itself
- Days 15-28: Secretory (postovulatory) phase – endometrium prepares for implantation of the embryo

Menses

- If fertilization does not occur, progesterone levels fall, depriving the endometrium of hormonal support
- Spiral arteries kink and go into spasms and endometrial cells begin to die (prostaglandin effect)
- The functional layer begins to digest itself
- Spiral arteries constrict one final time then suddenly relax and open wide
- The rush of blood fragments weakened capillary beds and the functional layer sloughs
- Fibrinolysin is produced to prevent clotting

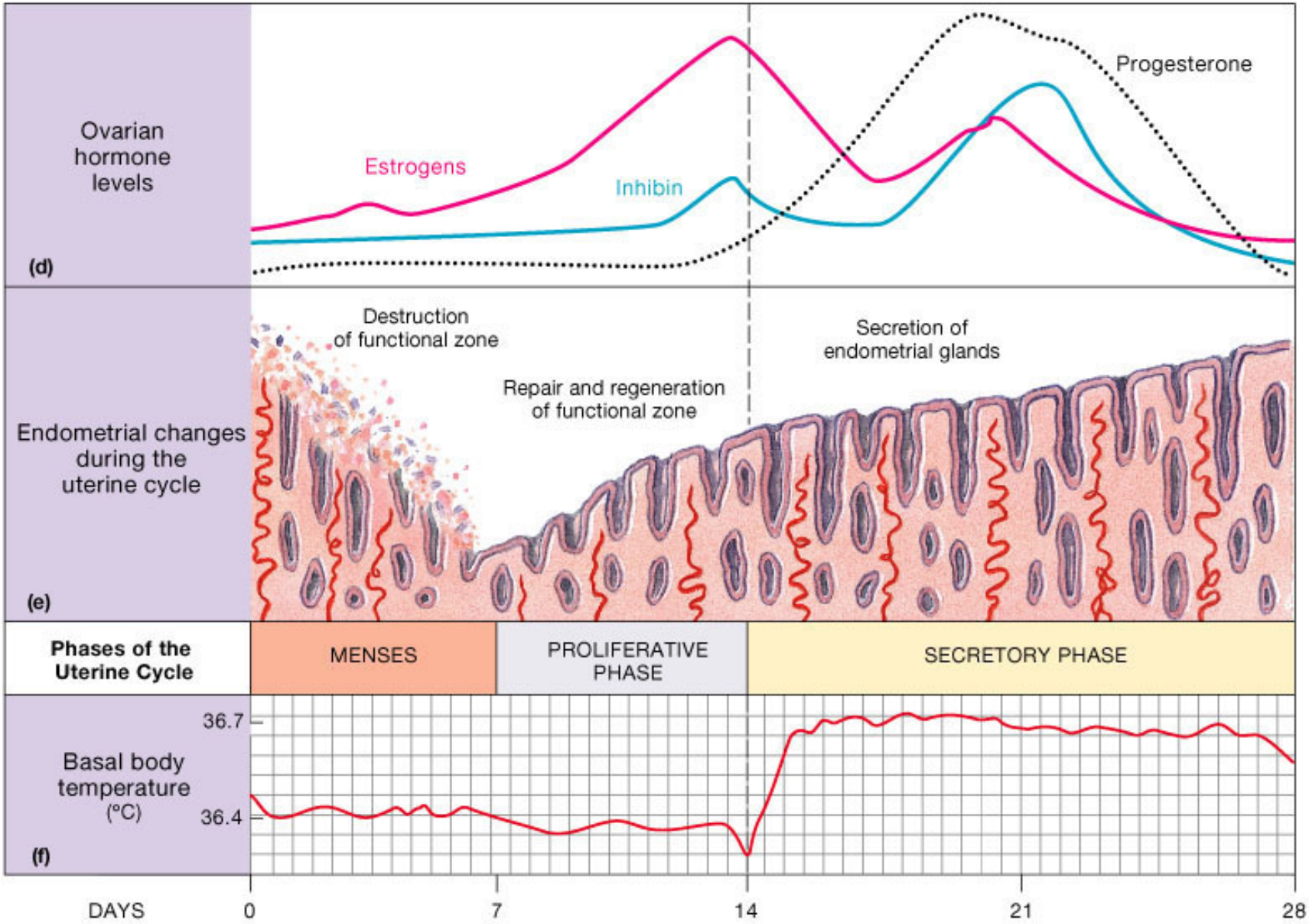
Proliferative Phase (estrogen phase)

- preovulation
- Rising levels of estrogens cause re-epithelialization of the endometrium, vascularization, and growth of endometrial glands
- At the time of ovulation, the endometrium is 3-5 mm thick

Secretory Phase (progesterone phase)

- After ovulation
- Estrogen and progesterone levels are high
- More growth, progesterone causes swelling and secretory development of the endometrium
- One week after ovulation, the endometrium is 5-6 mm thick
- Provide appropriate conditions for fertilized ovum

Overview of the Menstrual Cycle



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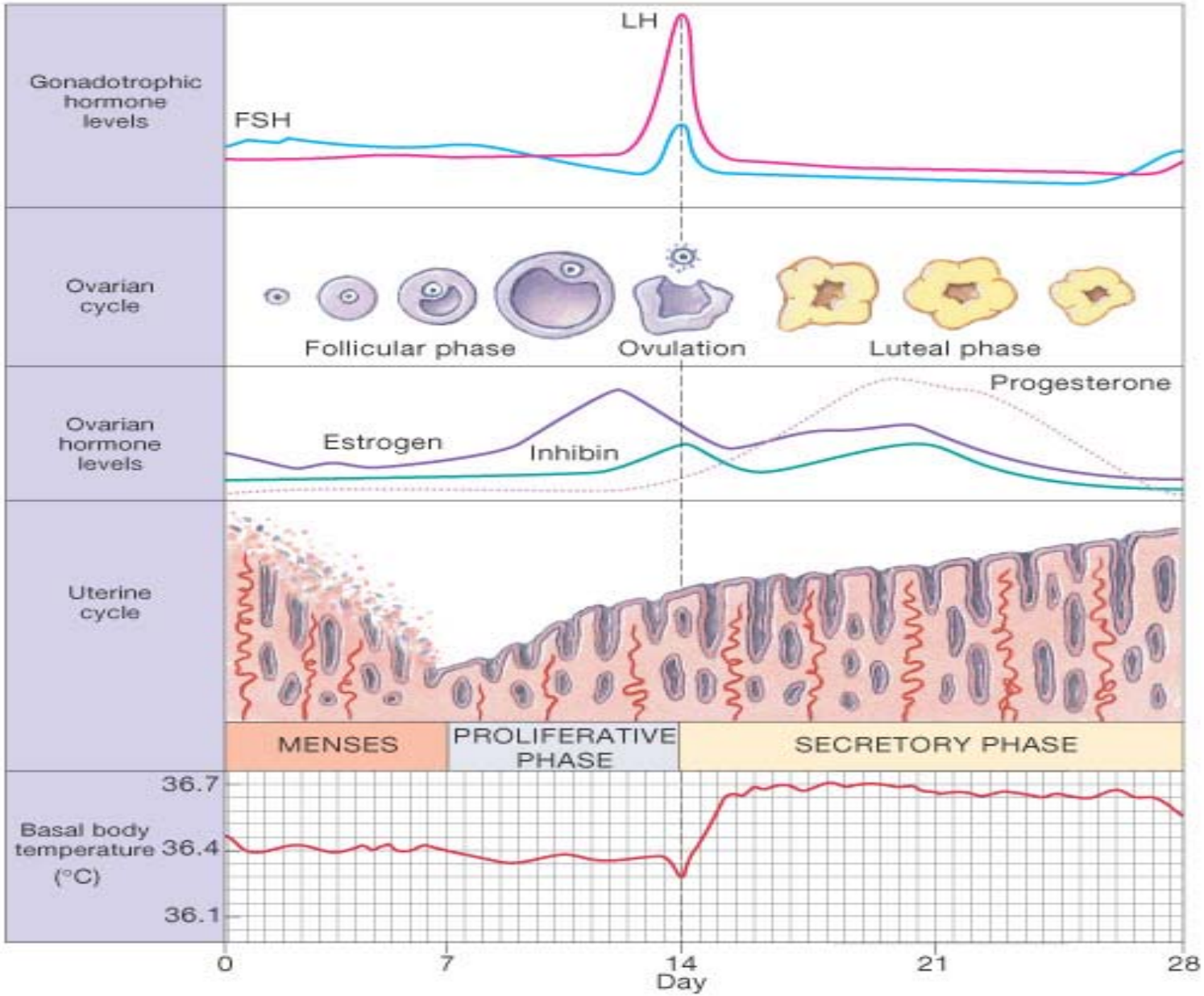

Effects of Estrogens

- Estrogen levels rise during puberty
- Change of vaginal epithelium from cuboidal to stratified
- 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
  - In breast, estrogen causes development of stromal cells, ductile system, and fat deposition

Effects of Estrogens (cont.)

- Estrogens cause increased osteoblastic activity as well as closure of epiphyseal plates
- The skin is thicker, smoother, and more vascular

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

Effects of Progesterone

- Promote secretory changes in the uterus
- Increased secreion of fallopian tubes
- Promote development of ducts and alveoli of the breast

Female Sexual Response

- Like in male, depends on psychic and local stimulation
- The clitoris, vaginal mucosa, and breasts engorge with blood
- Activity of vestibular glands lubricates 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

Menopause

- At age 40-50 years
- Ovulation and menses cease entirely
- Without sufficient estrogen, reproductive organs and breasts atrophy
  - Irritability and depression result
  - Skin blood vessels undergo intense vasodilation (hot flushes occur)
  - Gradual thinning of the skin and bone loss
- Males have no equivalent to menopause