Female Reproductive System

- more complex than the males because it serves more purposes
  - produce and deliver gametes, provide nutrition and safe harbor for fetal development, gives birth, and nourish the infant
  - more cyclic, and female hormones secreted in a more complex sequence than the relatively steady secretion in the male

The Ovaries

- **ovaries** – female gonads which produce **egg cells (ova)** and **sex hormones**
  - almond-shaped and nestled in the **ovarian fossa**
    - depression in the posterior pelvic wall
  - **outer cortex** where germ cells develop
  - **inner medulla** occupied by major arteries and veins
  - **lacks ducts**, instead each egg develops in its own fluid-filled **follicle**
  - **ovulation** – bursting of the follicle and releasing the egg

Anatomy of Ovary

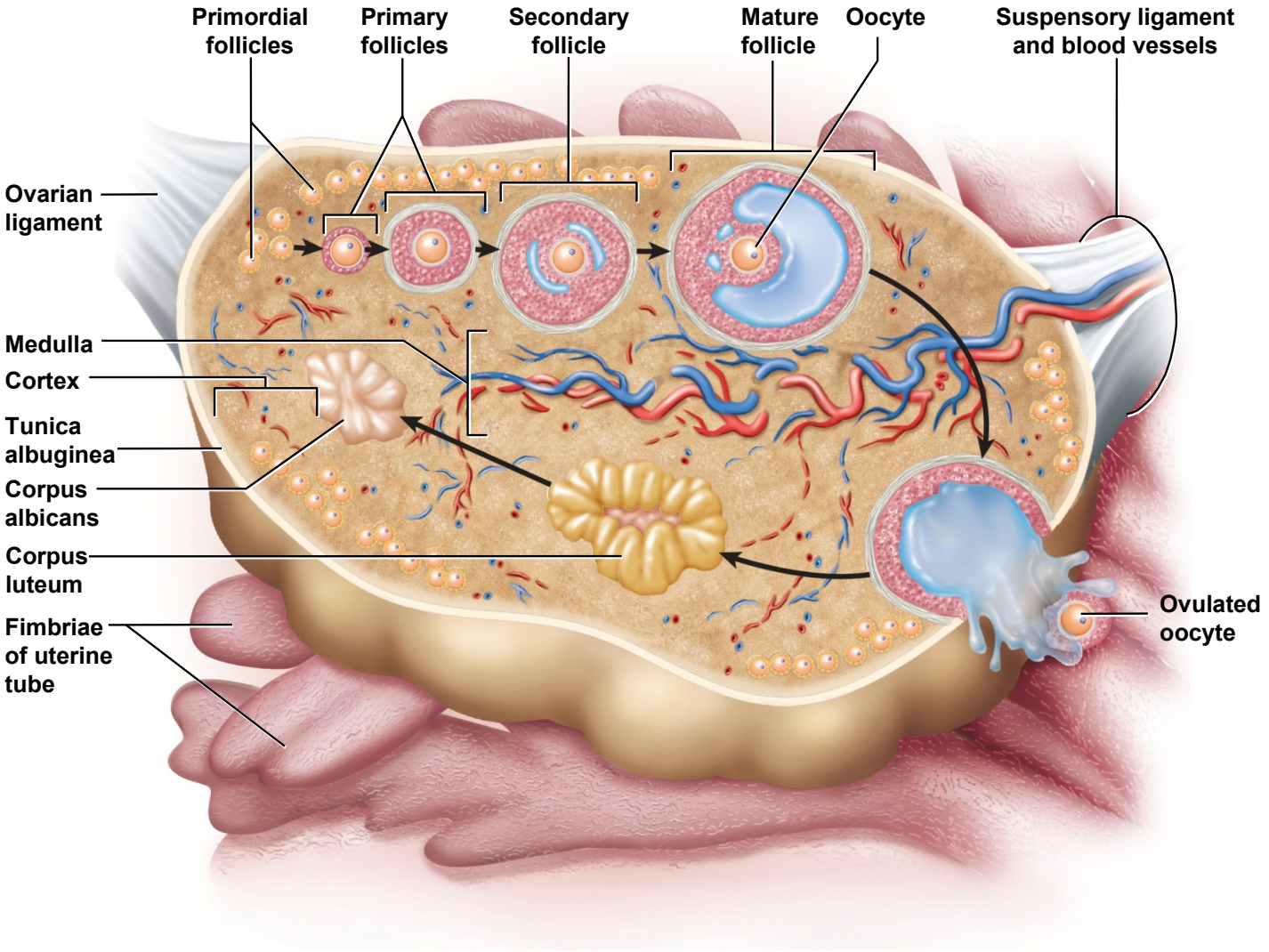


Figure 28.2

The Uterine Tubes

- **uterine tube** (oviduct) or (fallopian tube)
- canal about 10 cm long from ovary to uterus
- muscular tube lined with **ciliated cells**
  - highly folded into longitudinal ridges

The Uterus

- **uterus** – thick muscular chamber that opens into the roof of the vagina
  - usually tilts forward over the urinary bladder
  - harbors fetus, provides a source of nutrition, and expels the fetus at the end of its development

Uterus

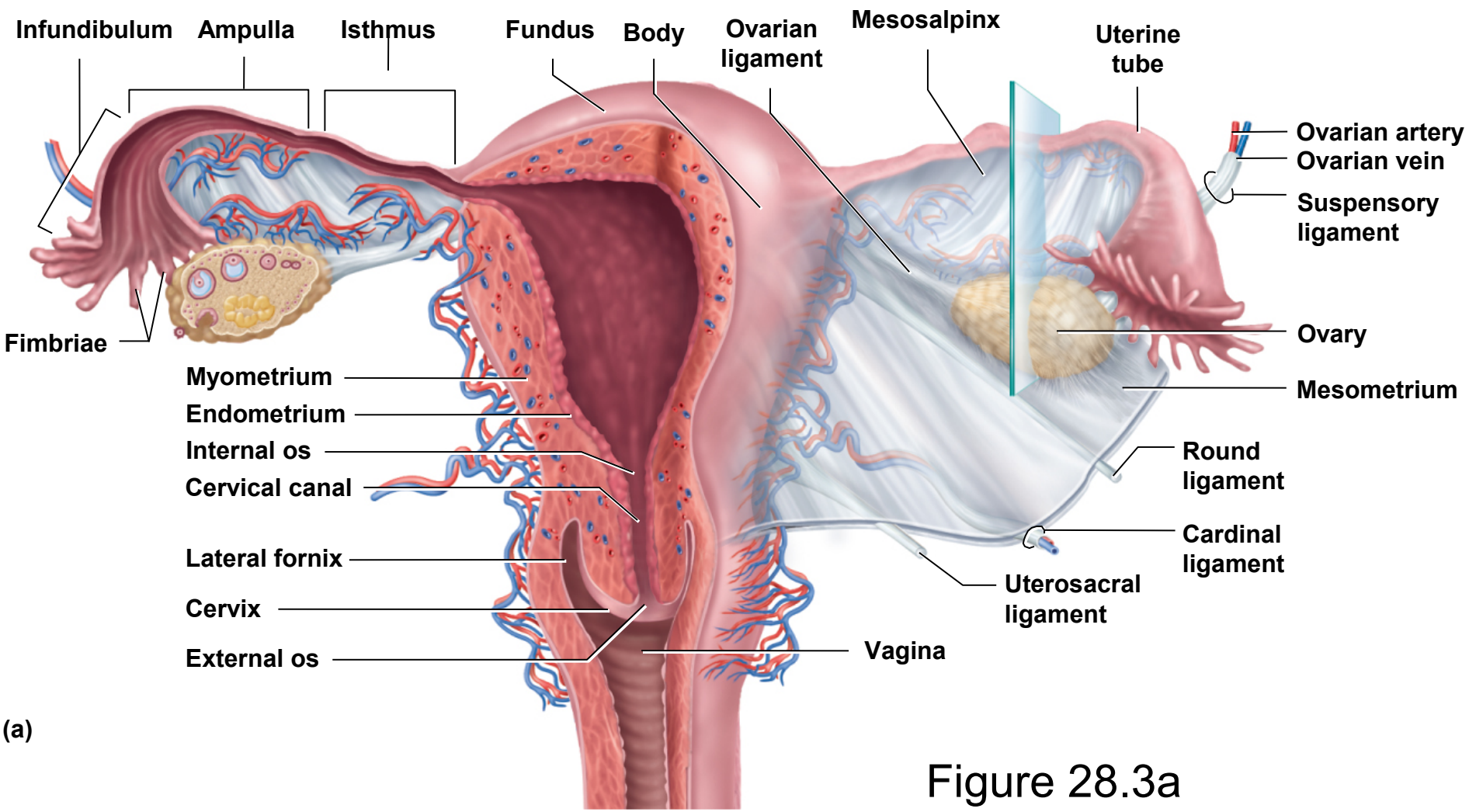


Figure 28.3a

Uterine Wall

- **perimetrium** - external serosa layer
- **myometrium** - middle muscular layer
  - **Smooth muscle**
  - **Contraction triggered by oxytocin**
    - produces labor contractions, expels fetus
- **endometrium** – inner mucosa
  - during pregnancy, the endometrium is the **site of attachment** of the embryo and forms the **maternal part of the placenta** from which the fetus is nourished

Histology of Endometrium

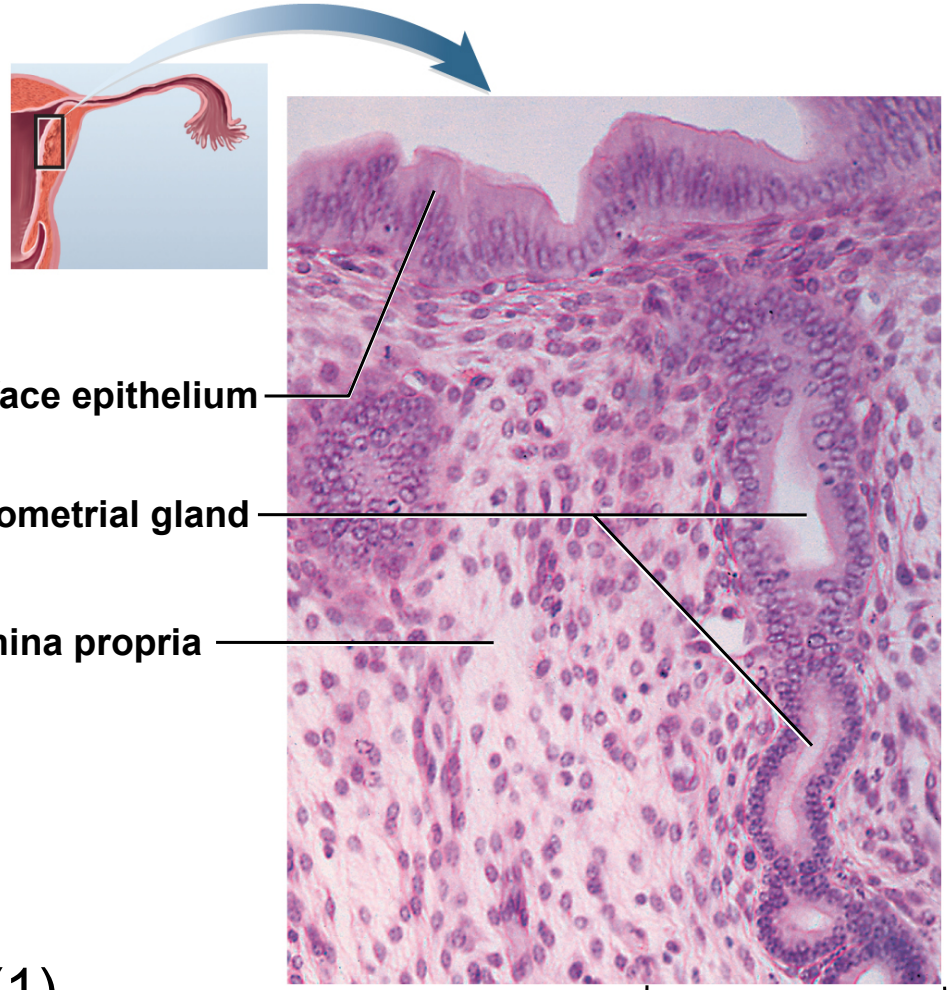


Figure 28.6 (1)

Puberty

- triggered by rising levels of GnRH
  - stimulates anterior lobe of pituitary to produce
    - follicle-stimulating hormone (FSH)
    - luteinizing hormone (LH)
- **FSH** stimulates developing ovarian follicles and they begin to secrete estrogen, progesterone, inhibin, and a small amount of androgen
- **estrogens** are feminizing hormones with widespread effects on the body
  - estradiol (most abundant), estriol, and estrone

Oogensis and Sexual Cycle

- **reproductive cycle** – sequence of events from fertilization to giving birth

- **sexual cycle** - events that recur every month when pregnancy does not intervene
  - consists of two interrelated cycles controlled by shifting patterns of hormone secretion
    - **ovarian cycle** - events in ovaries
    - **menstrual cycle** - parallel changes in uterus

Oogenesis

- **oogenesis** – egg production
  - produces **haploid gametes** by means of **meiosis**
  - distinctly cyclic event that normally releases **one egg each month**
  - accompanied by cyclic changes in hormone secretion
  - cyclic changes in histological structure of the ovaries and uterus
    - uterine changes result in monthly menstrual flow

Oogenesis

- egg development resumes in adolescence
  - **FSH** stimulates monthly cohorts of oocytes to complete meiosis I
  - each oocyte divides into two haploid daughter cells of unequal size and different destinies
  - important to produce an egg with as much cytoplasm as possible
  - if fertilized, it must divide repeatedly and produce numerous daughter cells
  - **secondary oocyte** – large daughter cell that is the product of meiosis I
  - **first polar body** – smaller one that sometimes undergoes meiosis II, but ultimately disintegrates
    - merely a means of discarding the extra set of haploid chromosomes
  - **secondary oocyte** proceeds as far as metaphase II
    - **arrests until after ovulation**
    - if not fertilized, it dies and never finishes meiosis
    - if fertilized, it completes meiosis II and casts off a **second polar body**
  - chromosomes of the large remaining egg unite with those of the sperm

Oogenesis and Follicle Development

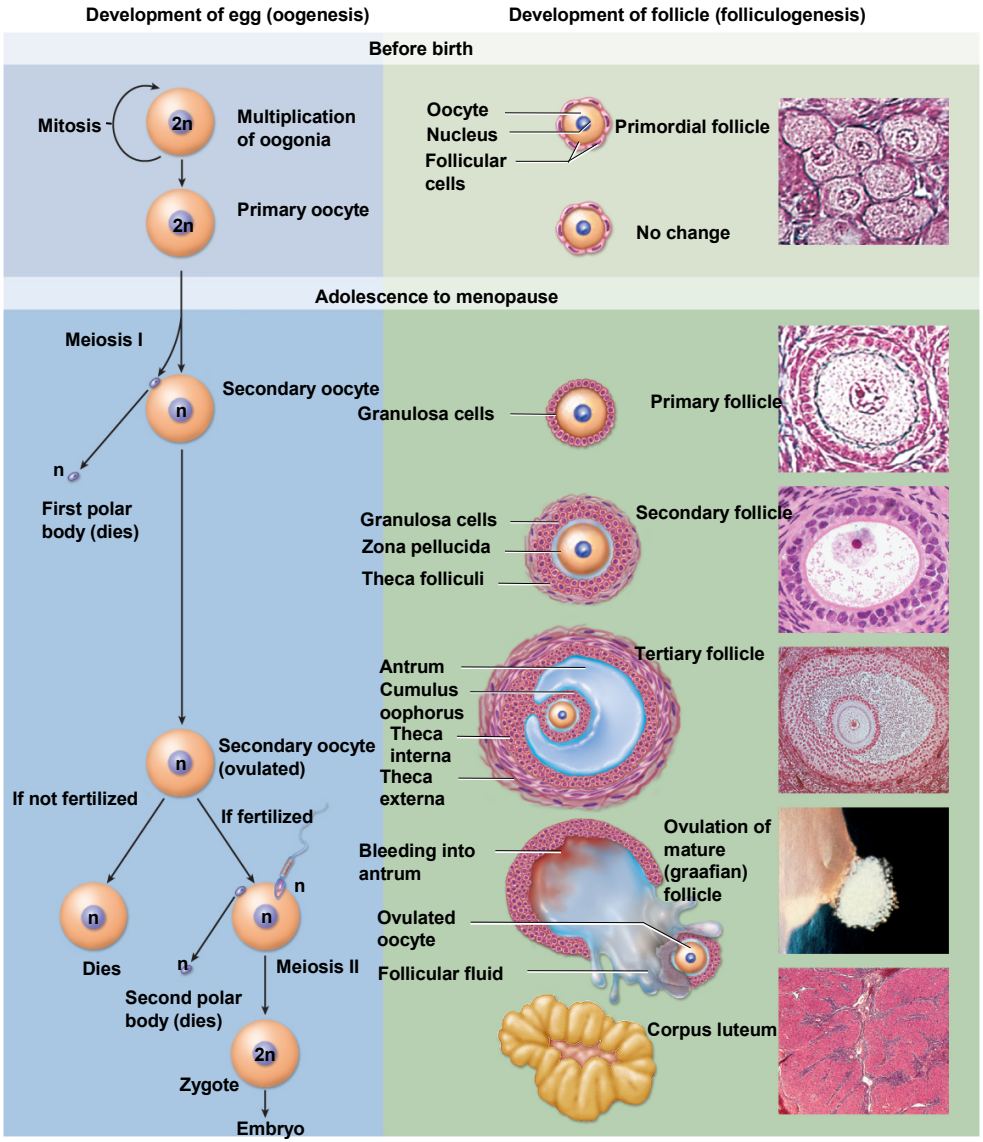


Figure 28.11

Folliculogenesis

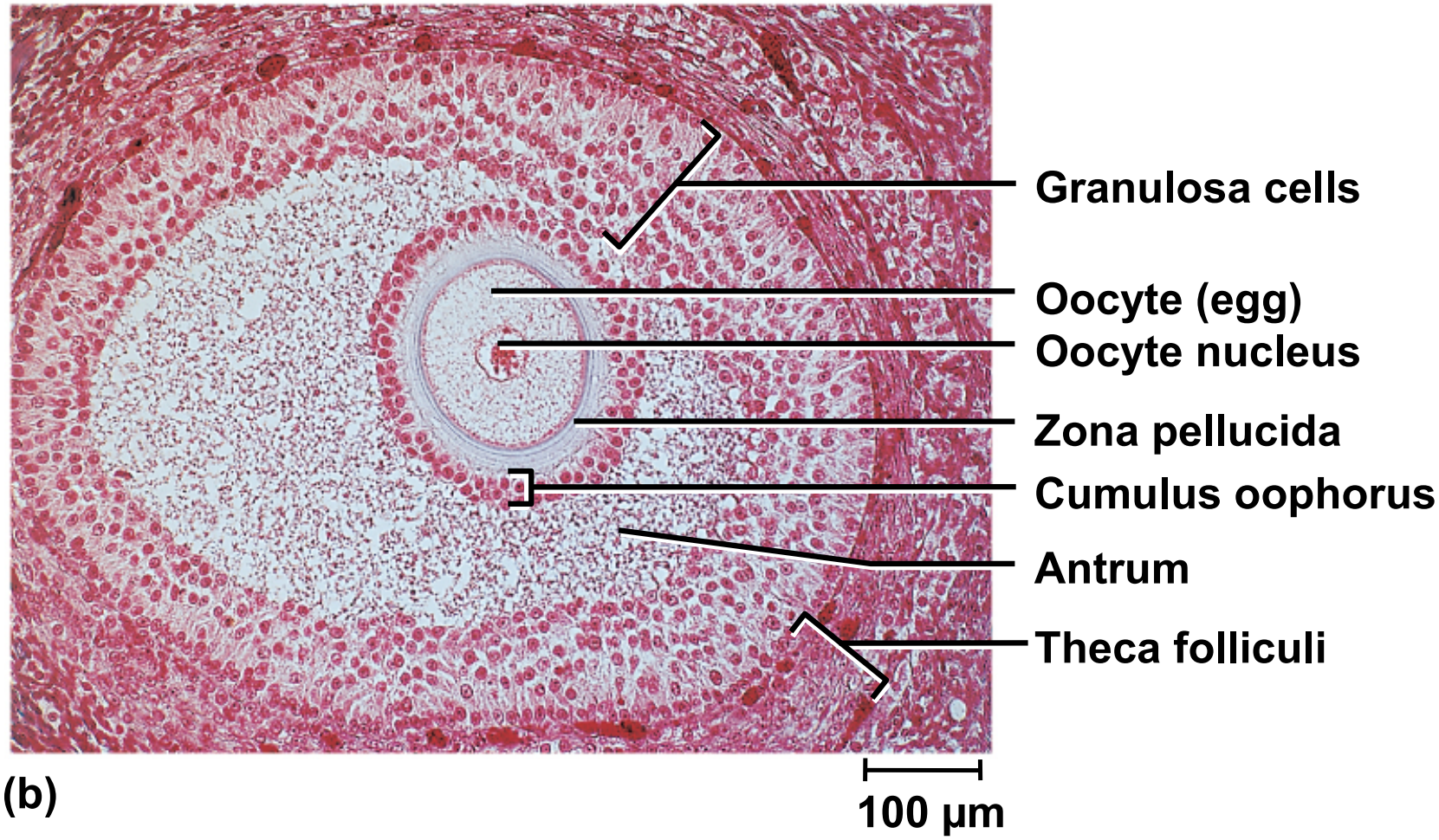
The development of the follicles around the egg than undergoes oogenesis

mature (graafian) follicles

normally only one follicle from each month's cohort becomes a mature follicle destined to ovulate

remainder degenerate

Histology of Ovarian Follicles



Manfred Kage/Peter Arnold, Inc

Figure 28.12b

The Sexual Cycle

- sexual cycle **averages 28 days**
- hormones of the **hypothalamus** regulate the pituitary gland
- **pituitary** hormones regulate the **ovaries**
- **ovaries** secrete hormones that regulate the **uterus**
- **basic hierarchy of hormonal control**
  - hypothalamus→ pituitary → ovaries → uterus
- ovaries exert feedback control over hypothalamus and pituitary
- cycle begins with 2 week **follicular phase**
  - **menstruation** occurs during first 3 to 5 days of cycle
  - uterus replaces lost tissue by mitosis and cohort of follicles grow
  - **ovulation** around day 14 –remainder the of follicle becomes **corpus luteum**
- next 2 weeks the **luteal phase**
  - **corpus luteum** stimulates endometrial secretion and thickening
  - if pregnancy does not occur, endometrium breaks down in the last 2 days
  - menstruation begins and the cycle starts over

The Ovarian Cycle

- **ovarian cycle** – in three principal steps
  - follicular phase, ovulation, and luteal phase

- this cycle reflects what happens in the ovaries and their relationship to the hypothalamus and pituitary

- much remains unknown about the timing of folliculogenesis

Follicular Phase

- **follicular phase** extends from the beginning of menstruation until ovulation
  - day 1 to day 14 of an average cycle
  - preparation for the follicular phase begins almost two month earlier
    - shortly after ovulation a new cohort of preantral follicles descend form the cortex deeper into the ovary
    - begins to grow and each develops an antrum
    - **selection window** of 5 days in which one of them is selected as the **dominant follicle** to mature and ultimately ovulate in the next cycle
    - FSH stimulates continued growth of the cohort, but the dominant follicle above all
    - FSH stimulates the granulosa cells of the antral follicles to secrete estradiol
    - dominant follicle becomes more sensitive to FSH and LH
    - grows and becomes mature (graafian) follicle while others degenerate

Ovulation

- **ovulation** – the rupture of the mature follicle and the release of its egg and attendant cells
  - typically **around day 14**
- estradiol stimulates a **surge of LH** and a lesser spike of FSH by anterior pituitary
  - LH causes final growth and rupture of follicle

Ovarian Cycle - Ovulation

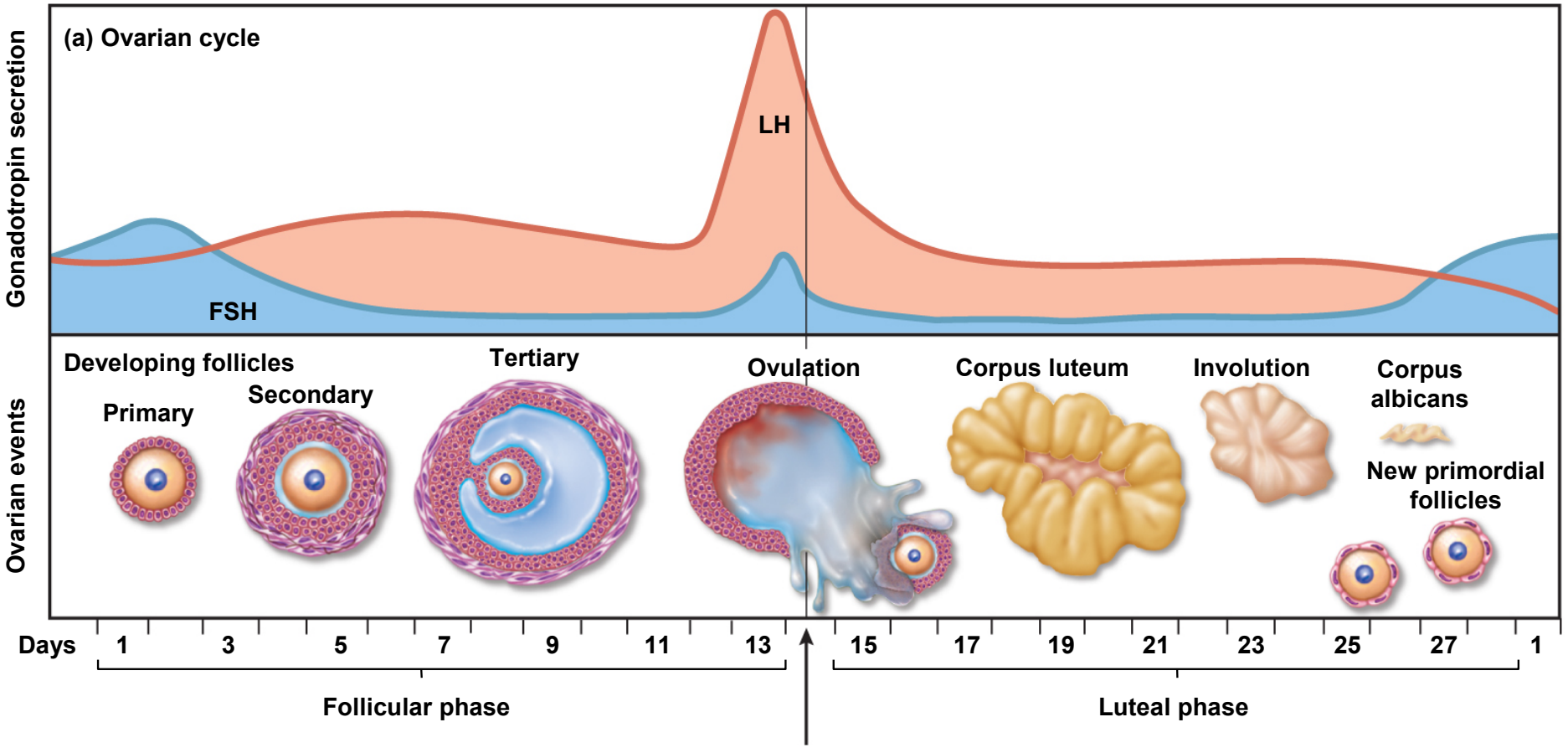


Figure 28.14a

Endoscopic View of Ovulation

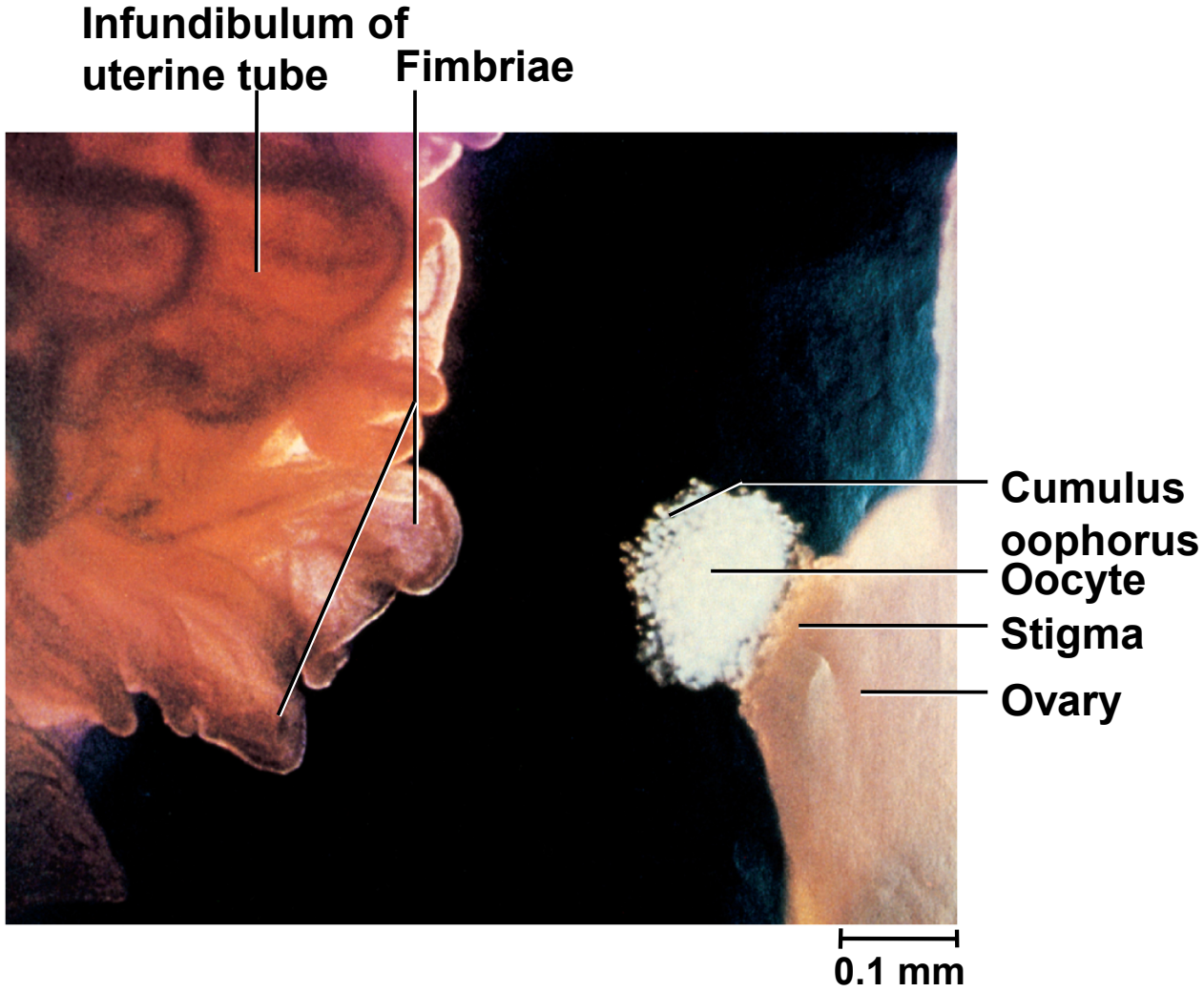


Figure 28.15

Pituitary-Ovarian Axis

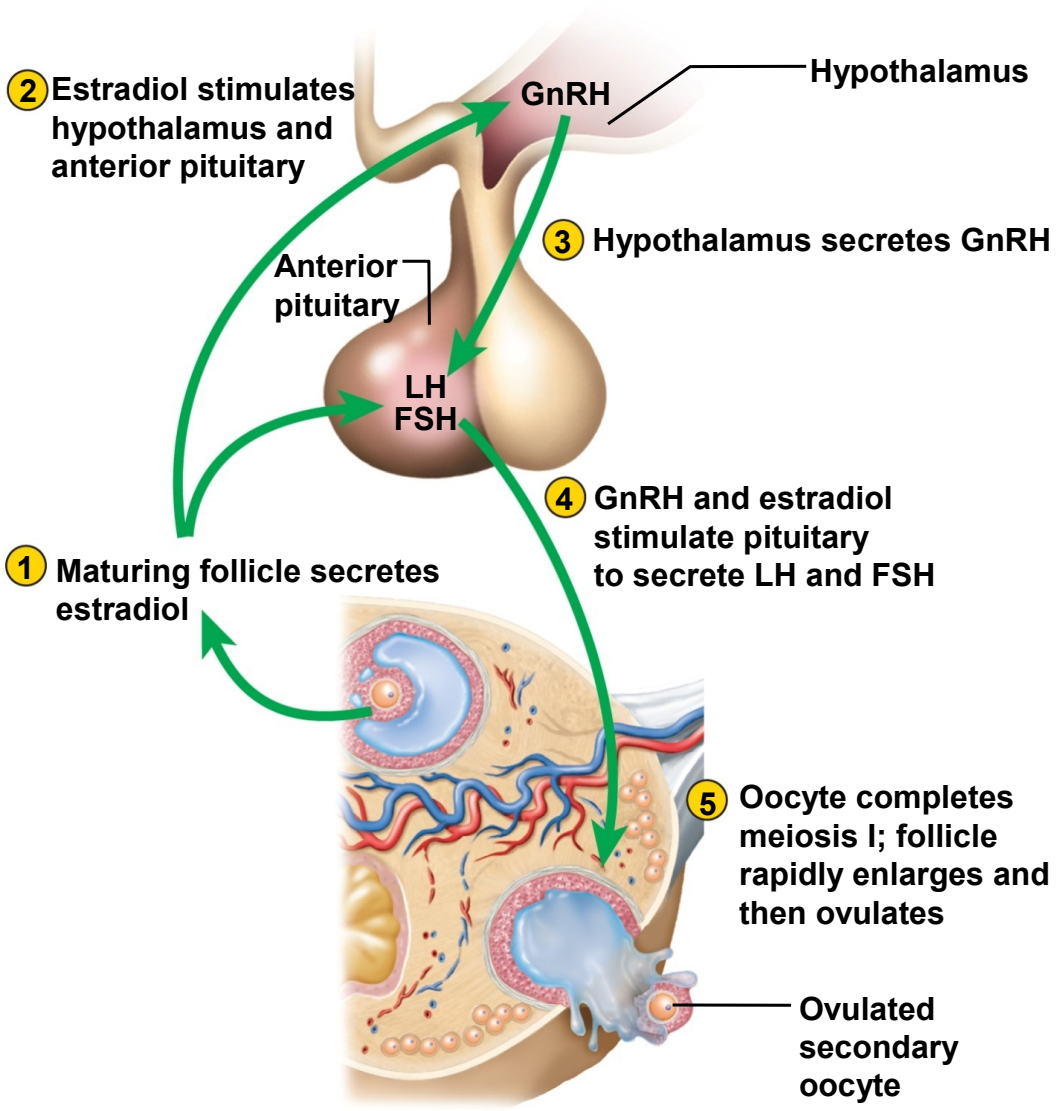


Figure 28.13

Luteal (Postovulatory) Phase

- **luteal (postovulatory) phase** - days 15 to day 28, from just after **ovulation to the onset of menstruation**
- if pregnancy does not occur, events happen as follows:
  - granulosa and theca interna cells multiply and fill antrum
  - dense bed of capillaries grows
  - ovulated follicle has now become the **corpus luteum**

Luteal (Postovulatory) Phase

- **transformation from ruptured follicle to corpus luteum is regulated by LH**
  - **LH** stimulates the **corpus luteum** to continue to grow and secrete rising levels of **estradiol** and **progesterone**
  - **10 fold increase** in progesterone is the most important aspect of the luteal phase
- progesterone has a crucial role in **preparing the uterus** for the possibility of pregnancy
- LH and FSH secretion declines over the rest of the cycle
- high levels of estradiol and progesterone, along with inhibin from the corpus luteum has a negative feedback effect on the pituitary
- if pregnancy does not occur, the corpus luteum begins the process of **involution** (shrinkage)
  - beginning about day 22 (8 days after ovulation)
  - by day 26 involution is complete and becomes inactive bit of scar tissue, the **corpus albicans**
  - with diminishing ovarian steroid secretion, FSH levels rise ripening a new cohort of follicles
- ovaries usually alternate from month to month

Menstrual Cycle

- **menstrual cycle** - consists of a buildup of the endometrium during most of the sexual cycle, followed by its breakdown and vaginal discharge
  - divided into four phases: **proliferative phase**, **secretory phase**, **premenstrual phase**, and **menstrual phase**
  - first day of noticeable vaginal discharge is defined as day 1 of the sexual cycle
    - averages 5 days long
- **proliferative phase** – layer of endometrial tissue (stratum functionalis) lost in the last menstruation is rebuilt
  - at day 5 of menstruation, the endometrium is about 0.5 mm thick
  - consists only of **stratum basalis**
  - as **new cohort of follicles** develop, they secrete more and more **estrogen**
  - estrogen stimulates mitosis in the stratum basalis and the prolific regrowth of blood vessels regenerating the **functionalis**
  - by day 14 is 2 to 3 mm thick
  - estrogen also stimulates endometrial cells to produce **progesterone receptors**

Menstrual Cycle - Proliferative Phase

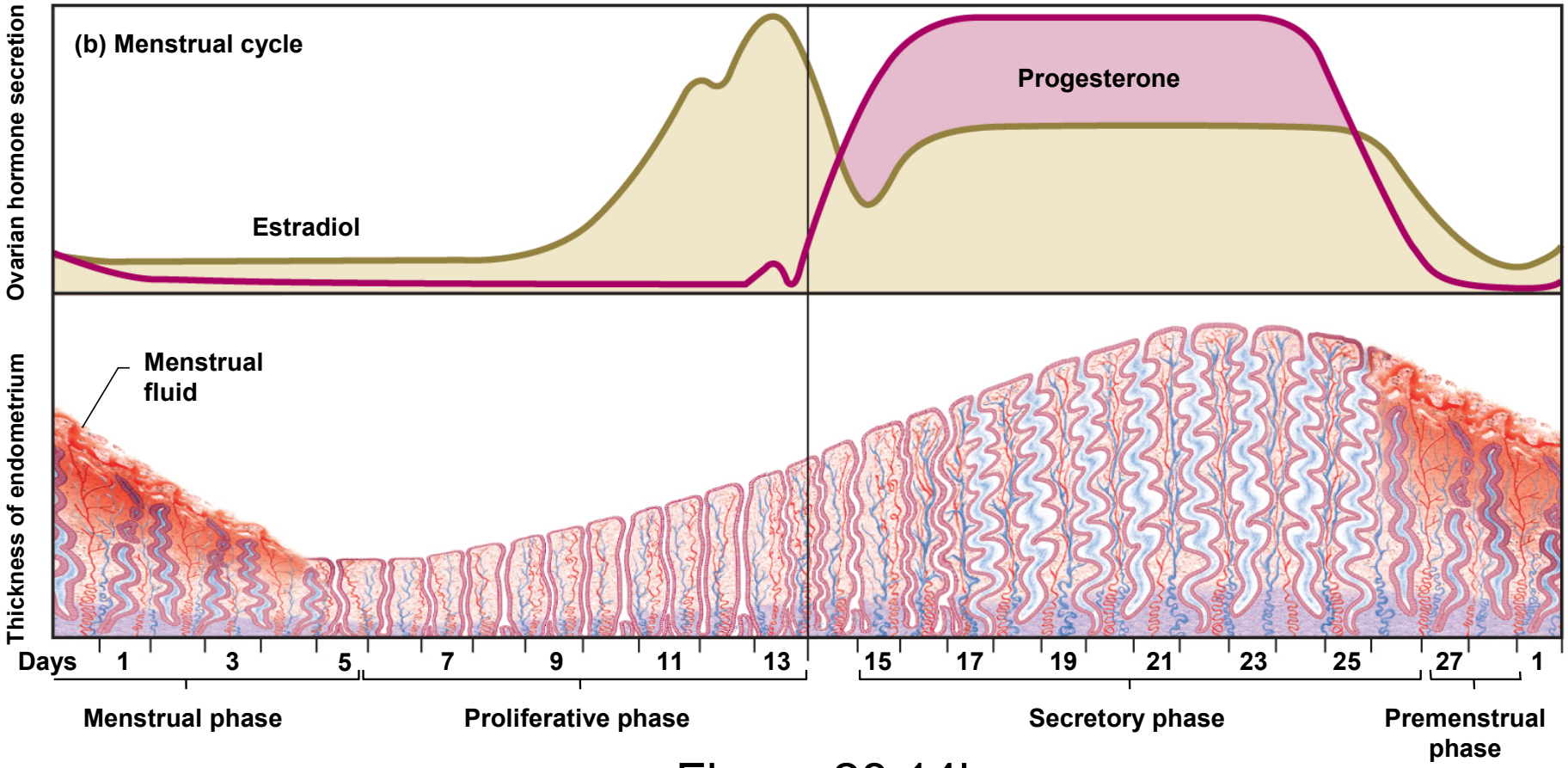


Figure 28.14b

- day 6-14 rebuild endometrial tissue
  - result of estrogen from developing follicles

Menstrual Cycle

- **secretory phase** – endometrium thickens still more in response to **progesterone from corpus luteum**
  - day 15 to day 26
  - secretion and fluid accumulation rather than mitosis
  - progesterone stimulates endometrial glands to secrete glycogen
  - glands grow wider, longer and more coiled
  - endometrium 5 to 6 mm thick
  - a soft, wet, nutritious bed available for embryonic development
- **premenstrual phase** – period of endometrial degeneration
  - last 2 days of the cycle
  - corpus luteum atrophies and progesterone levels fall sharply
  - triggers spasmodic contractions of spiral arteries
  - causes **endometrial ischemia** (interrupted blood flow)
  - brings about **tissue necrosis** and menstrual cramps
  - pools of blood accumulate in stratum functionalis
  - necrotic endometrium mixes with blood and serous fluid – **menstrual fluid**

Menstrual Cycle - Secretory Phase

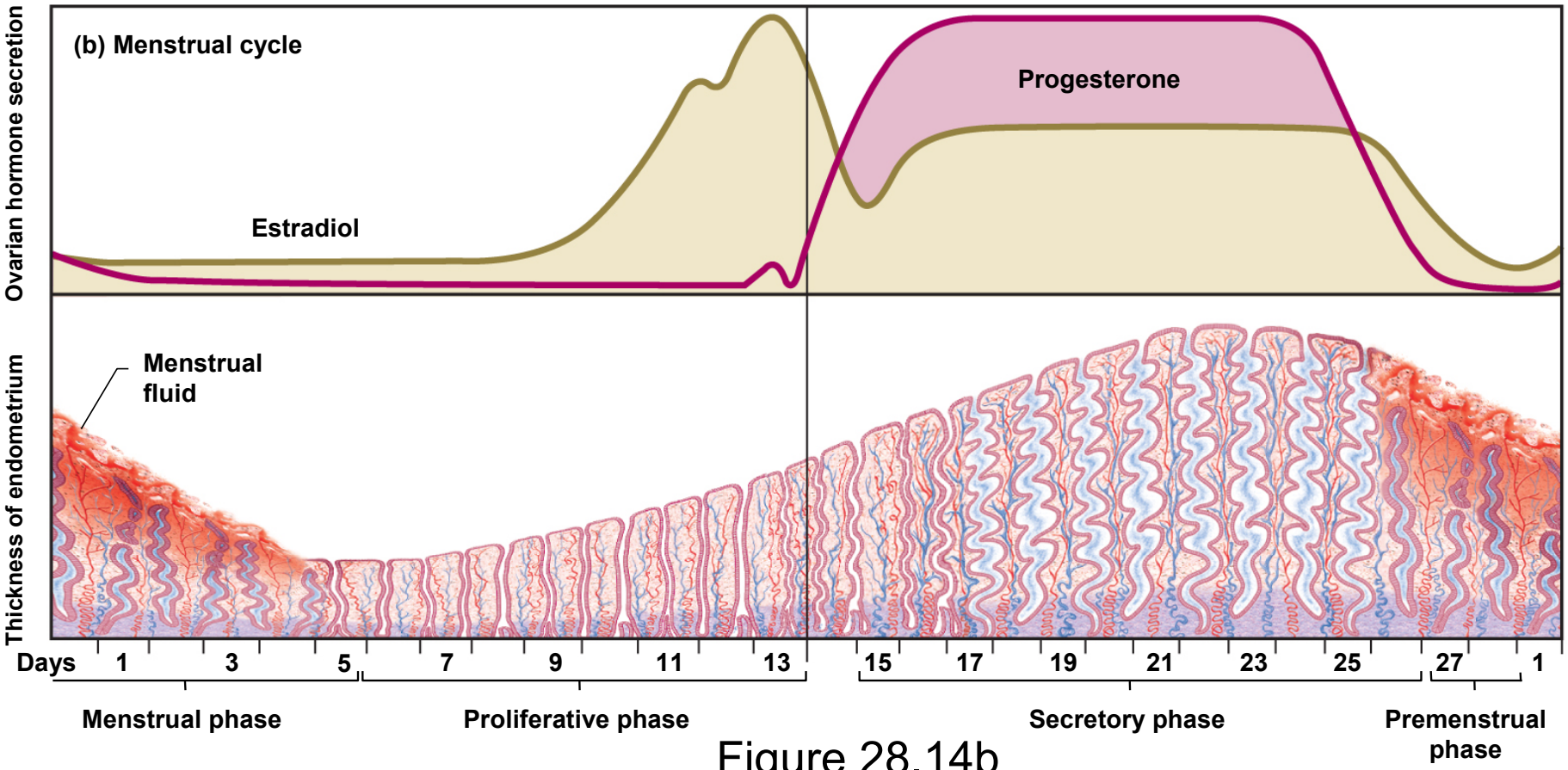


Figure 28.14b

- further thickening of endometrium due to secretion and fluid accumulation - not mitosis
- due to progesterone stimulation of glands

Menstrual Cycle Premenstrual Phase

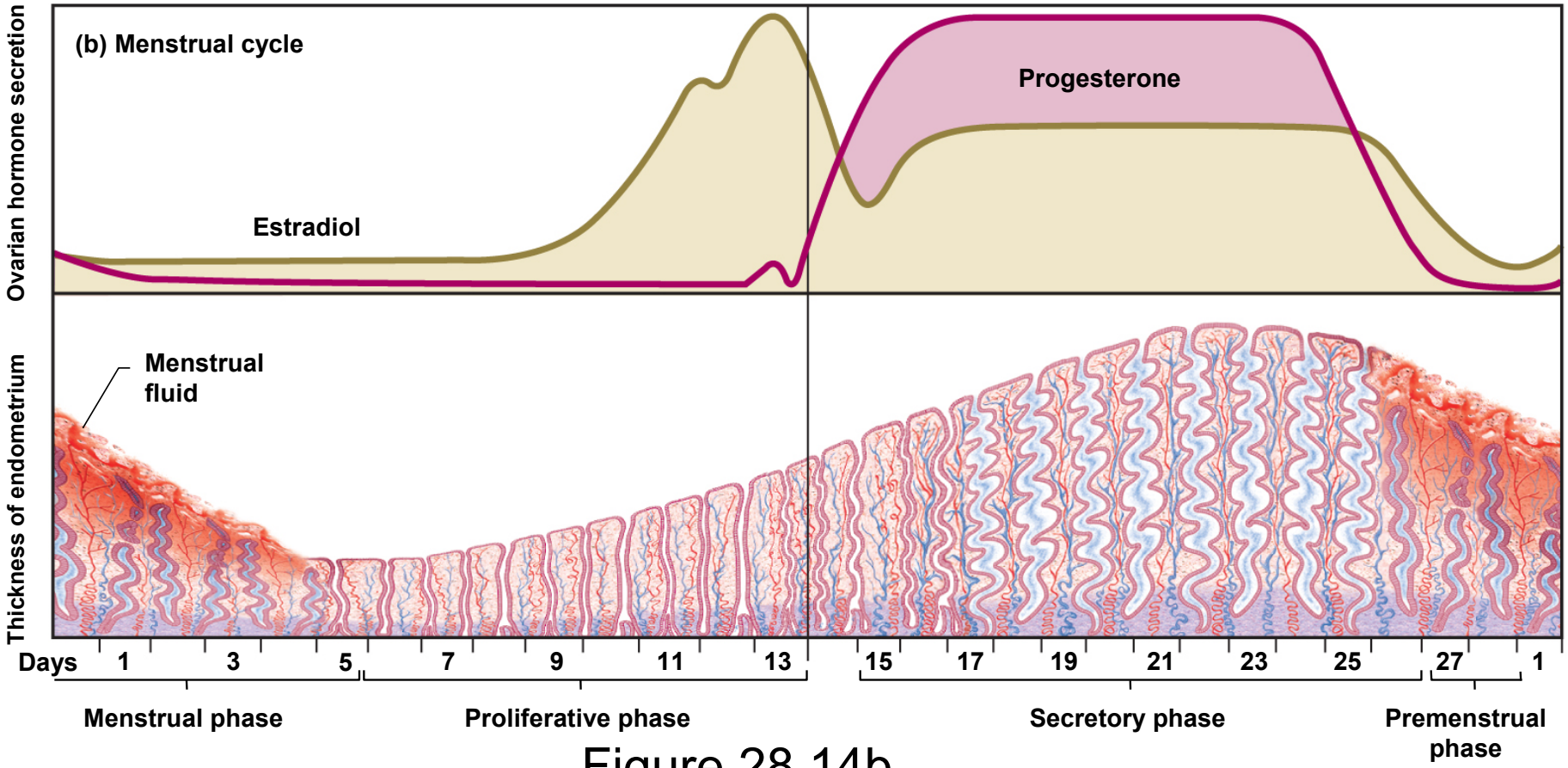


Figure 28.14b

- involution of corpus luteum, progesterone falls
  - spiral arteries constrict causes endometrial ischemia
  - stratum functionalis sloughs

Menstrual Cycle

- **menstrual phase** – discharge of menstrual fluid from the vagina (menses)
- first day of discharge is day 1 of the new cycle
- average woman expels about 40 mL of blood and 35 mL of serous fluid over a 5 day period
- contains fibrinolysin so it does not clot

Menstrual Cycle - Menstrual Phase

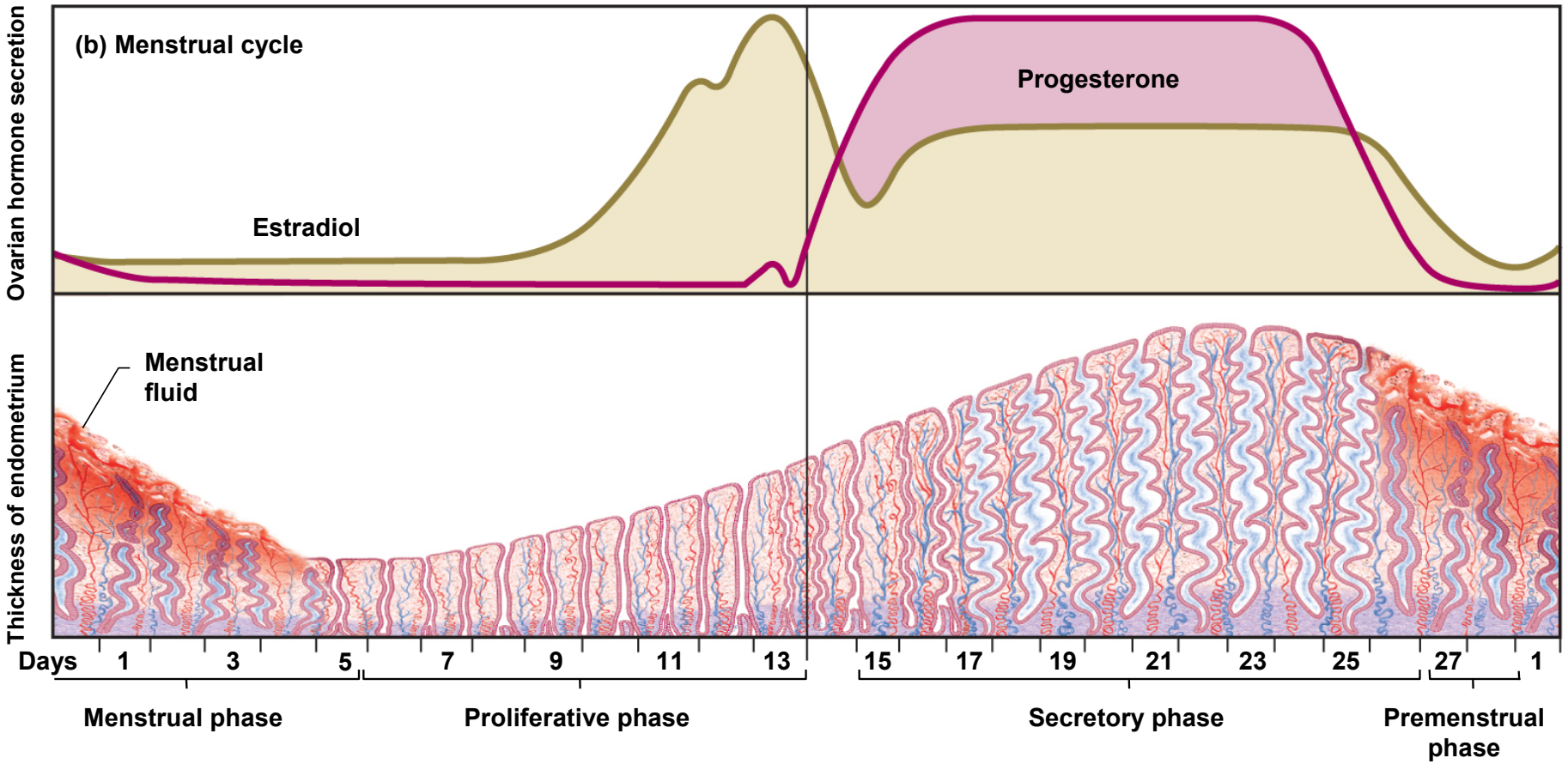


Figure 28.14b

- blood, serous fluid and endometrial tissue are discharged