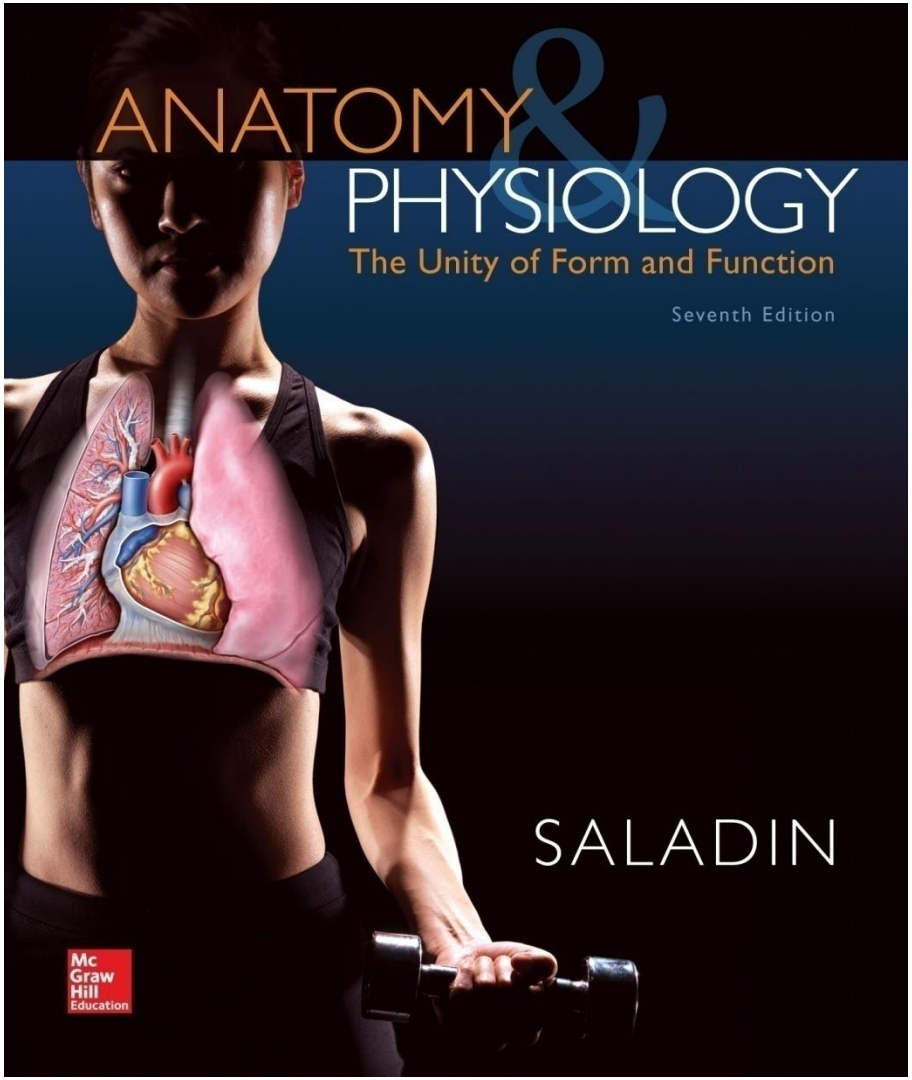
Chapter 28
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.



Introduction

- **The female reproductive system is more complex than the male system because it serves more purposes**
  - Produces and delivers gametes
  - Provides nutrition and safe harbor for fetal development
  - Gives birth
  - Nourishes infant
- **Female system is more cyclic, and hormones are secreted in a more complex sequence**

Reproductive Anatomy

- **Expected Learning Outcomes**
  - Describe the structure of the ovary.
  - Trace the female reproductive tract and describe the gross anatomy and histology of each organ.
  - Identify the ligaments that support the female reproductive organs.
  - Describe the blood supply to the female reproductive tract.
  - Identify the external genitalia of the female.
  - Describe the structure of the nonlactating breast.

Sexual Differentiation

- **The two sexes indistinguishable for first 8 to 10 weeks of development**
- Female reproductive tract develops from the **paramesonephric ducts**
  - Not because of the positive action of any hormone
  - Because of the **absence of testosterone** and **müllerian-inhibiting factor (MIF)**

Sexual Differentiation

- **Without testosterone:**
  - Causes mesonephric ducts to degenerate
  - Genital tubercle becomes the glans clitoris
  - Urogenital folds become the labia minora
  - Labioscrotal folds develop into the labia majora

- **Without MIF:**
  - Paramesonephric ducts develop into the uterine tubes, uterus, and vagina

The Genitalia

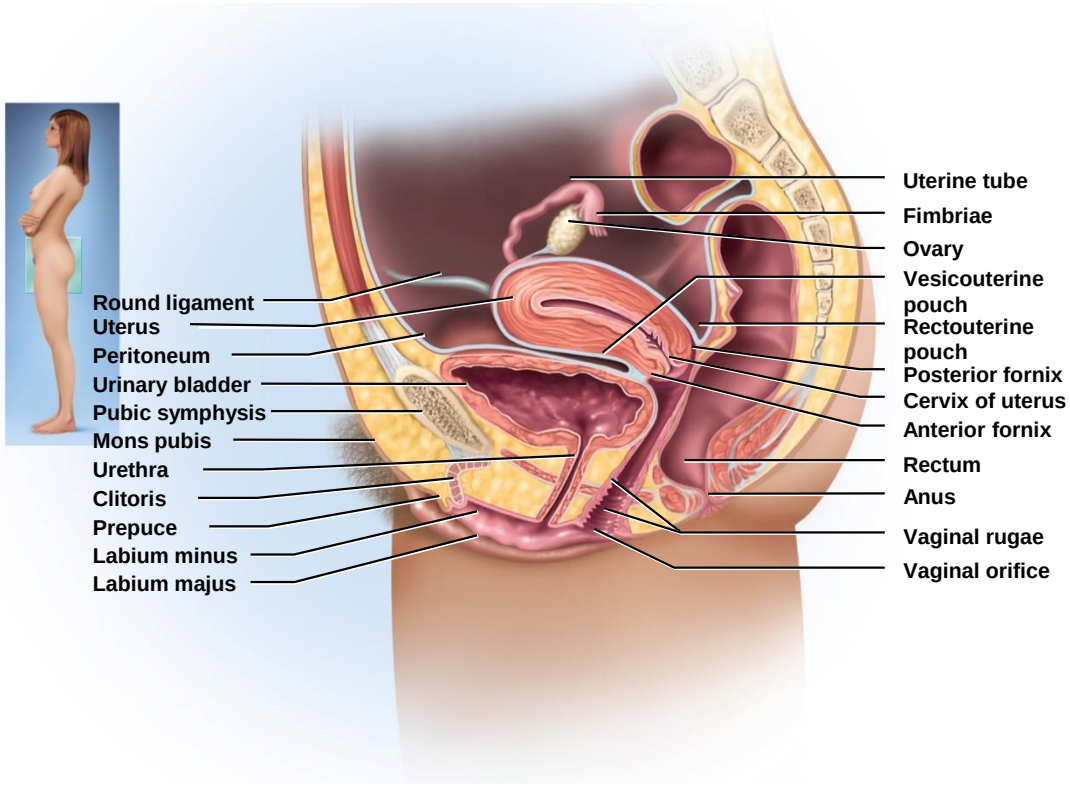


Figure 28.1

- **Internal genitalia**
  - Ovaries, uterine tubes, uterus, and vagina
- **External genitalia**
  - Clitoris, labia minora, and labia majora
- Occupy the **perineum**
- **Primary sex organs**
  - Ovaries
- **Secondary sex organs**
  - Other internal and external genitalia

The Ovaries

- **Ovaries—**female gonads that produce **egg cells (ova)** and **sex hormones**
  - Almond-shaped and nestled in the **ovarian fossa** of posterior pelvic wall
  - **Tunica albuginea** capsule, like on testes
  - **Outer cortex** where germ cells develop
  - **Inner medulla** occupied by major arteries and veins
  - Each egg develops in its own fluid-filled **follicle**
  - **Ovulation:** bursting of the follicle and releasing of the egg

The Ovaries

- **Ligaments of ovary**
  - Attached to uterus by **ovarian ligament**
  - Attached to pelvic wall by **suspensory ligament**
    - Contains ovarian artery, vein, and nerves
  - Anchored to **broad ligament** by **mesovarium**

- **Ovary receives blood from two arteries**
  - **Ovarian branch of the uterine artery**
  - **Ovarian artery**
    - Equivalent to testicular artery in male

The Ovaries

- **Ovarian and uterine arteries anastomose along margin of ovary**
  - Give off multiple small arteries that enter the ovary
- **Ovarian veins, lymphatics, and nerves also travel through the suspensory ligaments**

Structure of the Ovary

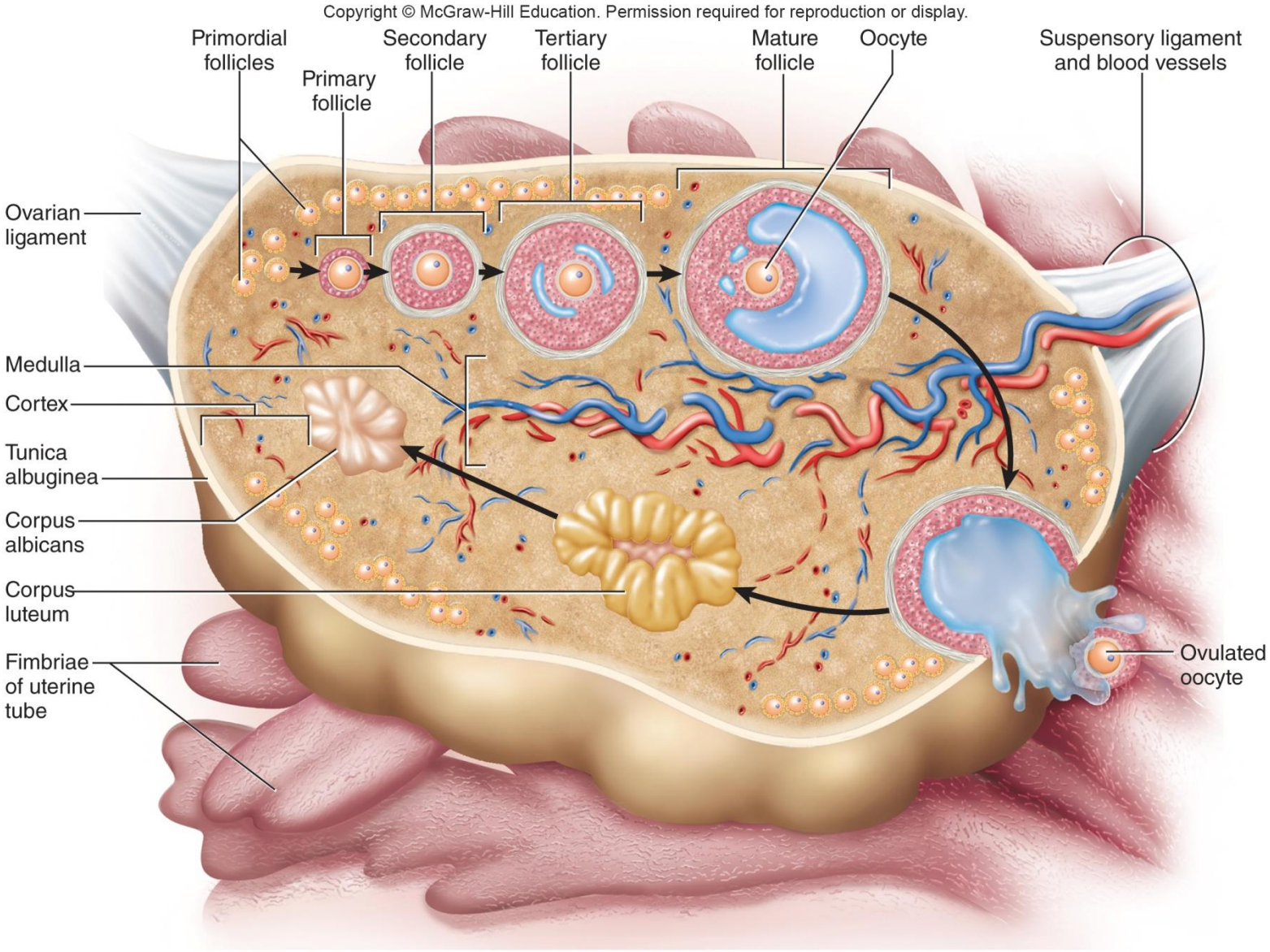


Figure 28.2

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

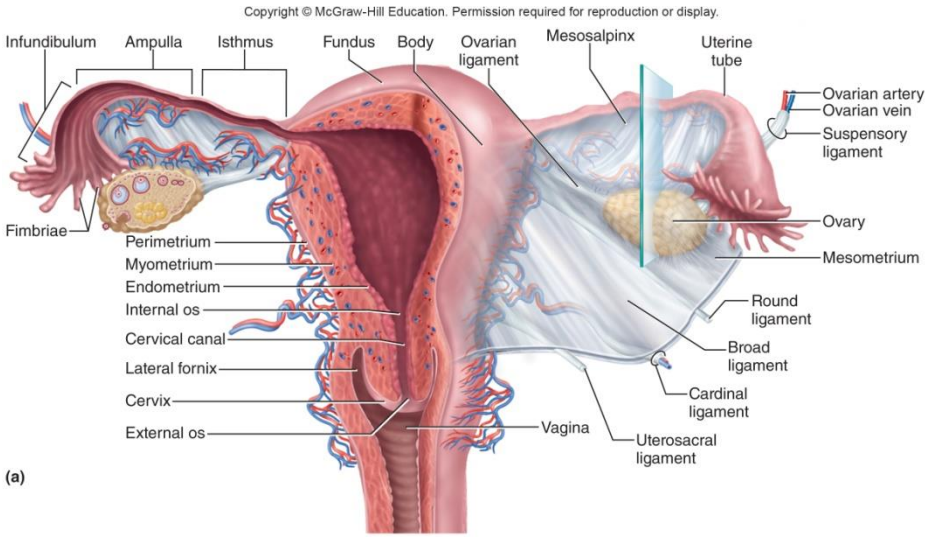


Figure 28.3a

The Uterine Tubes

- **Major portions**
  - **Infundibulum:** flared, trumpet-shaped distal (ovarian) end
  - **Fimbriae:** feathery projections on infundibulum
  - **Ampulla:** middle and longest part
  - **Isthmus:** narrower end toward uterus

- **Mesosalpinx:** superior portion of broad ligament that enfolds uterine tube

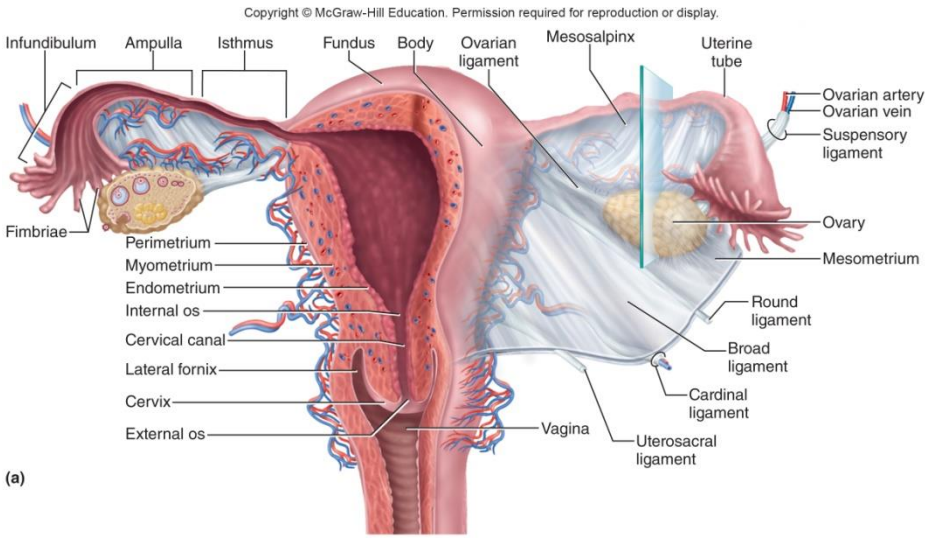


Figure 28.3a

Epithelial Lining of the Uterine Tube

Science Source

Figure 28.4

The Uterus

- **Uterus**—thick muscular chamber that opens into roof of the vagina
  - Usually tilts forward over urinary bladder
  - Harbors fetus, provides a source of nutrition, and expels the fetus at the end of its development
  - Pear-shaped organ
    - **Fundus**—broad superior curvature
    - **Body (corpus)—**middle portion
    - **Cervix**—cylindrical inferior end

The Uterus

(Continued)

- **Lumen** is roughly triangular
  - Upper two corners are openings to uterine tubes
  - Lower apex is internal os
  - Not a hollow cavity, but a **potential space** in nonpregnant uterus
- **Cervical canal** connects lumen of uterus to vagina
  - **Internal os**—superior opening of canal into body of uterus
  - **External os**—inferior opening of canal into vagina
- **Cervical glands:** secrete mucus that prevents spread of microorganisms from vagina to uterus

The Uterus

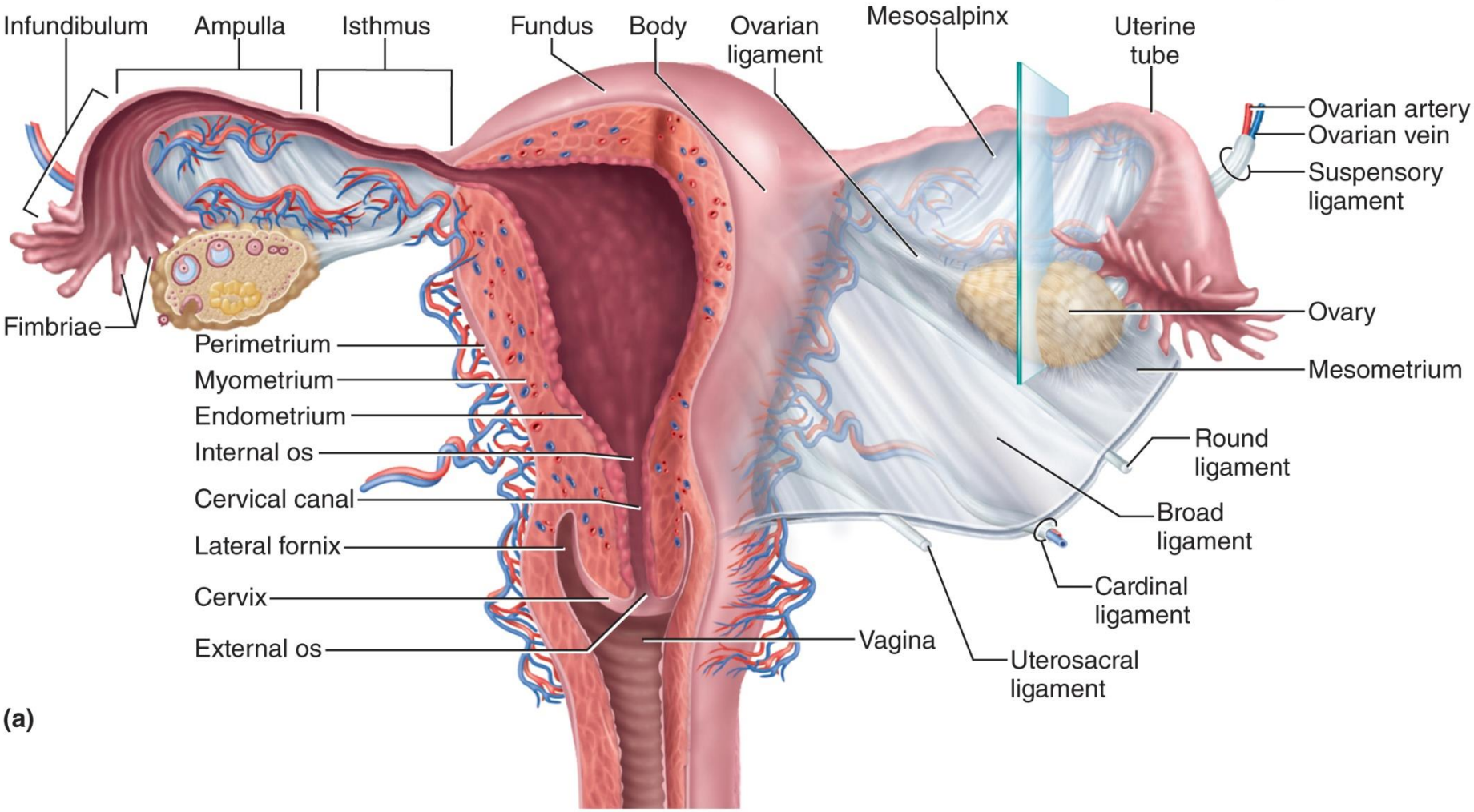


Figure 28.3a

Pap Smears and Cervical Cancer

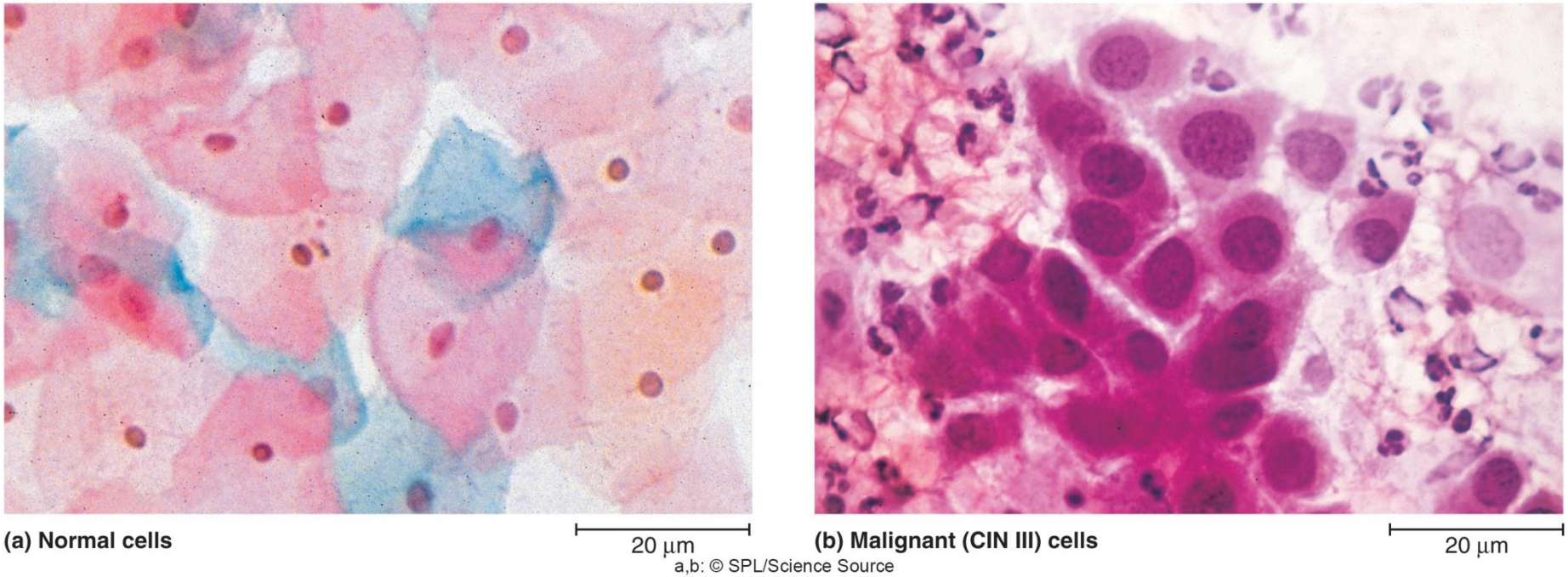


Figure 28.5a,b

- **Cervical cancer common among women ages 30 to 50**
  - Smoking, early-age sexual activity, STDs, and human papillomavirus
  - Usually begins in epithelial cells of lower cervix

Pap Smears and Cervical Cancer

- Best protection against cervical cancer is early detection by **Pap smear**
  - Cells removed from cervix and vagina and microscopically examined
- Three grades of **cervical intraepithelial neoplasia**
  - Class I is mild dysplasia
  - Class II calls for a biopsy
  - Class III results may call for radiation therapy or hysterectomy

The Uterus

- **Uterine wall: perimetrium, myometrium and endometrium**
  - **Perimetrium**—external serosa layer
  - **Myometrium**—middle muscular layer
    - Constitutes most of the uterine wall
    - Composed mainly of **smooth muscle**
      - Sweep downward from fundus; spiral around body
      - Less muscular and more fibrous near cervix
      - Produces labor contractions, expels fetus

The Uterus

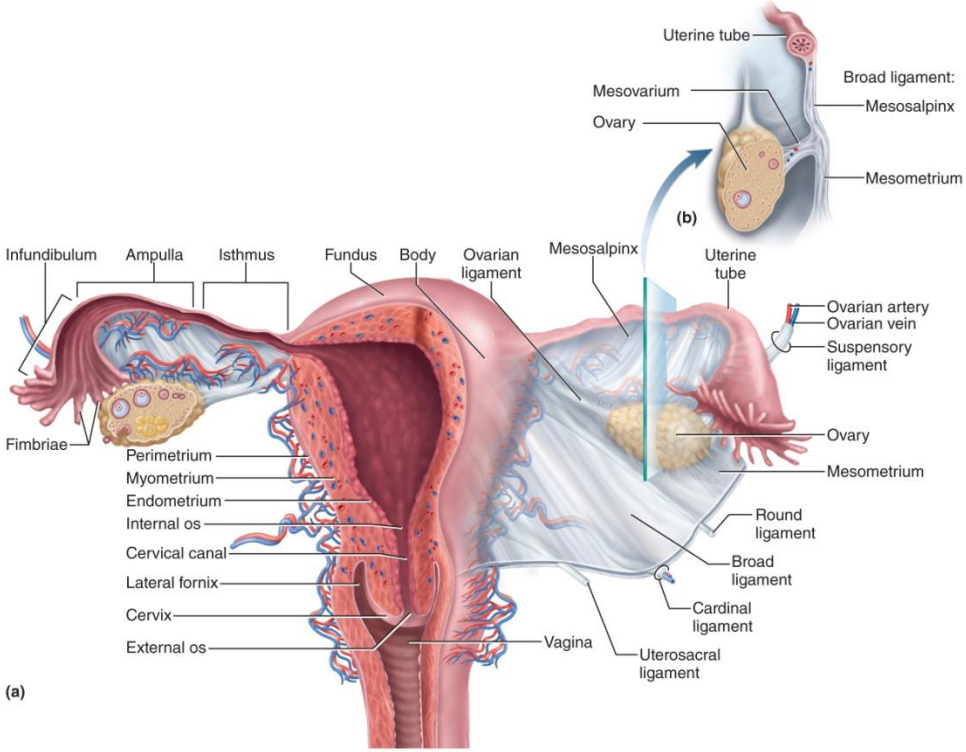
(Continued)

- **Endometrium**—inner mucosa
  - Simple columnar epithelium, compound tubular glands, and a stroma populated with leukocytes, macrophages, and other cells
    - **Functional layer (stratum functionalis)—**superficial half, shed each menstrual period
    - **Basal layer (stratum basalis)—**deep layer, stays behind and regenerates a new stratum functionalis with each menstrual cycle
  - During pregnancy, endometrium is the **site of attachment** of the embryo and forms the **maternal part of the placenta** from which the fetus is nourished

The Uterus

- **Uterus is supported by muscular floor of pelvic outlet and folds of peritoneum that form ligaments**
  - **Broad ligament** has two parts
    - Mesosalpinx
    - Mesometrium on each side of the uterus
  - **Cardinal (lateral cervical) ligaments:** support cervix and superior part of vagina extending to pelvic wall
  - **Uterosacral ligaments:** attach posterior side of uterus to the sacrum
  - **Round ligaments:** arise from anterior surface of uterus, pass through inguinal canals, and terminate in labia majora
    - Similar to gubernaculum terminating in male scrotum

The Female Reproductive Tract



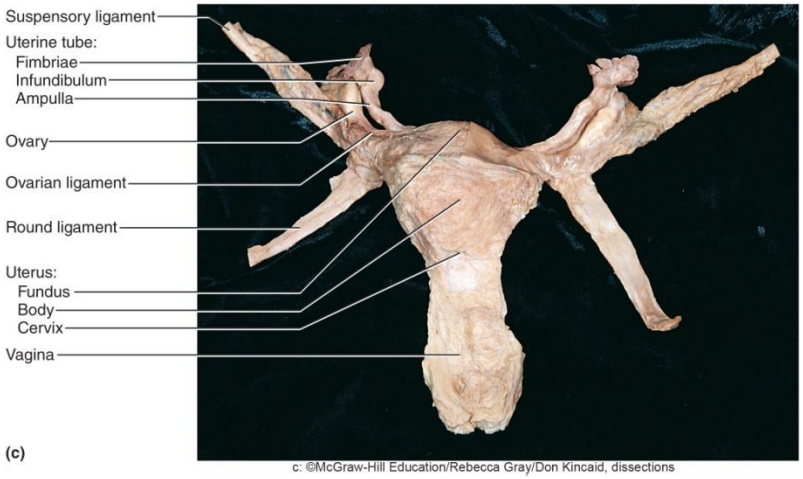


Figure 28.3

Histology of the Endometrium

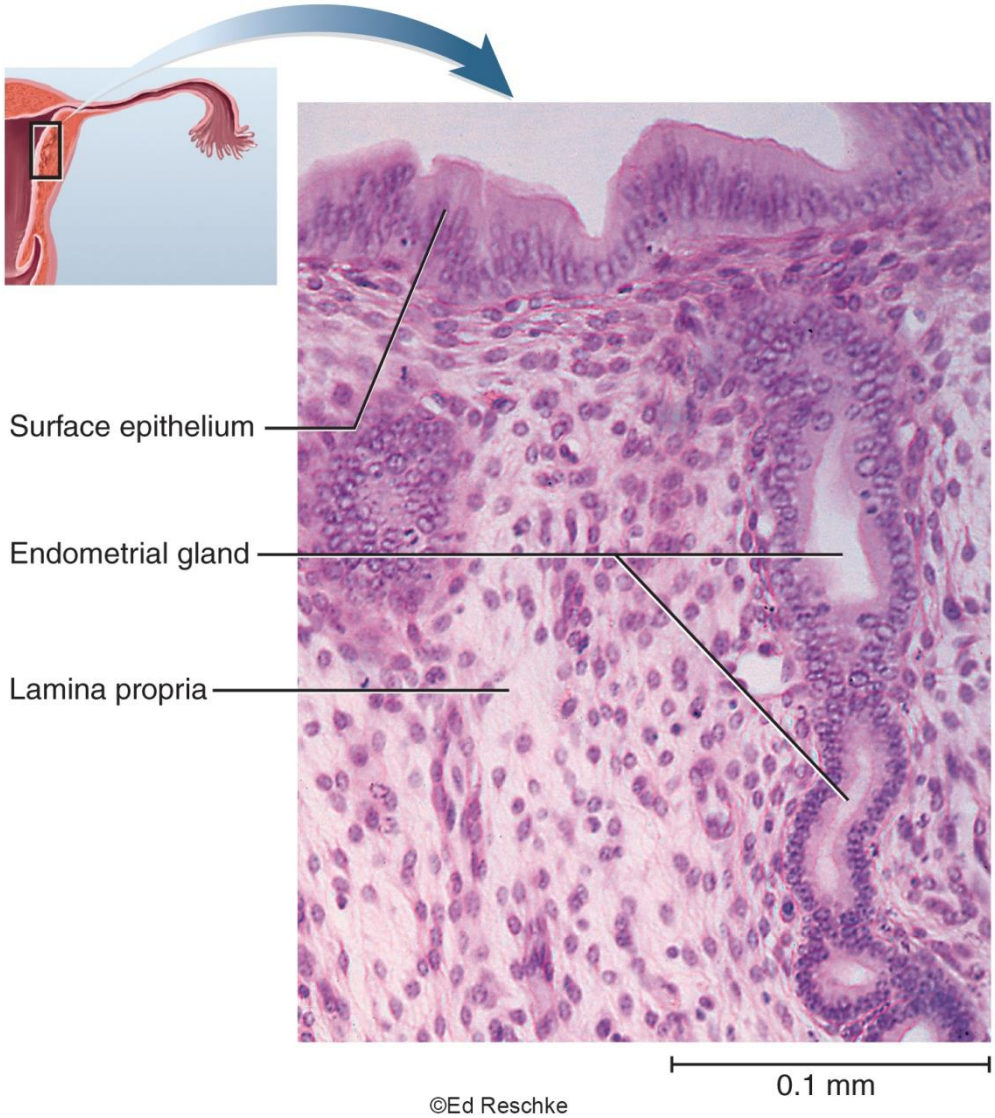


Figure 28.6

The Uterus

- Uterine **blood supply** is important to menstrual cycle and pregnancy
- **Uterine artery** arises from internal iliac artery
  - Gives off several branches that penetrate myometrium and lead to **arcuate arteries**
    - Each travels in a circle around the uterus
    - Anastomose with arcuate artery on the other side
    - **Spiral arteries** penetrate through the myometrium into the **endometrium**
      - Wind between endometrial glands toward surface of mucosa
      - Rhythmically constrict and dilate making mucosa alternately blanch and flush with blood

Blood Supply to the Female Reproductive Tract

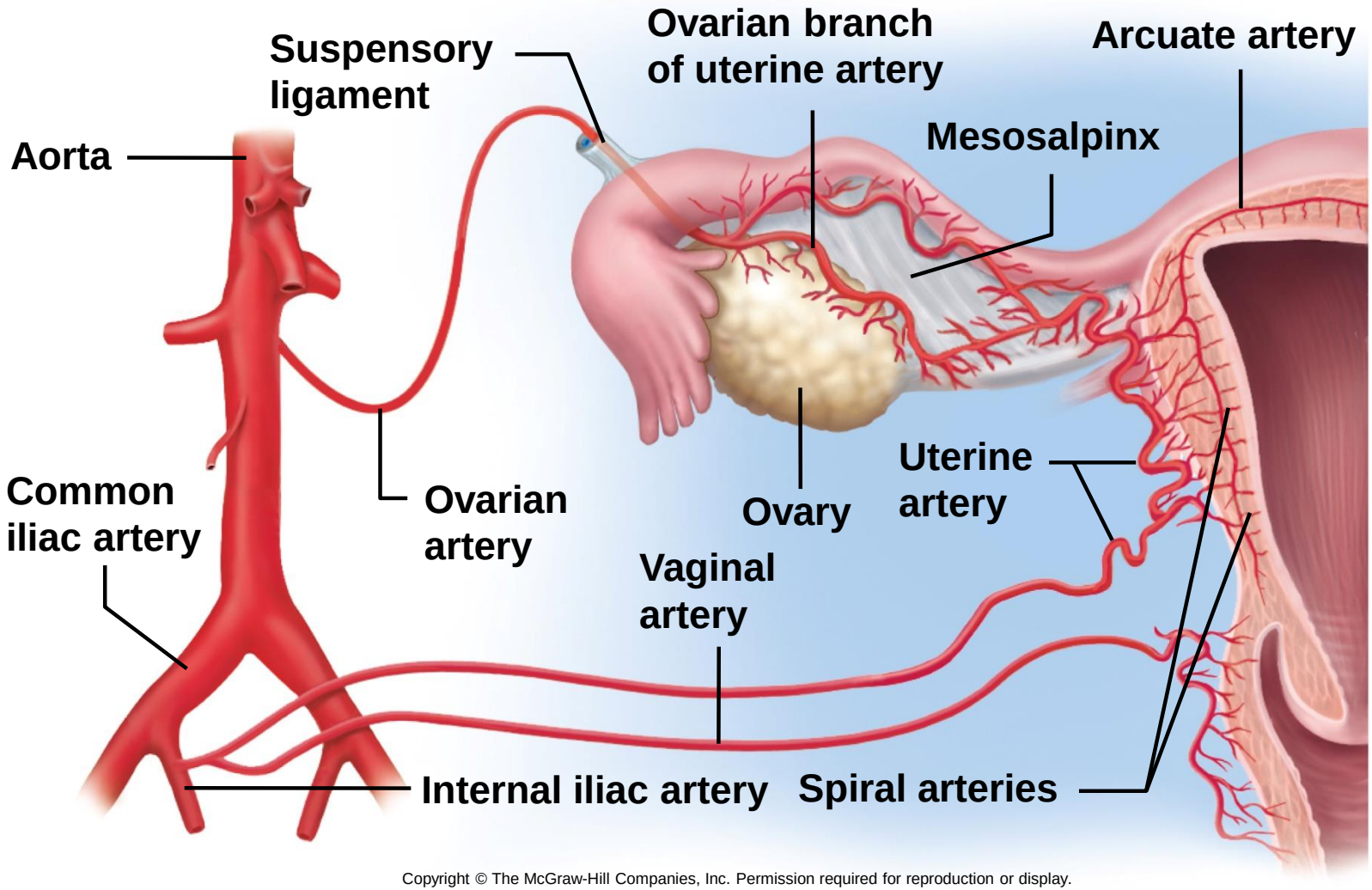


Figure 28.7

The Vagina

- **Vagina (birth canal)—**8 to 10 cm distensible muscular tube
  - Allows for discharge of menstrual fluid, receipt of penis and semen, and birth of baby
  - Outer adventitia, middle muscularis, and inner mucosa
  - Tilted posteriorly between rectum and urethra
  - Vagina has no glands
    - **Transudation** lubricates vagina—“vaginal sweating”
      - Serous fluid through its walls and by mucus from the cervical gland above it

The Vagina

(Continued)

- **Fornices:** blind-ended spaces at top of vagina that extend slightly beyond the cervix
- Transverse friction ridges **(vaginal rugae)** at lower end
- Mucosal folds form **hymen** across vaginal opening

The Vagina

- **Vaginal epithelium**
  - Undergoes **metaplasia:** transformation from one tissue type to another
    - Childhood: simple cuboidal
    - Puberty: estrogens transform it to stratified squamous
  - Bacteria ferment glycogen producing acidic pH in vagina to inhibit growth of pathogens
  - Has antigen-presenting **dendritic cells:** route by which HIV from infected semen invades the female body

The External Genitalia

- External genitalia are collectively called the **vulva** or **pudendum**
  - **Mons pubis:** mound of fat over pubic symphysis bearing most of the pubic hair
  - **Labia majora:** pair of thick folds of skin and adipose tissue inferior to the mons
    - Pudendal cleft—fissure between labia majora
  - **Labia minora:** thin, hairless folds medial to labia majora
    - Space between forms **vestibule** which contains **urethral** and **vaginal openings**
    - Anterior margins of labia minora join to form hood-like prepuce over clitoris

The External Genitalia

Vulva (Continued)

- **Clitoris:** erectile, sensory organ
  - Primary center for sexual stimulation
  - Glans, body, and crura
- **Vestibular bulbs:** erectile tissue deep to labia majora
  - Bracket the vagina
- **Greater and lesser vestibular** and **paraurethral glands** open into vestibule for lubrication

The Female Perineum

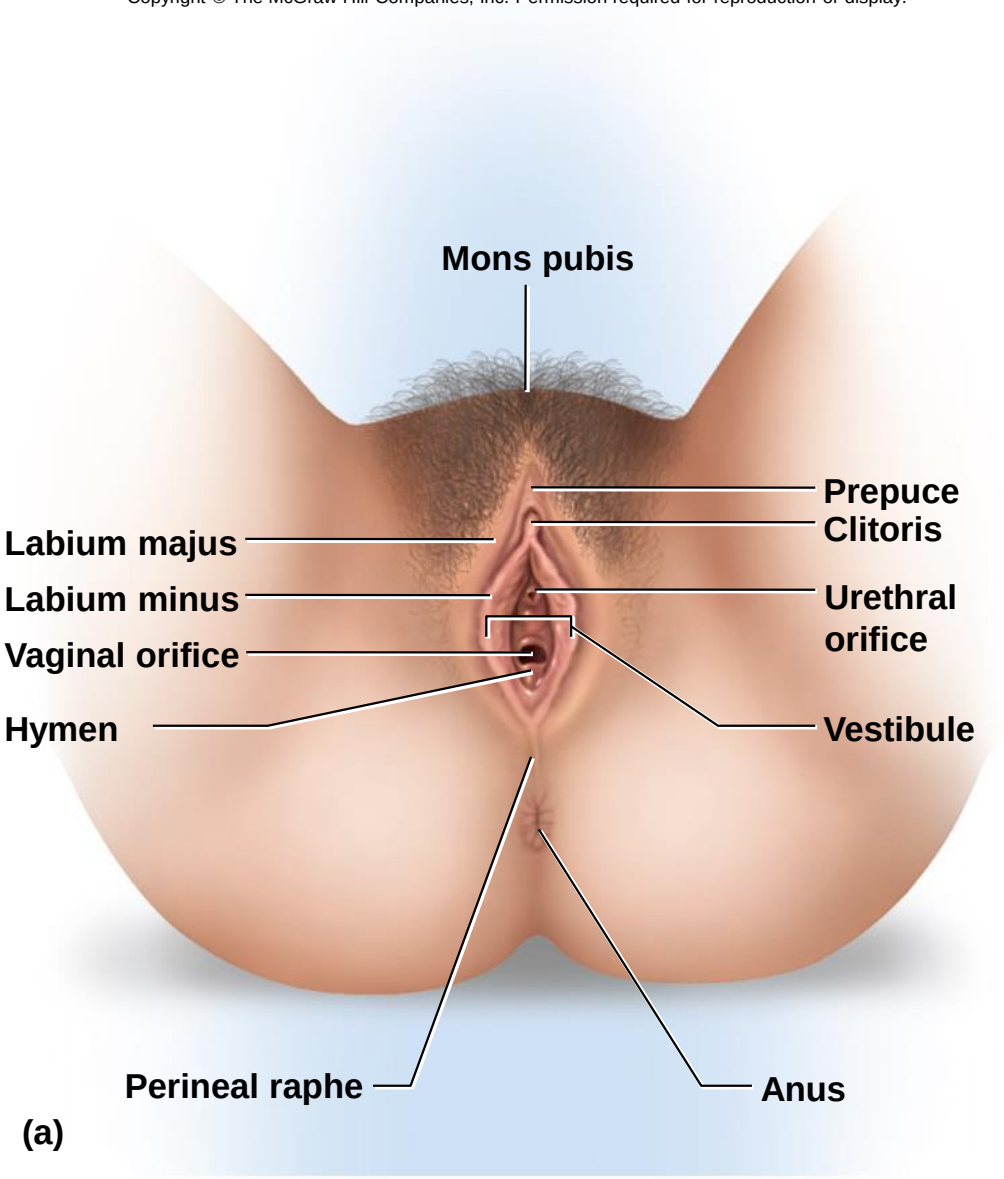


Figure 28.8a

The Female Perineum

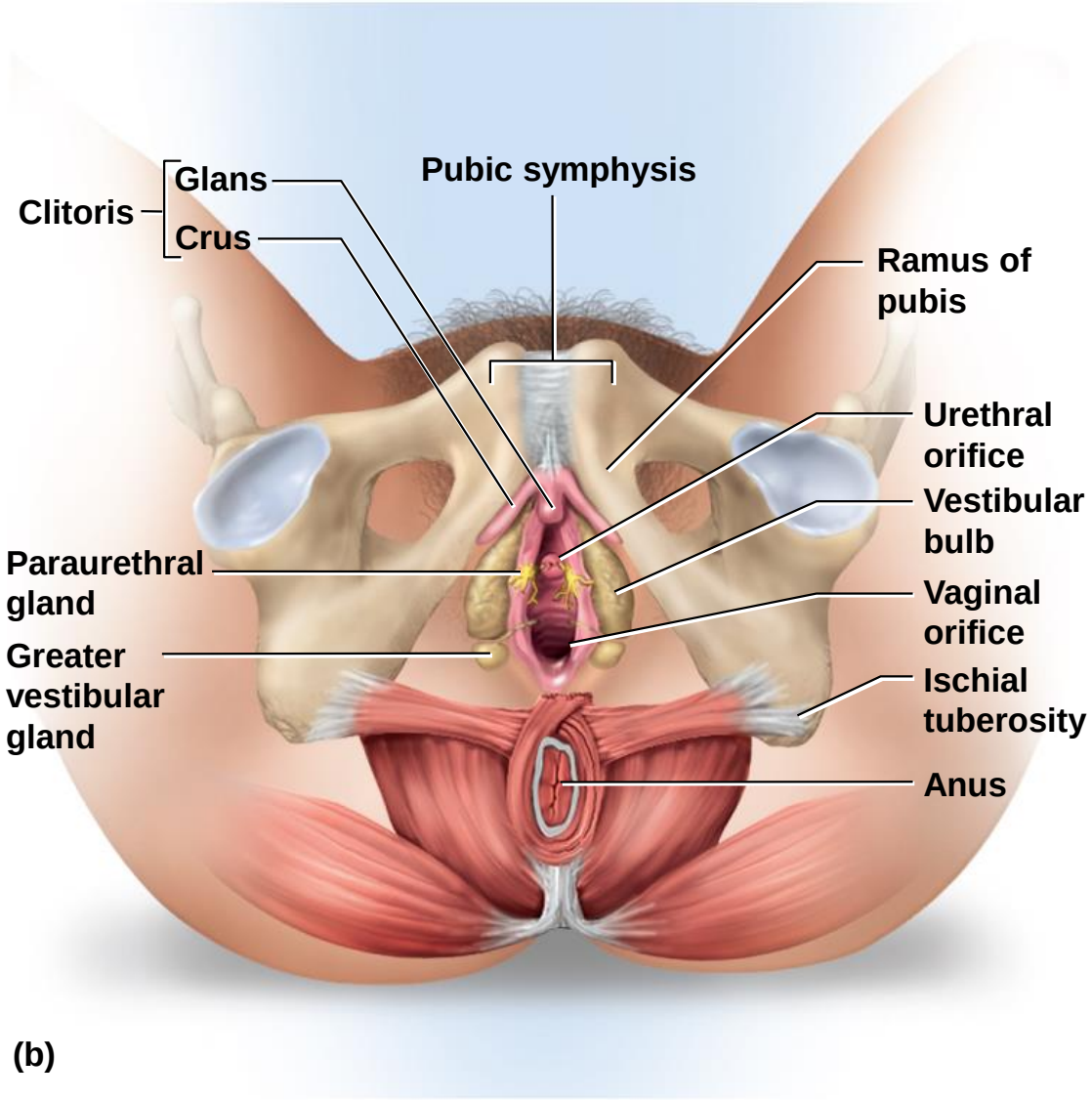


Figure 28.8b

(b)

The Breasts and Mammary Glands

- **Breast**—mound of tissue overlying pectoralis major
  - Enlarges at puberty and remains so for life
  - Most of the time it contains very little mammary gland
- **Mammary gland**—develops within the breast during pregnancy
  - Remains active in the lactating breast
  - Atrophies when a woman ceases to nurse

The Breasts and Mammary Glands

- **Two principal regions of the breast**
  - **Body:** conical to pendulous, with nipple at its apex
  - **Axillary tail:** extension toward armpit
    - Lymphatics in axillary tail are important as a route for **breast cancer metastasis**

- Nipple surrounded by circular colored zone, called the **areola**
  - Capillaries and nerves close to skin surface: more sensitive
  - Sensory nerve fibers of areola trigger a **milk ejection reflex** when an infant nurses

The Breasts and Mammary Glands

(Continued)

- **Areolar glands:** intermediate between sweat glands and mammary glands
  - Secretions protect the nipple from chapping and cracking during nursing
- **Smooth muscle fibers** in dermis of areola that contract in response to cold, touch, and sexual arousal, wrinkling the skin and erecting the nipple

The Breasts and Mammary Glands

- The **nonlactating breast** consists mostly of adipose and collagenous tissue
  - Breast size determined by amount of adipose tissue
- **Suspensory ligaments** attach breast to dermis of overlying skin and fascia of the pectoralis major

The Breasts and Mammary Glands

- **Ducts** branch through fibrous stroma and converge on the nipple
  - Mammary gland develops during pregnancy
  - 15 to 20 **lobes** around the nipple
  - **Lactiferous duct** drains each lobe
    - Dilates to form **lactiferous sinus** which opens into nipple
  - Ducts ends in acini (sacs)
    - Acini are surrounded by myoepithelial cells

The Breast in Lactating State

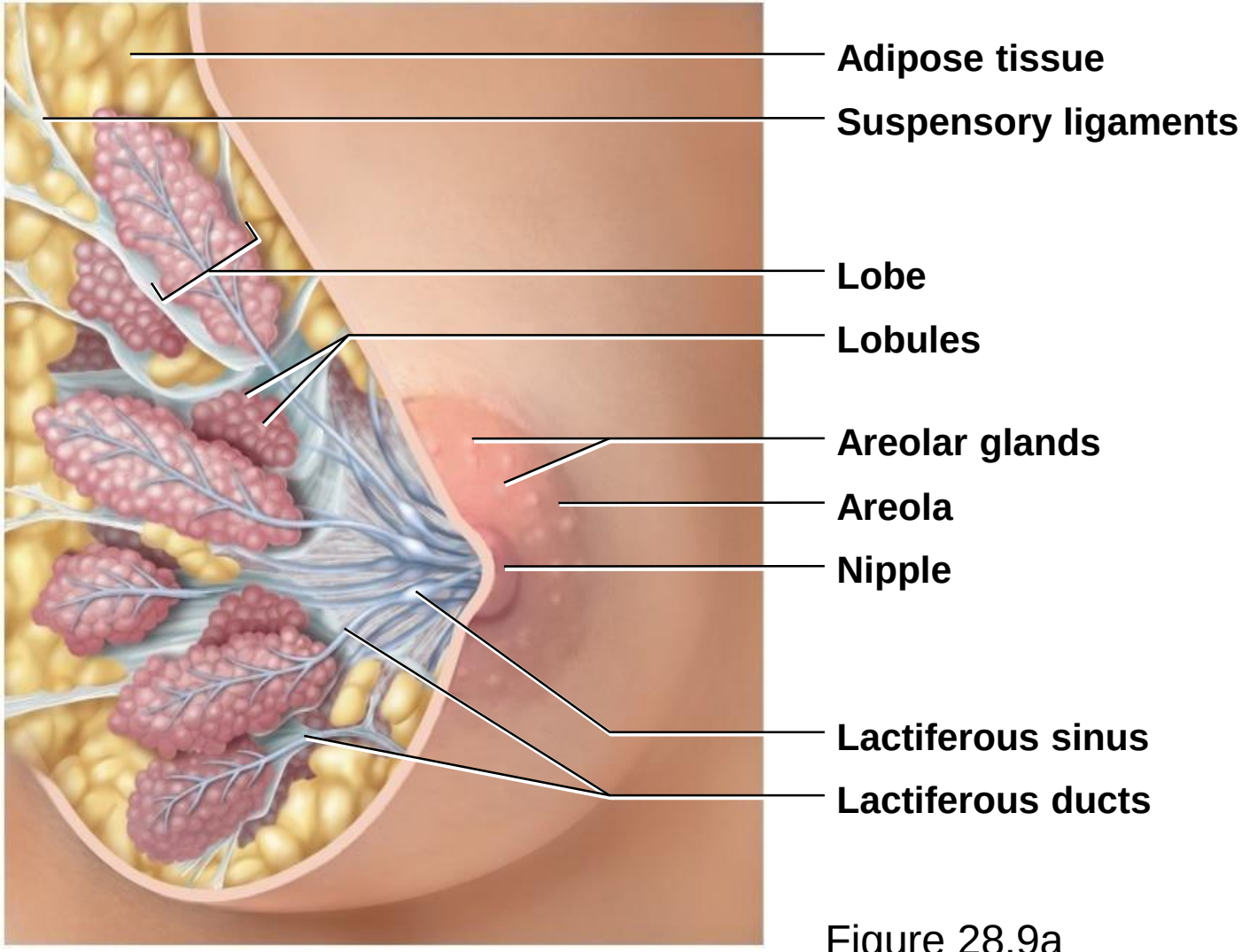
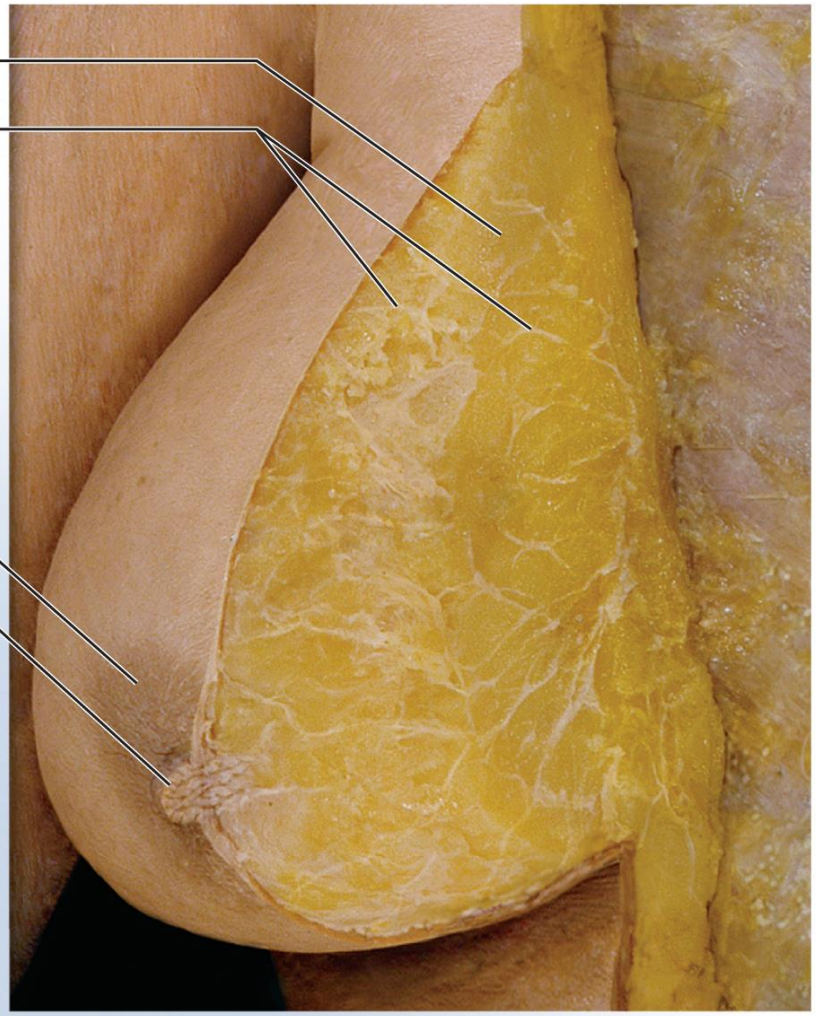


Figure 28.9a

(a) Anterior view

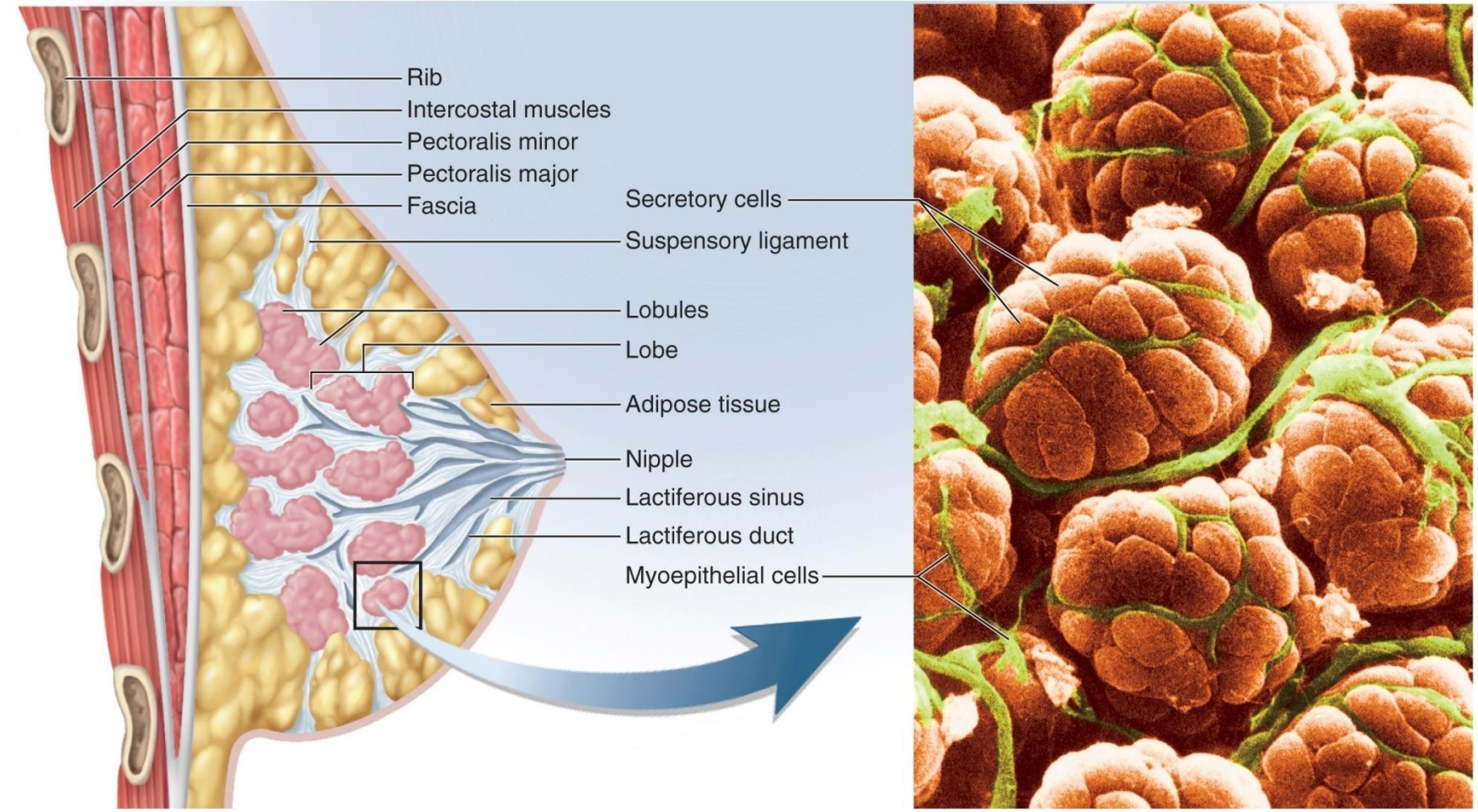
Breast of Cadaver



(b) Breast of cadaver

Figure 28.9b

The Breast



(c) Sagittal section

(d) Mammary acinus

d: ©Dr. Donald Fawcett/Science Source

Figure 28.9c,d

Breast Cancer

- **Breast cancer occurs in 1 out of 8 or 9 American women**
  - A leading cause of female mortality
- **Tumors begin with cells from mammary ducts**
  - May metastasize by mammary and axillary lymphatics
- **Signs may include lump, skin puckering, changes in skin texture, and drainage from nipple**

Breast Cancer

- **Contibuting causes**
  - BRCA1 and BRCA2: two breast cancer genes
    - But most breast cancer is nonhereditary
  - Some breast cancers are stimulated by estrogen

- **Risk factors**
  - Aging, exposure to ionizing radiation, carcinogenic chemicals, excessive alcohol and fat intake, and smoking
  - Over 70% of cases lack identifiable risk factors

Breast Cancer

- **Tumor discovery usually during breast self-examination (BSE)—monthly for all women**
- **Mammograms (breast X-rays)**
  - Late 30s: baseline mammogram
  - Ages 40 to 49: every 2 years
  - Over age 50: yearly

Breast Cancer

- **Treatment of breast cancer**
  - **Lumpectomy:** removal of tumor only
  - **Simple mastectomy:** removal of breast tissue only or breast tissue and some axillary lymph nodes
  - **Radical mastectomy:** removal of breast, underlying muscle, fascia, and lymph nodes
    - Rarely done as it generally does not improve outcome
  - Surgery is followed by **radiation** or chemotherapy
  - **Breast reconstruction** from skin, fat, and muscle from other parts of the body

Breast Cancer Treatment

(c)

(d)

c,d: ©Biophoto Associates/Science Source

Figure 28.10c,d

Puberty and Menopause

- **Expected Learning Outcomes**
  - Name the hormones that regulate female reproductive function, and state their roles.
  - Describe the principal signs of puberty.
  - Describe the hormonal changes of female climacteric and their effects.
  - Define and describe menopause, and distinguish menopause from climacteric.

Puberty

- **Puberty begins at age 8 to 10 for most girls in United States**
- **Triggered by rising levels of GnRH which stimulates anterior pituitary to secrete FSH and LH**
- **FSH** stimulates 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

Puberty

- **Thelarche**—onset of breast development, the earliest noticeable sign of puberty
  - Estrogen, progesterone, and prolactin trigger development of ducts and lobules
  - Completion of duct and lobules is governed by glucocorticoids and growth hormone
  - Adipose and fibrous tissue enlarge breast
- **Pubarche**—appearance of pubic and axillary hair, sebaceous glands, and axillary glands
  - Androgens from ovaries and adrenal cortex stimulate pubarche and libido

Puberty

- **Menarche**—first menstrual period
  - Requires at least 17% body fat in teenager
    - Improved nutrition has lowered age of onset to age 12
    - Leptin stimulates gonadotropin secretion
    - If body fat and leptin levels drop too low, gonadotropin secretion declines and menstrual cycle might cease
      - Menstruation ceases when body fat drops below 22% in adult woman
    - First few menstrual cycles are **anovulatory (no egg ovulated)**
    - Girls begin ovulating regularly about a year after they begin menstruating

Puberty

- **Estradiol** stimulates many changes in puberty
  - Stimulates vaginal metaplasia
  - Stimulates growth of ovaries and secondary sex organs
  - Stimulates growth hormone secretion
    - Increase in height and widening of pelvis
  - Stimulates fat deposition (breast, hips, etc…)
  - Thickens skin
    - But girls' skin is still thinner, softer, and warmer than boys
- **Progesterone**
  - Primarily acts on the uterus preparing it for possible pregnancy in the second half of the menstrual cycle

Puberty

- **Estrogens** and **progesterone** suppress FSH and LH secretion through negative feedback
- **Inhibin** selectively suppresses FSH secretion
- **Hormone secretion is distinctly cyclic and the hormones are secreted in sequence**

Climacteric and Menopause

- **Climacteric**—midlife change in hormone secretion
  - Accompanied by **menopause:** cessation of menstruation
- **Female born with about 2 million eggs, climacteric begins when there are about 1,000 follicles left**
  - Follicles less responsive to gonadotropins – secrete less estrogen and progesterone
  - Uterus, vagina, and breast atrophy
  - Intercourse may become uncomfortable
  - Vaginal infections more common
  - Skin becomes thinner

Climacteric and Menopause

(Continued)

- Cholesterol levels rise, increasing risk of cardiovascular disease
- Bone mass declines, increasing risk of osteoporosis
- Blood vessels constrict and dilate in response to shifting hormone balances
  - Dilations may produce **hot flashes:** spreading sense of heat from abdomen to thorax, neck, and face

- **Hormone replacement therapy (HRT)**—low doses of estrogen and progesterone to relieve some of these symptoms
  - Risks and benefits still being debated

Climacteric and Menopause

- **Menopause—**cessation of menstrual cycles
  - Usually occurs between ages of 45 and 55
  - Age of menopause has increased in last century
  - Menopouse considered complete when there has been no menstruation for a year

The Evolution of Menopause

- **Theory—older mother would not live long enough to rear an infant to a survivable age**
  - Better to become infertile and help rear her grandchildren
- **Pleistocene (Ice Age) skeletons show early hominids rarely lived past age 40**
  - Menopause may be an artifact of modern nutrition and medicine allowing us to live longer than our ancestors

Oogenesis and the Sexual Cycle

- **Expected Learning Outcomes**
  - Describe the process of egg production (oogenesis).
  - Describe changes in the ovarian follicles (folliculogenesis) in relation to oogenesis.
  - Describe the hormonal events that regulate the ovarian cycle.
  - Describe how the uterus changes during the menstrual cycle.
  - Construct a chart of the phases of the monthly sexual cycle showing the hormonal, ovarian, and uterine events of each phase.

Oogenesis and the Sexual Cycle

- **Reproductive cycle**—sequence of events from fertilization to giving birth and returning to fertility
- **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

- **Embryonic development of ovary**
  - Female germ cells arise from **yolk sac**
  - Colonize **gonadal ridges** the first 5 to 6 weeks of development
  - Differentiate into **oogonia** and multiply until the fifth month
    - 6 to 7 million in number

Oogenesis

(Continued)

- Transform into **primary oocytes:** early meiosis I
- Most degenerate **(atresia)** by the time the girl is born
- **Egg,** or **ovum:** any stage from the primary oocyte to the time of fertilization
- By puberty, 200,000 oocytes remain
  - **Lifetime supply—**probably will ovulate only 480 times

Oogenesis

- **Egg development resumes in adolescence**
  - **FSH** stimulates monthly cohorts of about 24 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 ultimately disintegrates
    - A means of discarding the extra set of haploid chromosomes

Oogenesis

(Continued)

- **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

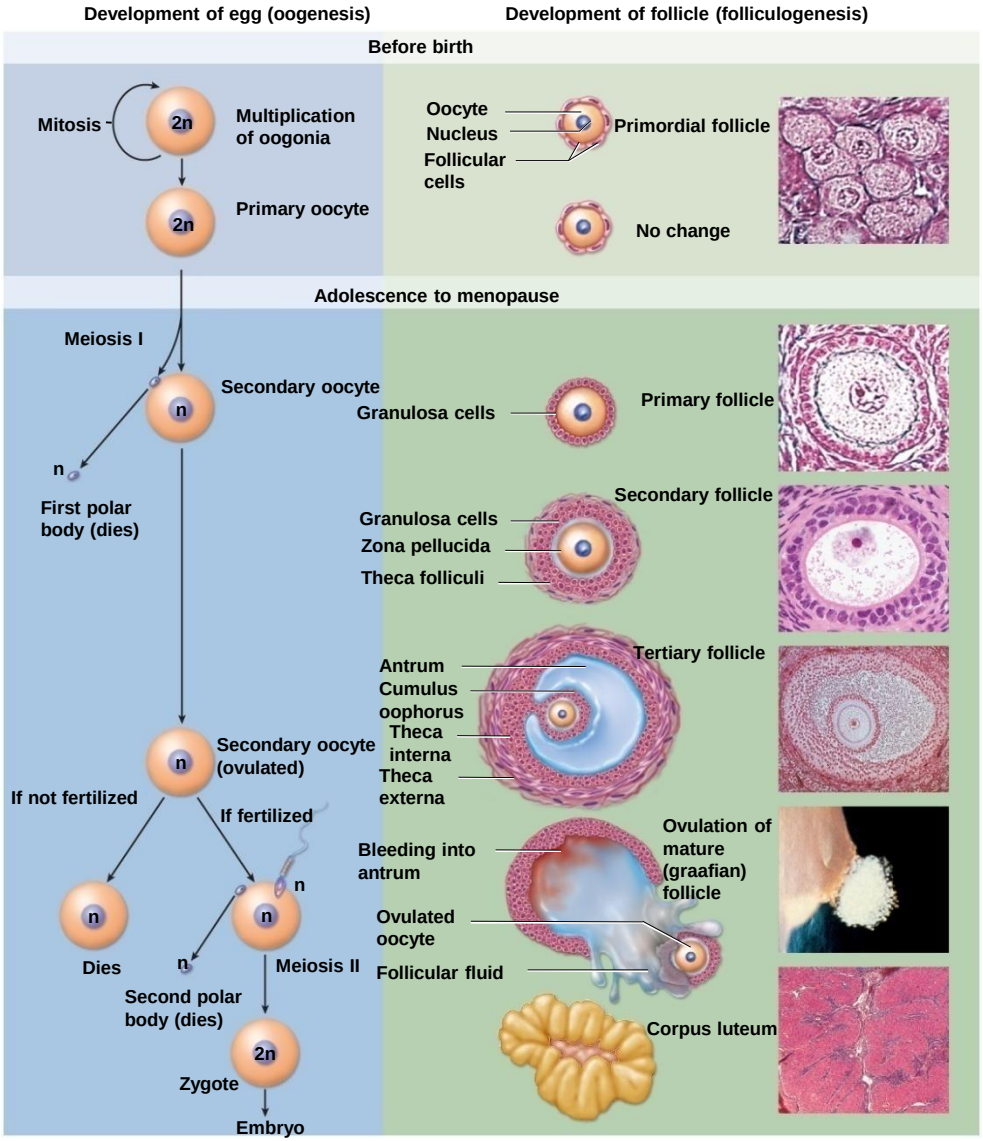


Figure 28.11

(Primordial & Primary follicle): © Ed Reschke; (Secondary follicle): © The McGraw-Hill Companies, Inc./Photo by Dr. Alvin Telser; (Tertiary follicle): Manfred Kage/Peter Arnold, Inc.; (Graafian): Landrum Dr. Shettles; (Corpus luteum): © The McGraw-Hill Companies, Inc./Photo by Dr. Alvin Telser

Ovarian Follicles

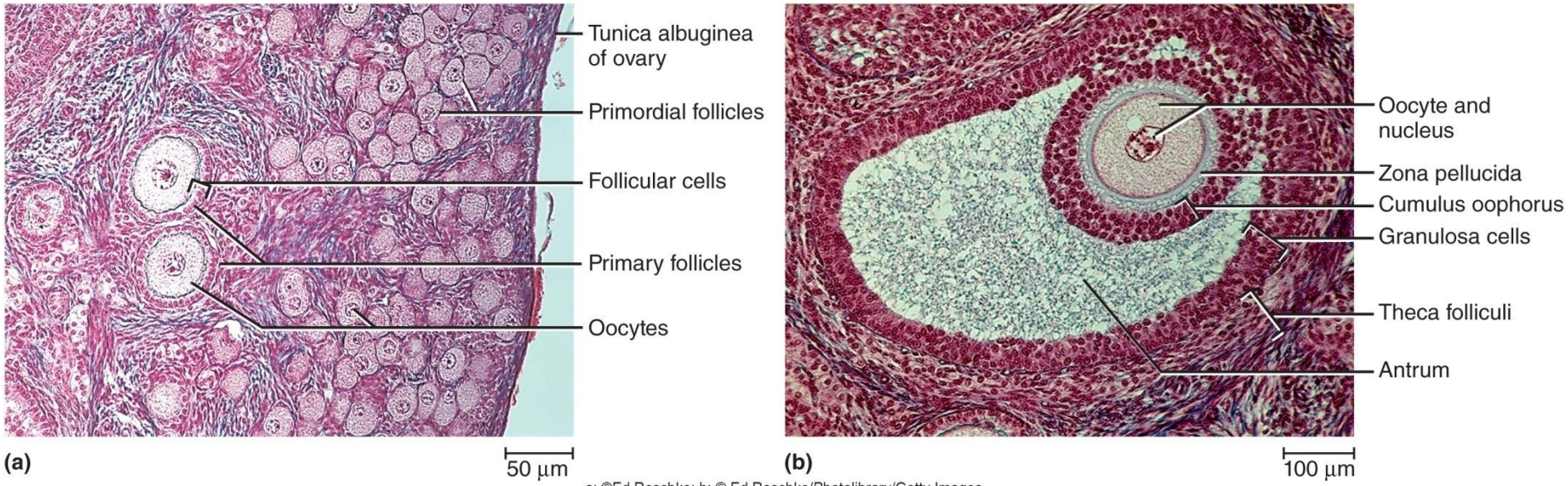


Figure 28.12a,b

Folliculogenesis

- **Folliculogenesis—development of the follicles around the egg that undergoes oogenesis**
  - **Primordial follicles**
    - Consists of a primary oocyte in early meiosis
    - Surrounded by a single layer of squamous **follicular cells**
    - Follicular cells connected to the oocyte by fine cytoplasmic processes for passage of nutrients and chemical signals
    - Concentrated in the **cortex of the ovary**
    - Wait 13 to 50 years before they develop further
    - Adult ovary has 90% to 95% primordial follicles
    - Monthly recruitment of about 24 follicles begins 290-day path to maturity that only one will finish (about 23 die)

Folliculogenesis

(Continued)

– **Primary follicles**
  - About 140 days into cycle, recruited primordial follicles become primary follicles
  - Contain larger, secondary oocytes and a surrounding layer of cuboidal follicular cells

– **Secondary follicles**
  - Appear about 140 days into cycle
  - Oocytes are even larger and follicular cells now in two or more layers **(granulosa cells)**
  - **Zona pellucida**—layer of glycoprotein gel secreted by granulosa cells around the oocyte
  - **Theca folliculi**—connective tissue around the granulosa cells condenses to form a fibrous husk

Folliculogenesis

Secondary follicles (Continued)

- Appear about 140 days into cycle
- Oocytes are even larger and follicular cells now in two or more layers **(granulosa cells)**
- **Zona pellucida**—layer of glycoprotein gel secreted by granulosa cells around the oocyte
- **Theca folliculi**—connective tissue around the granulosa cells condenses to form a fibrous husk that differentiates into two layers
  - **Theca externa:** outer fibrous capsule rich in blood vessels
  - **Theca interna:** inner cellular, hormone-secreting layer producing androgens (androstenedione and testosterone), and granulosa cells convert them to **estradiol**

Folliculogenesis

(Continued)

– **Tertiary follicles**

- Appear about 60 days before ovulation when granulosa cells begin secreting follicular fluid into small pools
- As pools enlarge, they merge, forming a single **antrum**
  - **Antral follicles**—tertiary and mature follicles
  - **Preantral follicles**—earlier stages of the follicles
- **Cumulus oophorus—**a mound of granulosa cells on one side of the antrum that covers the oocyte and secures it to the follicular wall
- **Corona radiata—**innermost layer of cells in the cumulus surrounding zona pellucida and oocyte
  - Forms a protective barrier around egg with function similar to blood–testis barrier

Folliculogenesis

(Continued)

- **Mature follicles**
  - About 20 days before ovulation, one follicle becomes dominant (the one destined to ovulate)
    - Remainder degenerate
  - It captures and holds FSH
  - At about 5 days before ovulation it is large enough to be considered a **preovulatory (graafian) follicle**

Ovarian Follicles

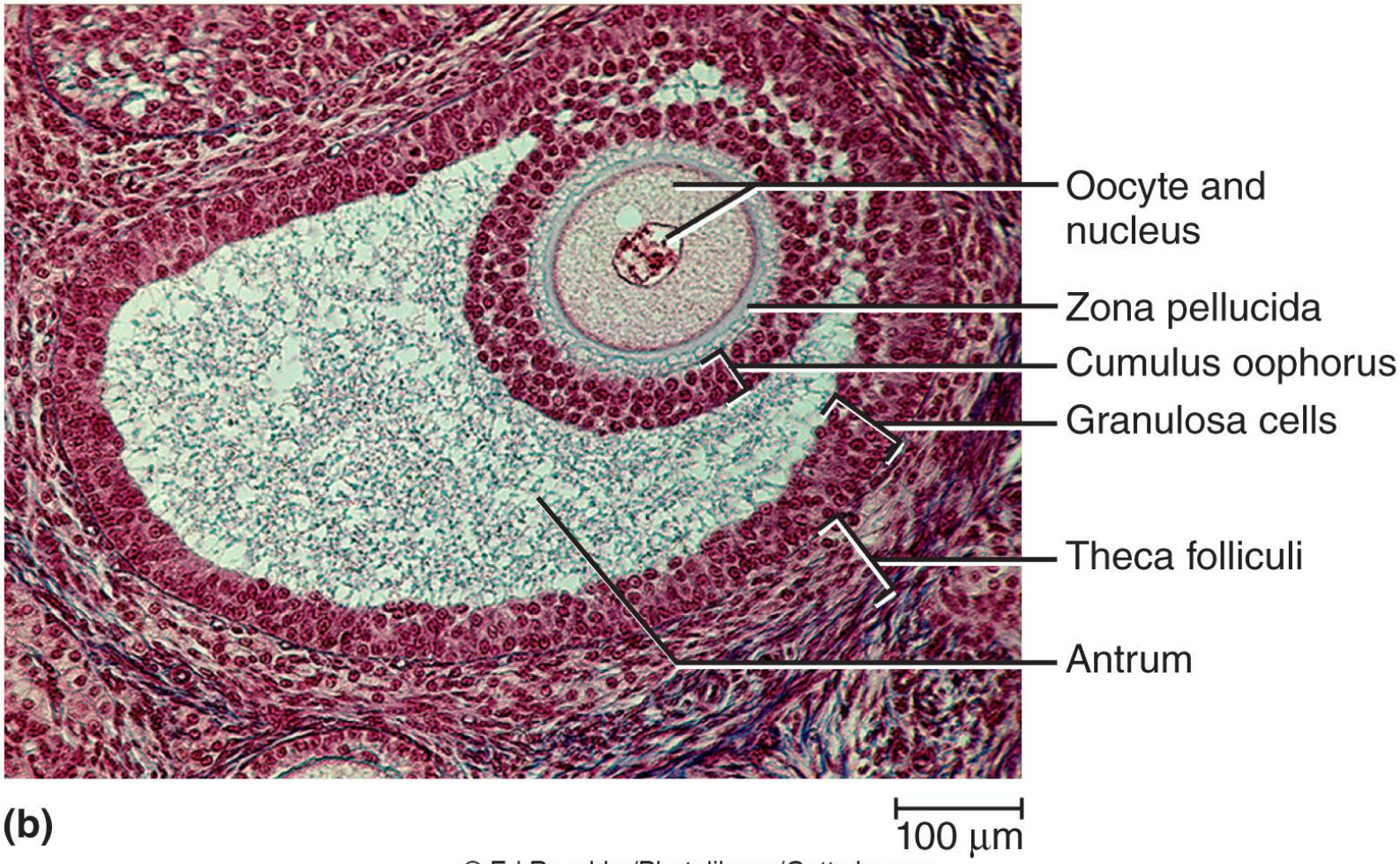


Figure 28.12b

The Sexual Cycle

- Sexual cycle **averages 28 days,** varies from 20 to 45 days
- Hormones of **hypothalamus** regulate 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**

The Sexual Cycle

- 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 of that follicle becomes **corpus luteum**
- Next 2 weeks: **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—**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**

The Sexual Cycle

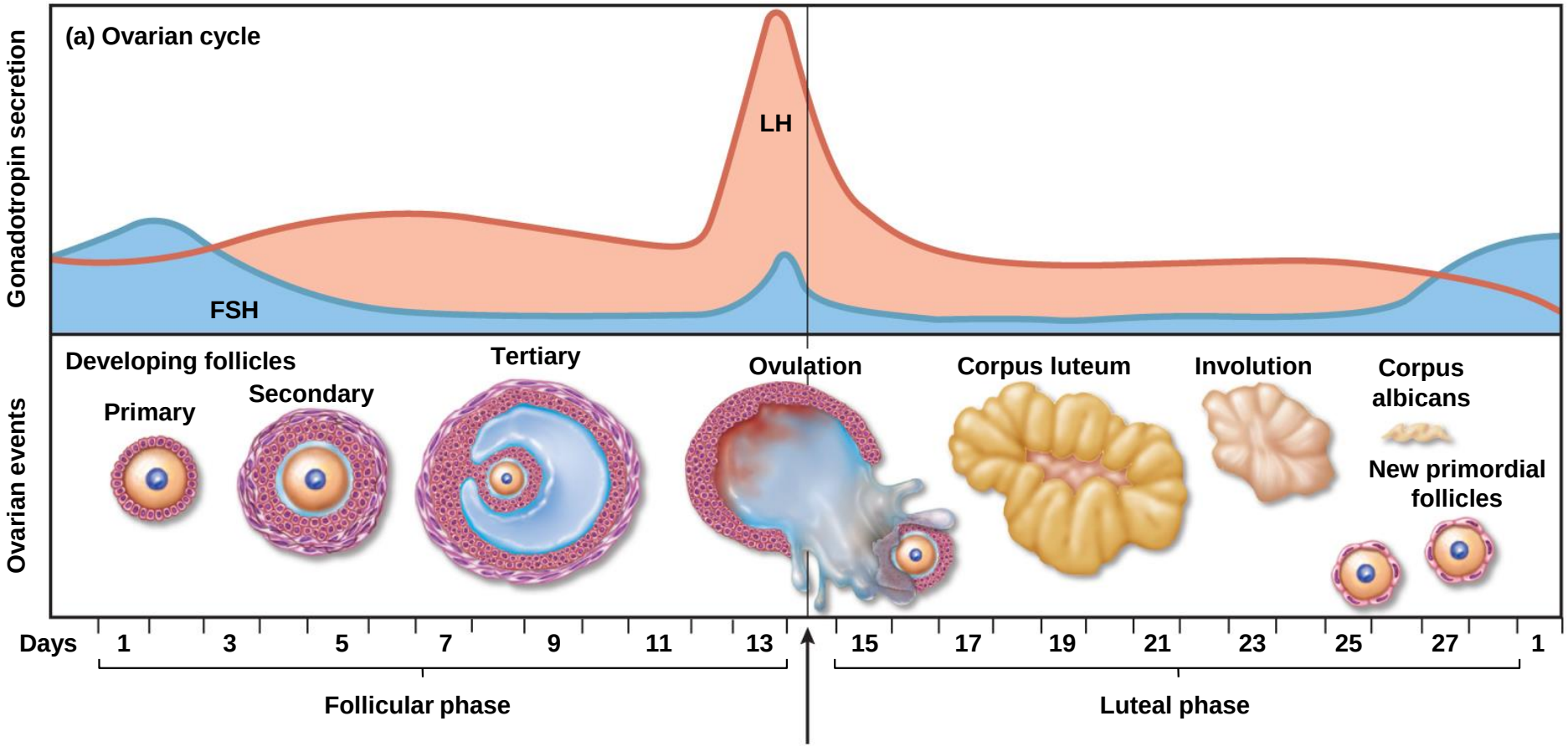


Figure 28.14a

The Ovarian Cycle

- **Follicular phase** extends from beginning of menstruation until ovulation (Days 1-14)
  - Includes **preovulatory phase:** from end of menstruation until ovulation
  - Most variable part of cycle; seldom possible to predict date of ovulation
  - FSH stimulates follicles to grow and secrete estradiol
  - Dominant follicle becomes increasingly sensitive to FSH, LH, and estradiol
    - Dominant follicle has rich blood supply and large number of FSH receptors, so it becomes preovulatory follicle
    - Other antral follicles degenerate (atresia)
    - Ovary also contains follicles at earlier stages for maturation in future cycles

The Ovarian Cycle

- **Ovulation**—rupture of the mature follicle and 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 induces several events
    - Primary oocyte completes meiosis I (producing secondary oocyte and first polar body)
    - Follicular fluid builds rapidly and follicle swells (resembles blister on ovary)
    - Macrophages and leukocytes secrete enzymes that weaken follicle wall
    - Nipple-like stigma appears on surface

Control of Ovulation

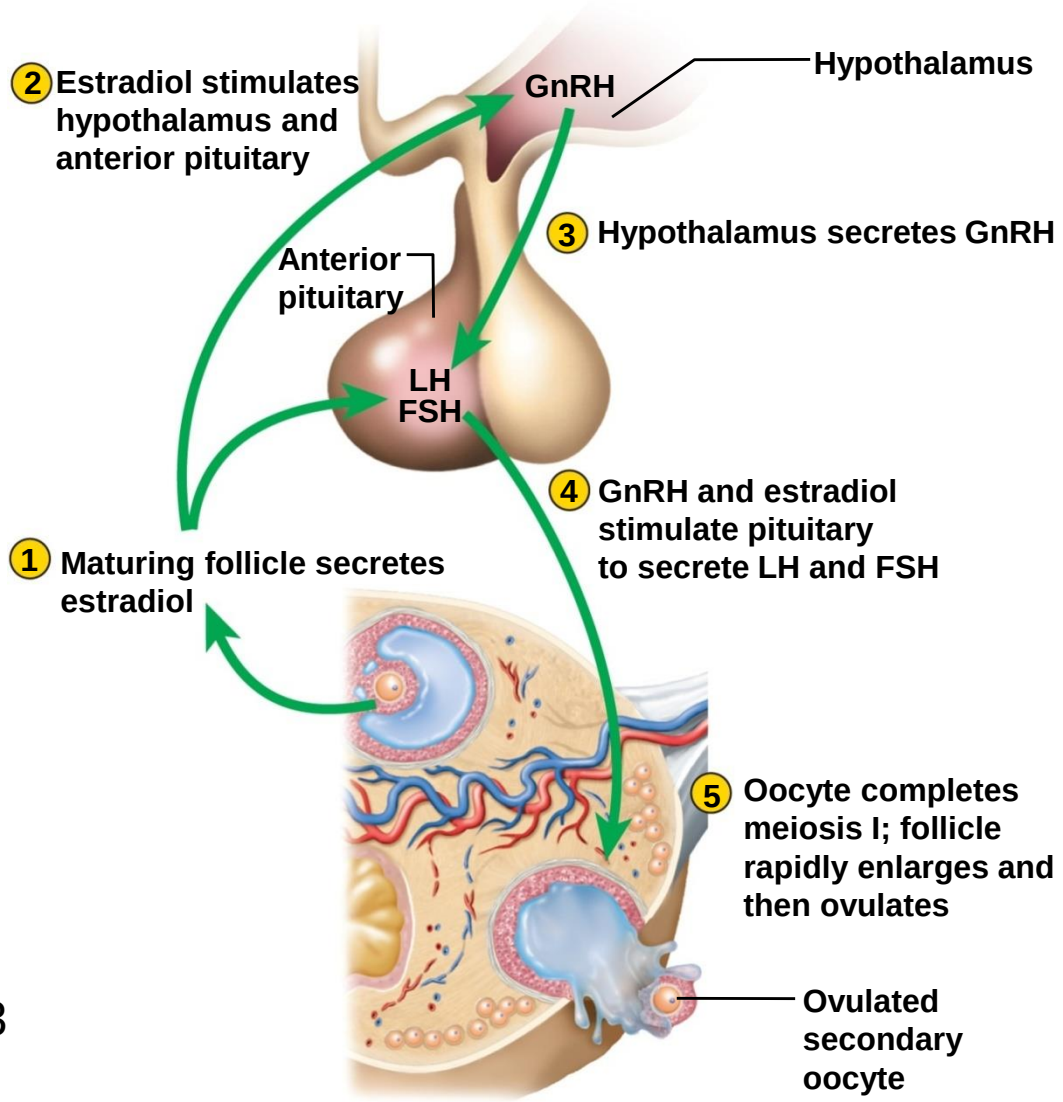


Figure 28.13

The Ovarian Cycle

(Continued)

- Ovulation takes only 2 to 3 minutes
  - Stigma seeps follicular fluid for 1 to 2 minutes
  - Follicle bursts and remaining fluid oozes out carrying the **secondary oocyte** and **cumulus oophorus**
  - Normally swept up by **ciliary current** and taken into uterine tube

Endoscopic View of Human Ovulation

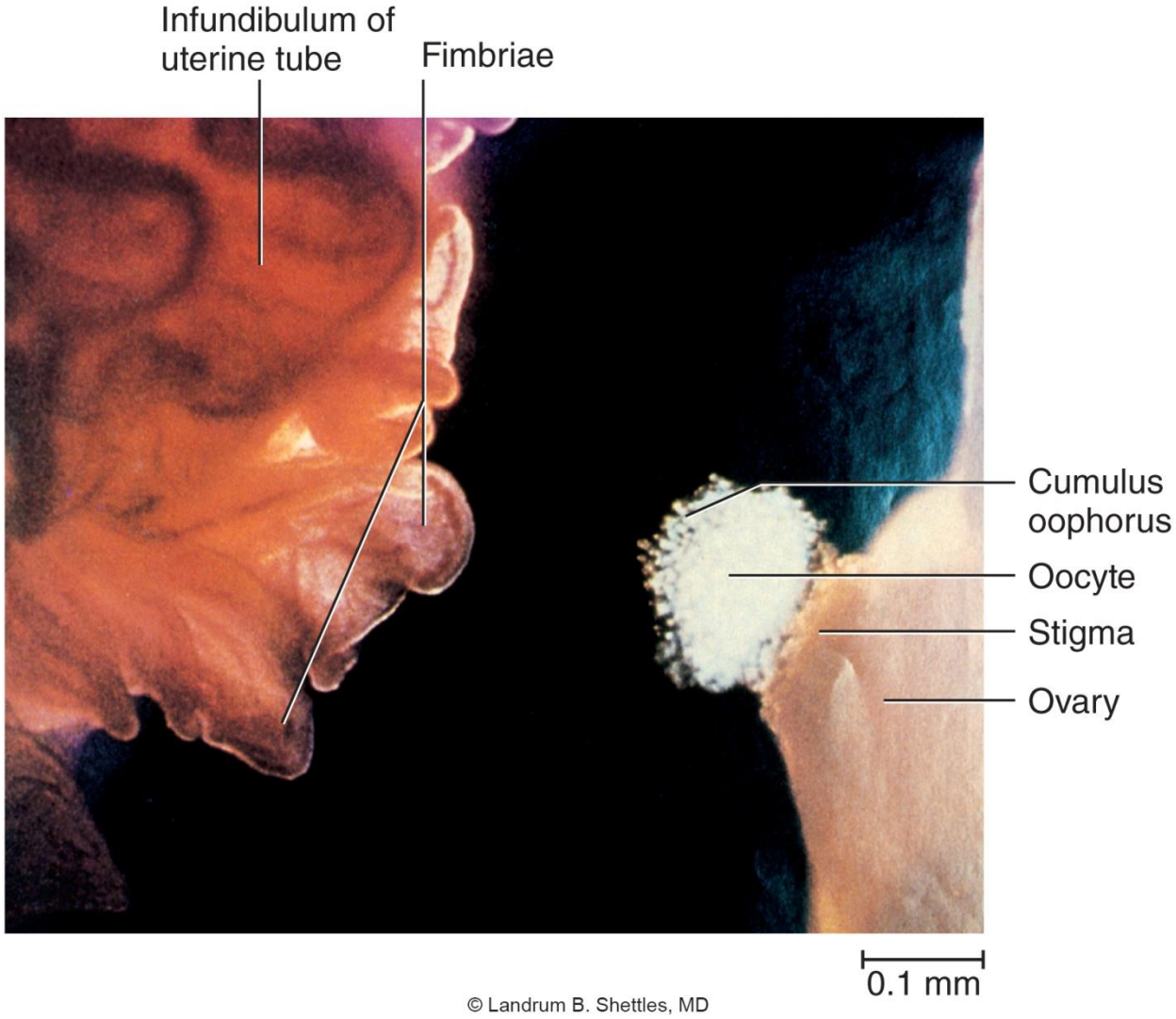


Figure 28.15

The Ovarian Cycle

- **Uterine tube** prepares to catch oocyte
  - It swells with edema
- Its **fimbriae** envelop and caress the ovary in synchrony with the woman's heartbeat
- **Cilia** create gentle current in nearby peritoneal fluid

Signs of Ovulation

- **Couples attempting to conceive a child (or avoid pregnancy) may wish to know when ovulation occurs**
  - **Cervical mucus** becomes thinner and more stretchy
  - **Resting body temperature** rises 0.4° to 0.6°F
    - Best measured first thing in the morning before arising from bed
    - Record for several days to see the difference
  - **Mittelschmerz**—twinges of pain at time of ovulation

- **Best time for conception**
  - Within 24 hours after the cervical mucus changes and the basal temperature rises

The Ovarian Cycle

- **Luteal (postovulatory) phase**—day 15 to day 28, from just after ovulation to onset of menstruation
- **If pregnancy does not occur, events happen as follows:**
  - When follicle ruptures it collapses and bleeds into antrum
  - Clotted blood is slowly absorbed
  - Granulosa and theca interna cells multiply and fill antrum
  - Dense bed of capillaries grows amid them
  - Ovulated follicle has now become the **corpus luteum**
    - Named for yellow lipid that accumulates in theca interna cells, now called **lutein cells**

The Ovarian Cycle

(Continued)

- **Transformation from ruptured follicle to corpus luteum is regulated by LH**
  - **LH** stimulates **corpus luteum** to grow and secrete rising levels of **estradiol** and **progesterone**
  - **10-fold increase** in progesterone is most important aspect of luteal phase
- Progesterone has a crucial role in **preparing the uterus** for possibility of pregnancy
- LH and FSH secretion declines over the rest of the cycle

The Ovarian Cycle

(Continued)

- High levels of estradiol and progesterone, along with inhibin from the corpus luteum, have a negative feedback effect on the pituitary
- Corpus luteum begins process of **involution (shrinkage)**
  - Beginning about day 22 (8 days after ovulation)
  - By day 26 involution is complete and what was corpus luteum becomes **corpus albicans**—small scar
  - With diminishing ovarian steroid secretion, FSH levels rise, ripening a new cohort of follicles
- Ovulation occurs in one ovary per cycle with the two ovaries usually alternating from month to month
- Ovulated oocyte began ripening 290 days earlier and began development before birth

The Menstrual Cycle

- **Menstrual cycle**—consists of a buildup of 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
    - Menstrual phase average: 5 days

The Menstrual Cycle

- **Proliferative phase—**rebuilding of functional layer of endometrium that was lost in last menstruation
  - At day 5 of menstruation, the endometrium is about 0.5 mm thick and consists only of **basal layer**
  - As **new cohort of follicles** develops, they secrete more **estrogen**
  - Estrogen stimulates mitosis in basal layer and regrowth of blood vessels to regenerate the **functional layer**
  - By day 14, endometrium is 2 to 3 mm thick
  - Estrogen also stimulates endometrial cells to produce **progesterone receptors**

The Menstrual Cycle

- **Secretory phase**—endometrium thickens more in response to progesterone from corpus luteum
  - Day 15 to day 26
  - Thickening due to secretion and fluid accumulation rather than mitosis
  - Endometrial glands secrete **glycogen**
  - Glands grow wider, longer, and more coiled
  - Endometrium 5 to 6 mm thick
  - Soft, wet, nutritious bed available for embryonic development

The Menstrual Cycle

- **Premenstrual phase:** period of endometrial degeneration
  - Last 2 days of the cycle
  - Corpus luteum atrophies and progesterone levels fall
  - Triggers spasmodic contractions of spiral arteries
  - Causes **endometrial ischemia (interrupted blood flow)**
  - Brings about **tissue necrosis** and menstrual cramps
  - Pools of blood accumulate in the functional layer
  - Necrotic endometrium mixes with blood and serous fluid: **menstrual fluid**

The Menstrual Cycle

- **Menstrual phase (menses)—**discharge of menstrual fluid from the vagina
- 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

The Female Sexual Cycle

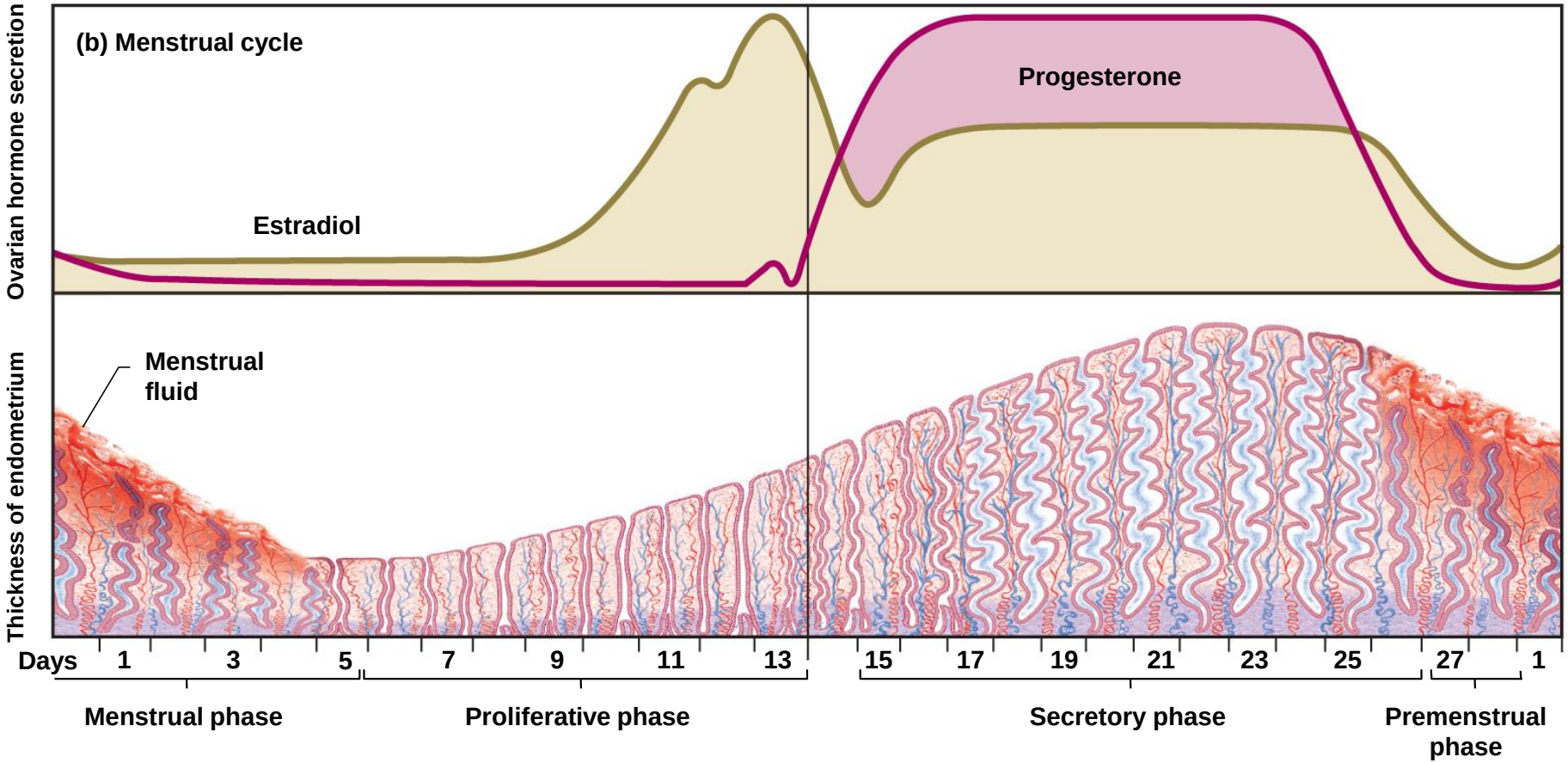


Figure 28.14b

Endometrial Changes

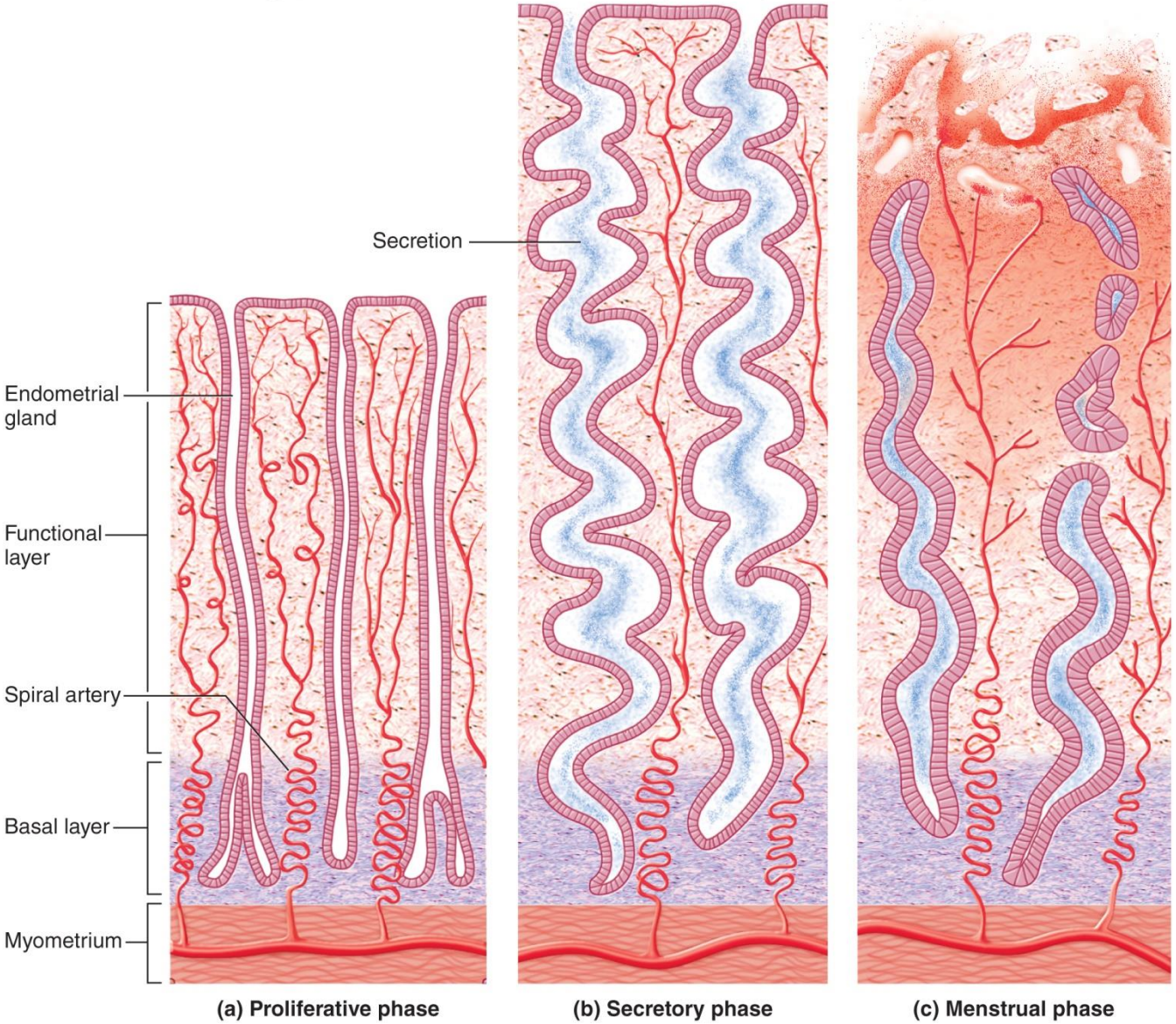


Figure 28.16

Endometriosis

- **Endometriosis**—growth of endometrial tissue outside of the uterus
  - Growth is often on peritoneum of pelvic cavity or on surface of ovary
  - Prevalence: 6% - 10% of women
  - Causes pain, sometimes infertility
  - Believed to result from retrograde menstruation—backward flow of menstrual fluid that exits uterine tube

Female Sexual Response

- **Expected Learning Outcomes**
  - Describe the female sexual response at each phase of intercourse.
  - Compare and contrast the female and male responses.

Female Sexual Response

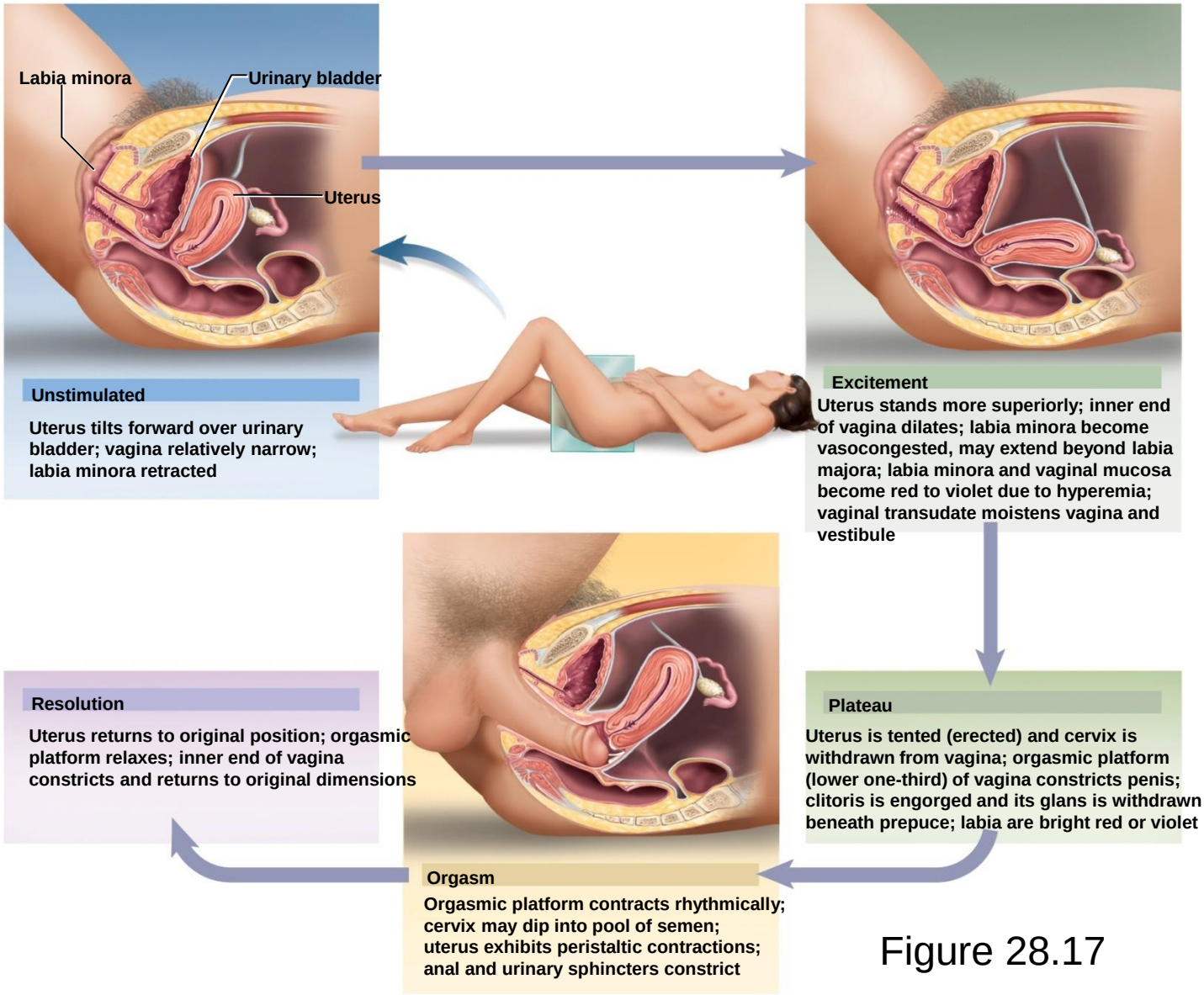


Figure 28.17

Excitement and Plateau

- **Excitement** and **plateau**
  - **Labia minora** become congested with blood and often protrude beyond labia majora
  - **Labia majora** become reddened and enlarged
    - Then flatten and spread away from vaginal orifice
  - **Vaginal transudate:** serous fluid that seeps through the walls of the canal
  - **Greater vestibular gland** secretions moisten the vestibule and provide lubrication

Excitement and Plateau

(Continued)

- Lower one-third of vagina constricts: **orgasmic platform**
  - **Narrower canal** and **vaginal rugae** enhance stimulation and help induce orgasm in both partners
- Upper end of vagina dilates (becomes cavernous)
- **Tenting effect:** uterus stands nearly vertical, where normally it tilts forward over the bladder
- Breasts swell and nipples become erect
- Erectile **clitoris** is primary focus of sexual stimulation

Orgasm

- **Orgasm**
  - Late in plateau phase, many women experience involuntary pelvic thrusts, followed by 1 to 2 sec of “suspension” or “stillness” preceding orgasm
  - **Orgasm:** intense sensation spreading from clitoris through the pelvis
    - Sometimes with **pelvic throbbing** and a spreading sense of **warmth**
    - Pelvic platform gives three to five strong contractions about 0.8 sec apart
    - **Cervix** plunges spasmodically into vagina

Orgasm

(Continued)

- **Uterus** exhibits peristaltic contraction
- Anal and urethral sphincters constrict
- **Paraurethral glands** (homologous to prostate) sometimes expel copious fluid similar to prostatic fluid (female ejaculation)
- Tachycardia, hyperventilation
- Sometimes women experience **reddish, rash-like flush** on the lower abdomen, chest, neck, and face

Resolution

- During resolution, the **uterus** drops forward to its resting position
- **Orgasmic platform** quickly relaxes
  - Rest of vagina returns more slowly to normal dimensions
- **Flush** disappears quickly
- **Areolae and nipples** undergo rapid detumescence
  - Breasts may take 5 to 10 minutes to return to normal size
- Postorgasmic **perspiration**
- Women do not have **refractory period**
  - May quickly experience additional orgasms

Pregnancy and Childbirth

- **Expected Learning Outcomes**
  - List the major hormones that regulate pregnancy and explain their roles.
  - Describe a woman's bodily adaptations to pregnancy.
  - Identify the physical and chemical stimuli that increase uterine contractility in late pregnancy.
  - Describe the mechanisms of labor contractions.
  - Name and describe the three stages of labor.
  - Describe the physiological changes that occur in a woman during the weeks following childbirth.

Pregnancy and Childbirth

- **Gestation (pregnancy)**
  - Lasts an average of **266 days** from conception to childbirth
  - Gestational calendar measured from first day of the woman's **last menstrual period (LMP)**
- **Birth predicted 280 days (40 weeks) from LMP**
  - **Term:** the duration of pregnancy
  - **Trimesters:** three 3-month intervals in the term

Prenatal Development

- **Conceptus**—all products of conception: the embryo or fetus, the placenta, and associated membranes
  - **Blastocyst:** the developing individual is a hollow ball for the first 2 weeks
  - **Embryo:** from day 16 through week 8
  - **Fetus:** from beginning of week 9 to birth
    - Attached by way of **umbilical cord** to a disc-shaped **placenta**
      - Provides fetal nutrition and waste disposal, secretes hormones that regulate pregnancy, mammary development, and fetal development
  - **Neonate:** newborn to 6 weeks

Hormones of Pregnancy

- **Hormones with strongest influence on pregnancy:**
  - **Estrogens**
  - **Progesterone**
  - **Human chorionic gonadotropin**
  - **Human chorionic somatomammotropin**
- All primarily secreted by the **placenta**
  - **Corpus luteum** is important source for first several weeks
    - If corpus luteum removed before 7 weeks, pregnancy terminates
  - From week 7 to week 17, the corpus luteum degenerates and placenta takes over its endocrine function

Hormones of Pregnancy

- **Human chorionic gonadotropin (HCG)**
  - Secreted by blastocyst and placenta
  - Detectable in urine 8 to 9 days after conception by home pregnancy test kits
  - Stimulates growth of corpus luteum
    - Corpus luteum secretes increasing amounts of progesterone and estrogen

Hormones of Pregnancy

- **Estrogens**
  - Increases to 30 times normal by the end of gestation
  - **Corpus luteum** is source for first 12 weeks until **placenta** takes over
  - Causes **tissue growth** in fetus and mother
    - Mother's uterus and external genitalia enlarge
    - Mammary ducts grow, breasts increase to nearly twice their normal size
    - Relaxes pubic symphysis and widens pelvis

Hormones of Pregnancy

- **Progesterone**
  - Secreted by placenta and corpus luteum
  - Suppresses secretion of FSH and LH, preventing follicular development during pregnancy
  - Suppresses uterine contractions
  - Prevents premature childbirth and menstruation
  - Promotes proliferation of **decidual cells** of the endometrium on which the blastocyst feeds
  - Stimulates development of acini in breast

Hormones of Pregnancy

- **Human chorionic somatomammotropin (HCS)**
  - Placenta begins its secretion about week 5
    - Amount secreted increases steadily until term
      - High concentration of hormone but function is poorly understood
    - Effects seem similar to growth hormone, but weaker
    - Seems to reduce the mother's insulin sensitivity and glucose usage, leaving more for the fetus

Hormones of Pregnancy

- Woman's **pituitary gland** grows about 50% larger during pregnancy
  - Produces markedly elevated levels of thyrotropin, prolactin, and ACTH
- **Thyroid gland** becomes 50% larger under influence of HCG, pituitary thyrotropin, and human chorionic thyrotropin from placenta
  - Increases metabolic rate of mother and fetus
- **Parathyroid glands** enlarge and increase osteoclast activity

Hormones of Pregnancy

- **ACTH** stimulates glucocorticoid secretion
  - This mobilizes amino acids for fetal protein synthesis
- **Aldosterone** secretion rises, promoting fluid retention and increasing mother's blood volume
- **Relaxin** secreted by corpus luteum and placenta
  - Synergizes progesterone in stimulating multiplication of decidual cells
  - Promotes growth of blood vessels in the pregnant uterus

Hormone Levels over Course of Pregnancy

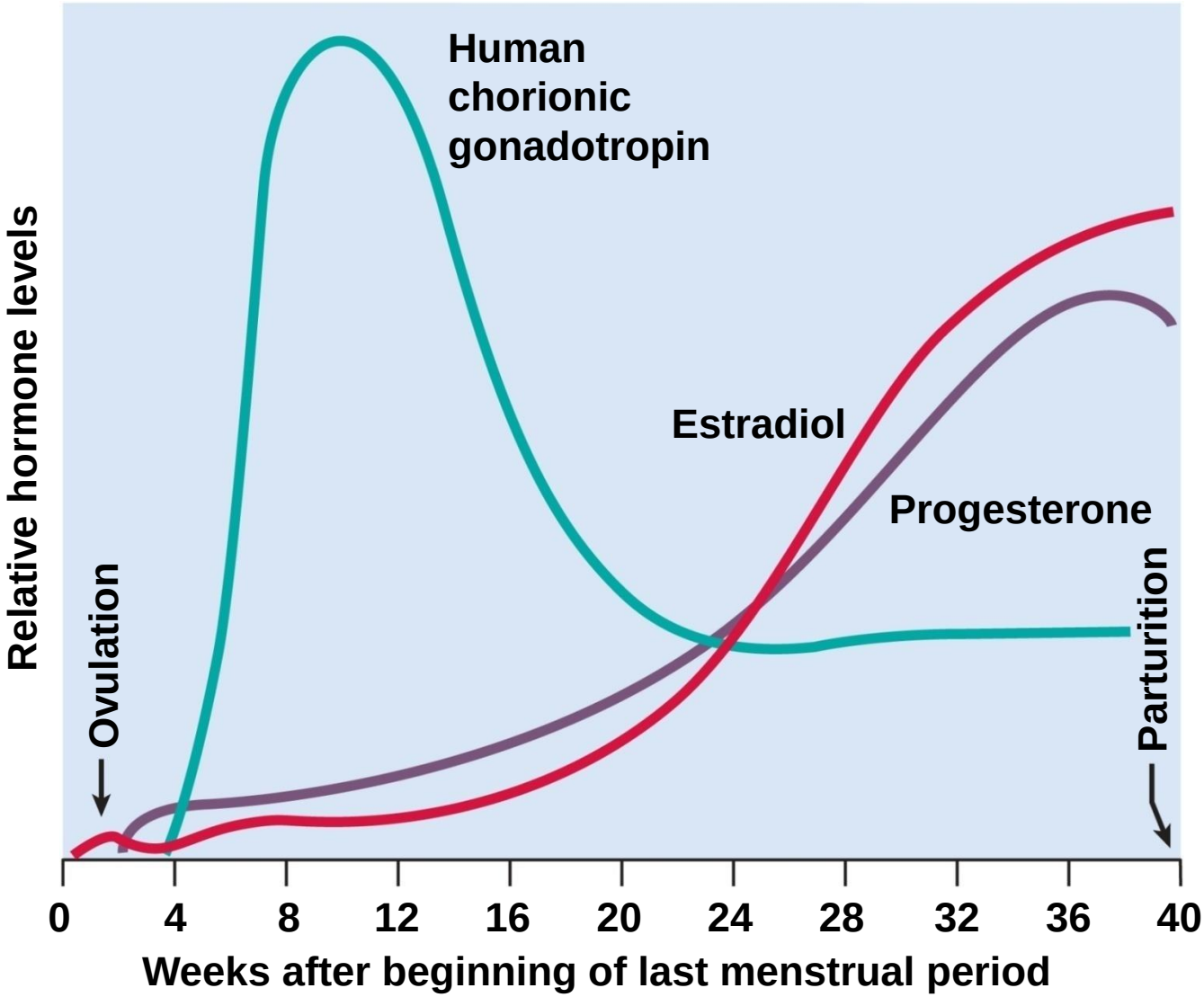


Figure 28.18

Adjustments to Pregnancy

- **Digestive system**
  - **Morning sickness:** nausea; especially arising from bed in first few months of gestation
    - Unknown cause
  - **Constipation** and **heartburn** due to:
    - Reduced intestinal motility
    - Pressure on stomach causing reflux of gastric contents into esophagus
- **Metabolism**
  - **Basal metabolic rate (BMR):** rises about 15% in second half of gestation
    - Appetite may be strongly stimulated
    - Healthy average weight gain: 24 lb

Adjustments to Pregnancy

- **Nutrition**
  - Placenta stores nutrients in early gestation and releases them in the last trimester
  - Demand especially high for **protein, iron, calcium,** and **phosphates**
  - Pregnant woman needs **extra iron** during late pregnancy or will become anemic

Adjustments to Pregnancy

(Continued)

- **Vitamin K** given in late pregnancy and to newborns to promote prothrombin synthesis
  - Minimizes risk of neonatal hemorrhage, especially in the brain
- **Vitamin D** supplements help ensure adequate calcium absorption to meet fetal demand
- **Folic acid** reduces the risk of neurological fetal disorders
  - Spina bifida, anencephaly
  - Supplements must be started before pregnancy

Adjustments to Pregnancy

- **Circulatory system**
  - By full term, **placenta** requires 625 mL of blood per minute from the mother
  - Mother's **blood volume** rises about 30% during pregnancy
    - Due to fluid retention and hemopoiesis
    - Mother has about 1 to 2 L of extra blood

Adjustments to Pregnancy

(Continued)

- Mother's **cardiac output** rises 30% to 40% above normal by week 27
  - Falls almost to normal during the last 8 weeks
- Pregnant uterus puts pressure on large pelvic blood vessels: interferes with venous return from legs
  - Can result in hemorrhoids, varicose veins, and edema of the feet

Adjustments to Pregnancy

- **Respiratory system**
  - Tidal volume and minute ventilation increase about 40%
    - Respiratory rate remains constant
  - Two reasons for increased ventilation
    - Oxygen demand rises in proportion to the woman's increase in metabolic rate and the increasing needs of the fetus
    - Progesterone increases the sensitivity of the woman's chemoreceptors to carbon dioxide
      - Ventilation adjusted to keep carbon dioxide levels lower than normal

Adjustments to Pregnancy

Respiratory system adjustments (Continued)

- Low carbon dioxide level in mother's blood promotes CO_2 diffusion from fetal bloodstream into maternal blood
- Some mothers feel "air hungry" from sensitiveity to CO_2 and from pressure on diaphragm from growing uterus
- Breathes more easily in the last month due to pelvic expansion, causing the fetus to drop lower in the pelvic cavity, and thus taking pressure off diaphragm

Adjustments to Pregnancy

- **Urinary system**
  - Aldosterone and steroids of pregnancy promote **water and salt retention by kidneys**
  - **Glomerular filtration rate** increases 50% and urine output is slightly elevated
    - Enables woman to dispose of both her own and the fetus's metabolic wastes
  - Pregnant uterus **compresses the bladder** and reduces its capacity
    - Frequent urination and uncontrollable leakage of urine **(incontinence)**

Adjustments to Pregnancy

- **Integumentary system**
  - Skin grows to accommodate expansion of abdomen and breasts
  - Added fat deposition in hips and thighs
  - Striae or **stretch marks** can result from tearing the stretched connective tissue
    - Reddish at first, but fade after pregnancy
  - **Melanocyte activity** increases in some areas
    - Darkening of the areolae and linea alba (linea nigra)
  - Temporary blotchy darkening of the skin over the nose and cheeks
    - “Mask of pregnancy” or **chloasma**
    - Disappears after pregnancy

Uterine Growth and Weight Gain

- **Uterus weighs about 900 g at the end of pregnancy**
  - Weighs only 50 g when not pregnant
  - Reaches almost to the xiphoid process

TABLE 28.3	Distribution of Weight Gain in Pregnancy
Fetus	3 kg (7 lb)
Placenta, fetal membranes, and amniotic fluid	1.8 kg (4 lb)
Blood and tissue fluid	2.7 kg (6 lb)
Fat	1.4 kg (3 lb)
Uterus	0.9 kg (2 lb)
Breasts	0.9 kg (2 lb)
Total	**11 kg (24 lb)**

The Full-Term Fetus in Vertex Position

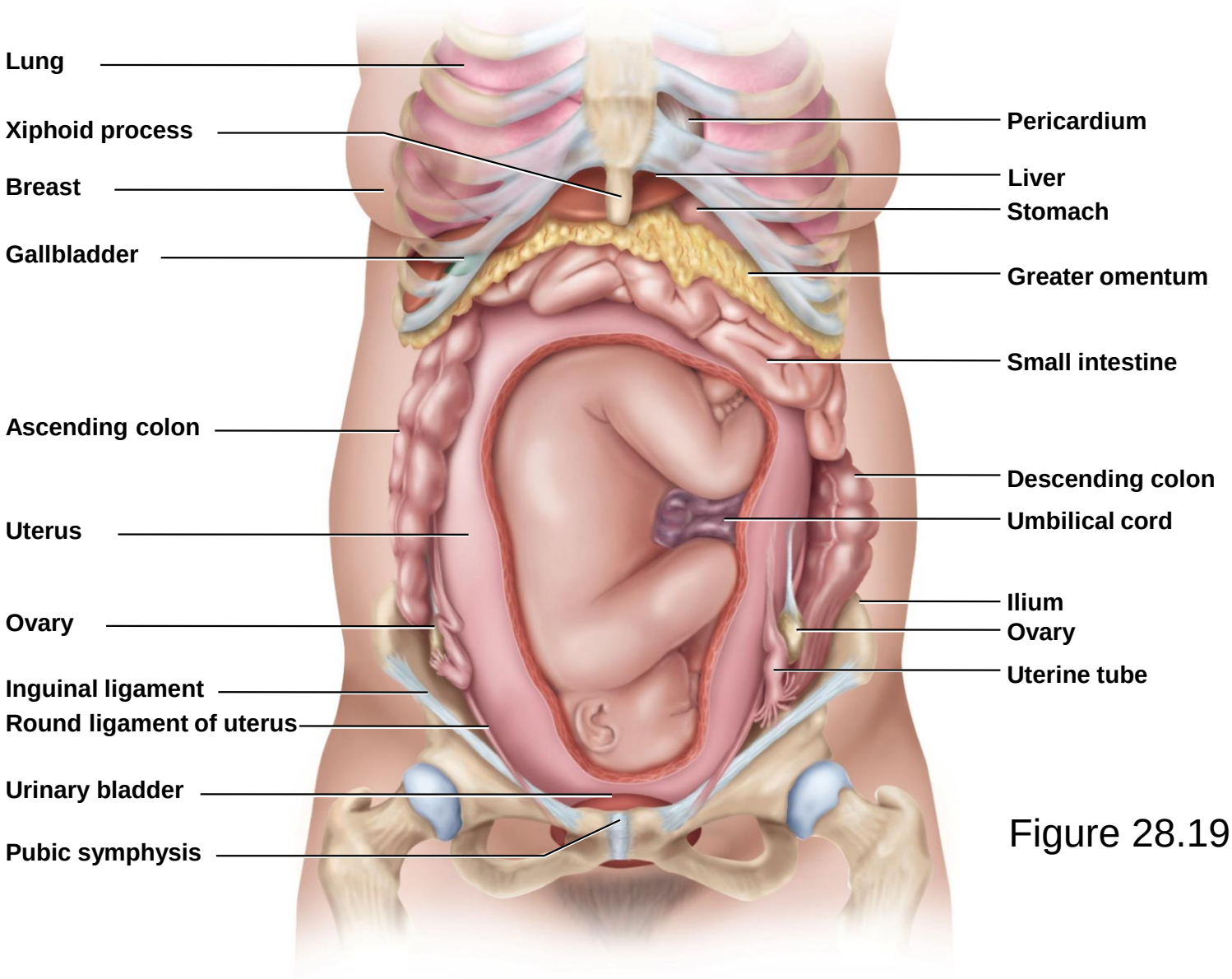


Figure 28.19

Childbirth

- In the seventh month of gestation, the fetus normally turns into the head-down **vertex position**
  - Most babies born head first
  - Head acting as a wedge that widens the mother's cervix, vagina, and vulva during birth
- **Fetus is a passive player in its own birth**
  - Expulsion achieved by contractions of mother's uterine and abdominal muscles
  - Fetus may play a role chemically by stimulating labor contractions
  - Sending chemical messages that signify when it is developed enough to be born

Uterine Contractility

- **Braxton Hicks contractions**—relatively weak contractions of the uterus over the course of gestation
  - Strengthen late in pregnancy: **false labor**
  - Contractions transform suddenly into more powerful labor contractions
- **Parturition**—the process of giving birth
  - Marked by the onset of true labor contractions

Uterine Contractility

- **Progesterone and estradiol balance may be one factor in this pattern of increasing contractility**
  - **Progesterone** inhibits uterine contractions, but its secretion levels off or declines after 6 months
  - Estradiol stimulates uterine contractions, and continues to rise

Uterine Contractility

(Continued)

- As pregnancy nears full term—**posterior pituitary** releases more **oxytocin (OT),** uterus produces more OT receptors
  - Oxytocin promotes labor in two ways
    - Directly stimulates muscles of myometrium
    - Stimulates fetal membranes to produce prostaglandins, which are synergists of oxytocin in producing labor contractions

Uterine Contractility

- **Conceptus may produce chemical stimuli promoting its own birth**
  - Fetal cortisol rises and may increase estrogen secretion by the placenta
  - Fetal pituitary produces oxytocin, which may stimulate fetal membranes to produce prostaglandin
- **Uterine stretching thought to play a role in initiating labor**
  - Stretching of smooth muscle increases contractility of smooth muscle

Labor Contractions

- **Labor contractions begin about 30 minutes apart and eventually occur every 1 to 3 minutes**
  - Periodically relax to increase blood flow and oxygen delivery to placenta and fetus
  - Contractions strongest in fundus and body of uterus
    - Weakest in the cervix
    - Pushes fetus downward

Labor Contractions

- **Positive feedback theory of labor**
  - Labor induced by stretching of cervix
  - Triggers a reflex contraction of the uterine body
  - Pushes the fetus downward
  - Stretches the cervix even more
  - Self-amplifying cycle of stretch and contraction

Labor Contractions

(Continued)

- Cervical stretching induces a **neuroendocrine reflex** through spinal cord, hypothalamus, and posterior pituitary
  - Posterior pituitary releases **oxytocin**
  - Carried by the blood and stimulates uterine muscles
    - Directly and through the action of prostaglandin
- **Cervical stretching → oxytocin secretion → uterine contraction → cervical stretching**

Labor Contractions

- Woman feels need to **“bear down”**
  - Contraction of abdominal muscles aids in expelling the fetus
  - Especially when combined with the **Valsalva maneuver** for increasing intra-abdominal pressure

Labor Contractions

- At first, **pain** of labor is mainly due to **ischemia** of the myometrium
  - Muscles hurt when they are deprived of blood, and contractions restrict circulation
- **As fetus enters vagina, pain becomes stronger**
  - Stretching of the cervix, vagina, and perineum, sometimes with tearing
  - **Episiotomy** may be necessary: an incision in the vulva to widen the vaginal orifice to prevent random tearing
  - Pain is an evolutionary product of two factors
    - Unusually large brain and head of the human infant
    - Narrowing of the pelvic outlet which helped humans adapt to bipedal locomotion

Stages of Labor

- Labor occurs in **three stages**
  - **Dilation**
  - **Expulsion**
  - **Placental stage**
- Duration of each stage tends to be longer in **primipara**
  - Woman giving birth for the first time
- Shorter in **multipara**
  - Woman who has previously given birth

Stages of Labor

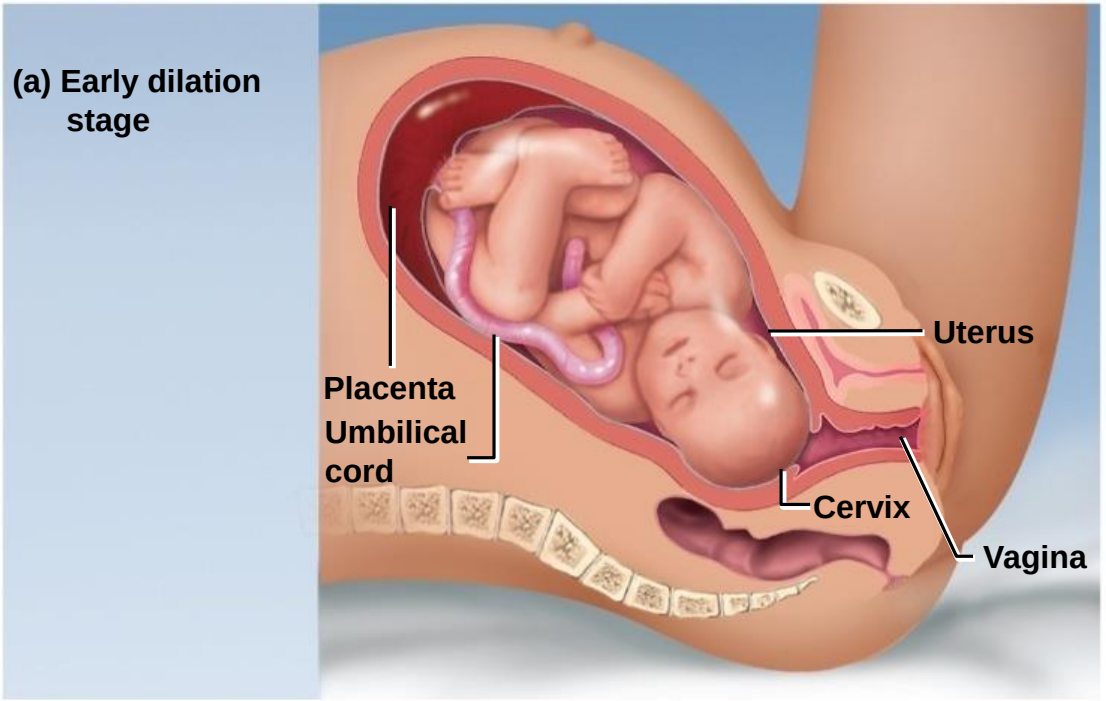


Figure 28.20a

- **Dilation stage**: longest stage—lasting 8 to 24 hours
- **Dilation of cervical canal to 10 cm (size of fetal head) and effacement (thinning) of cervix**
- **Rupture of fetal membranes and loss of amniotic fluid**
  - "Breaking of the waters"

Stages of Labor

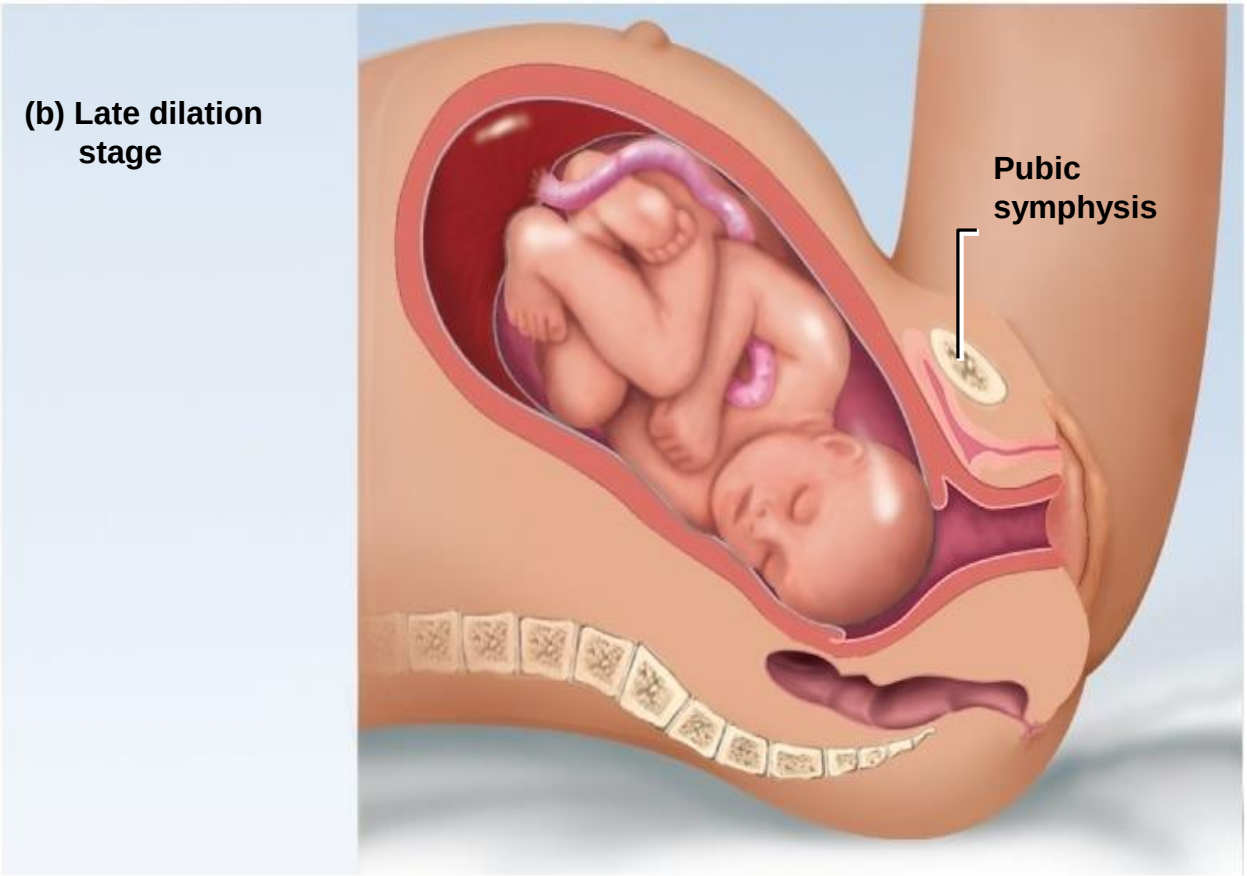


Figure 28.20b

Late dilation—dilation reaches 10 cm in 24 hours or less in primipara (first baby) and in as little as a few minutes in multipara

Stages of Labor

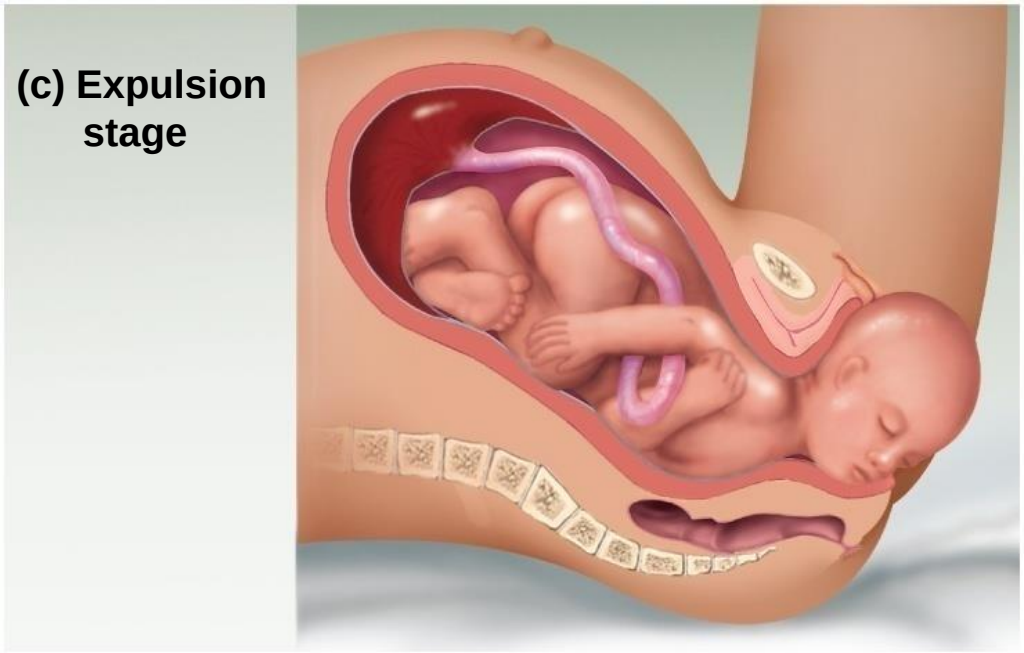


Figure 28.20c

- **Expulsion stage:** from entry of head into vagina until baby is expelled
  - 30-60 minutes in primipara; shorter in multipara
- **Crowning—**when baby's head is visible
  - Delivery of the head is the most difficult part
- **After expulsion, attendant drains blood from umbilical vein into baby**
  - Umbilical cord is clamped and cut

Stages of Labor

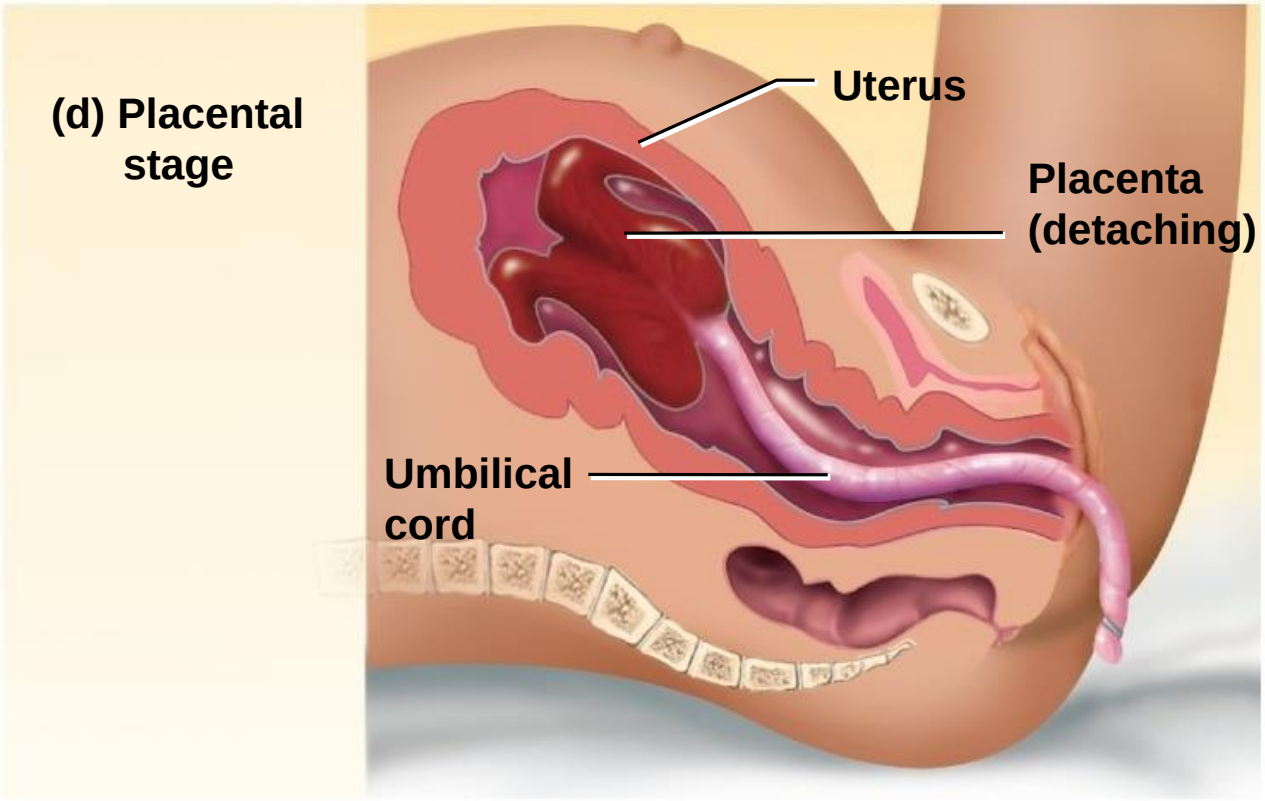


Figure 28.20d

- **Placental stage**: uterine contractions cause placental separation
- **Membranes (afterbirth) inspected to be sure everything has been expelled**

Childbirth

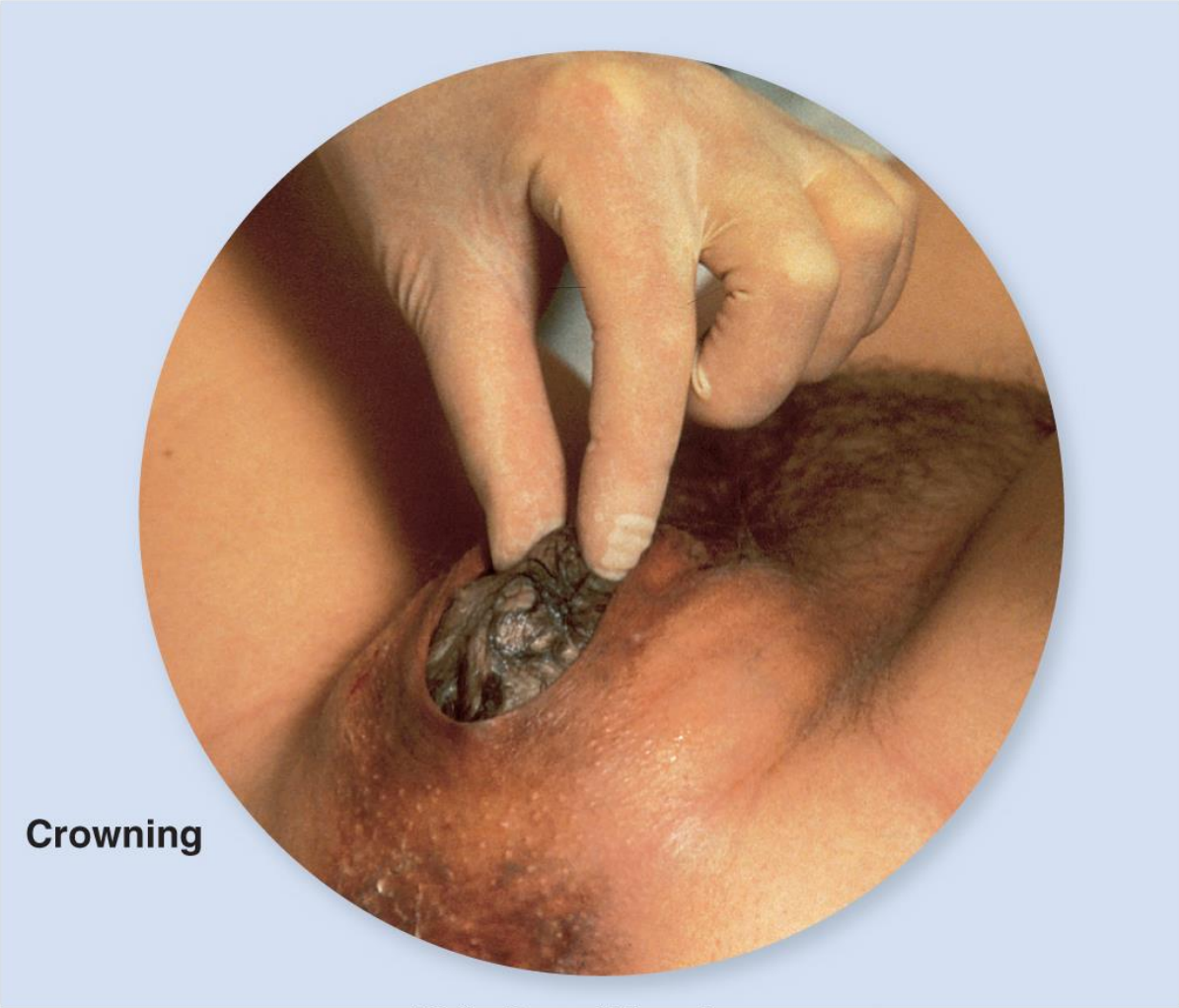


Figure 28.20a

Childbirth

Figure 28.20b

Childbirth

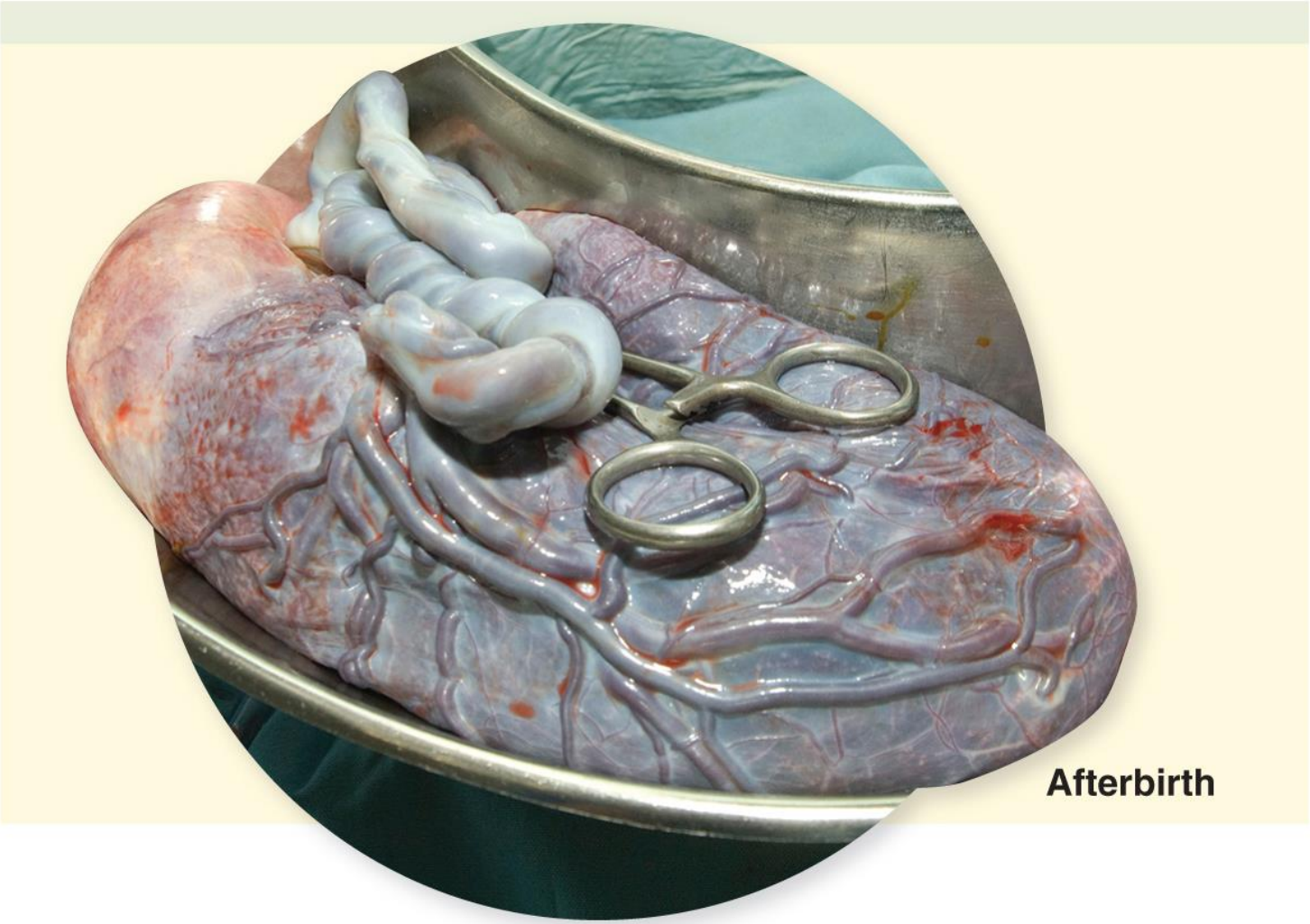


Figure 28.20c

The Puerperium

- First 6 weeks **postpartum (after birth): puerperium**
  - Period in which mother's anatomy and physiology stabilize and reproductive organs return nearly to **pregravid state (condition prior to pregnancy)**
    - **Involution—**shrinkage of the uterus
      - Loses 50% of its weight in the first week
      - Involution is achieved by **autolysis (self-digestion)** of uterine cells by their own lysosomal enzymes
      - For about 10 days produces a vaginal discharge, called **lochia**
      - Bloody at first and then turns serous

The Puerperium

- **Breast-feeding** promotes involution
  - Suppresses estrogen secretion which would make the uterus more flaccid
  - Stimulates oxytocin secretion which causes myometrium to contract and firm up the uterus sooner

Lactation

- **Expected Learning Outcomes**
  - Describe development of the breasts in pregnancy.
  - Describe the shifting hormonal balance that regulates the onset and continuation of lactation.
  - Describe the mechanism of milk ejection.
  - Contrast colostrum with breast milk.
  - Discuss the benefits of breast-feeding.

Lactation

- **Lactation**—the synthesis and ejection of milk from the mammary glands
  - Lasts as little as 1 week in women who do not breast-feed their infants
  - Can continue for many years as long as the breast is stimulated by a nursing infant or a mechanical device **(breast pump)**
  - Women traditionally nurse their infants until a median age of about **2.8 years**

Development of the Mammary Glands in Pregnancy

- High estrogen level in pregnancy causes ducts of mammary glands to grow and branch
- Growth hormone, insulin, glucocorticoids, and prolactin contribute to this development
- Progesterone stimulates the budding and development of acini at the end of the ducts
- Acini organized into grape-like clusters (lobules) within each breast lobe

Colostrum and Milk Synthesis

- **Colostrum** forms in late pregnancy
  - Similar to breast milk in protein and lactose, but contains one-third less fat
  - Sole nutrition source for first 1 to 3 days after birth
  - Thin watery consistency and a cloudy yellow color
  - Contains IgA to protect baby from gastroenteritis

Colostrum and Milk Synthesis

- **Prolactin (from anterior pituitary)** promotes milk synthesis
  - Inhibited by dopamine when not pregnant
  - Synthesis of hormone begins 5 weeks into pregnancy, by full term it is 10 to 20 times normal level
    - Little effect on mammary glands until after birth since steroids from placenta oppose it
  - Milk synthesis also requires growth hormone, cortisol, insulin, and parathyroid hormone to mobilize necessary amino acids, fatty acids, glucose, and calcium

Colostrum and Milk Synthesis

- **At birth, prolactin secretion drops to nonpregnancy levels**
- **Every time infant nurses, prolactin levels jump to 10 to 20 times this level for an hour**
  - Stimulates synthesis of milk for the next feeding
  - Without nursing, milk production stops in 1 week
- **Only 5% to 10% of women become pregnant while breast-feeding**
  - Inhibition of GnRH and reduced ovarian cycling
  - Natural means of spacing births

Prolactin Secretion in the Lactating Female

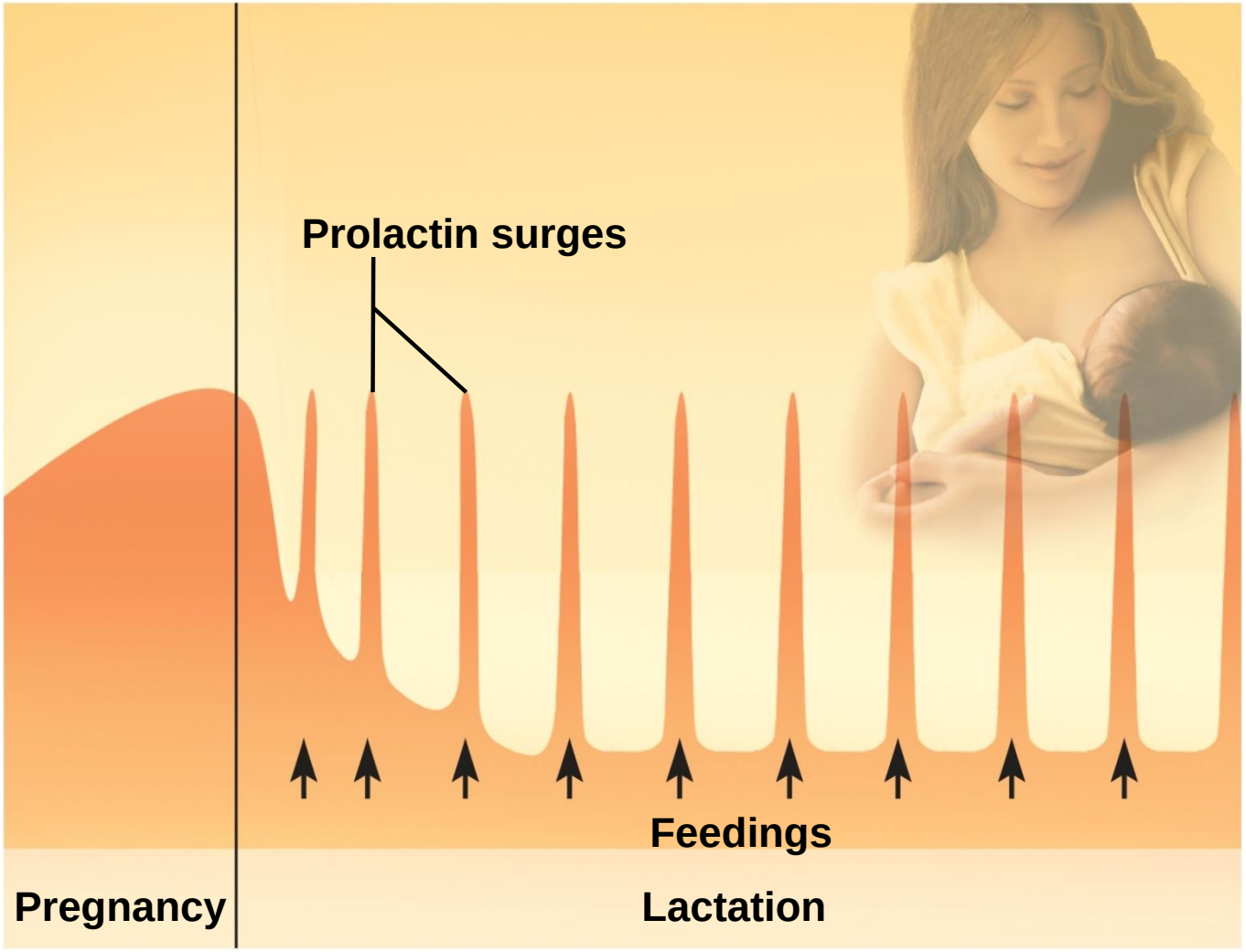


Figure 28.21

Milk Ejection

- **Milk is continually secreted into mammary acini, but does not easily flow into the ducts**
- **Milk ejection (letdown)** is controlled by a **neuroendocrine reflex**
  - Infant's suckling stimulates sensory receptors in nipple, signaling hypothalamus and posterior pituitary to release oxytocin
  - **Oxytocin** stimulates **myoepithelial cells** around each acinus
  - Contract to squeeze milk into duct
    - Milk flow within 30 to 60 seconds after suckling begins

Breast Milk

- **Breast milk changes composition**
  - Changes over the first 2 weeks
  - Varies from one time of day to another
  - At the end of a feeding there is less lactose and protein, but six times the fat
- **Cow's milk not a good substitute**
  - One-third less lactose but three times as much protein
  - Harder to digest and more nitrogenous waste (diaper rash)

Breast Milk

- Colostrum and milk have a laxative effect that clears intestine of **meconium** (green, bile-filled fecal material in newborn)
- **Supplies antibodies and colonizes intestine with beneficial bacteria**
- **Nursing woman can produce 1.5 L of milk per day**

Methods of Contraception

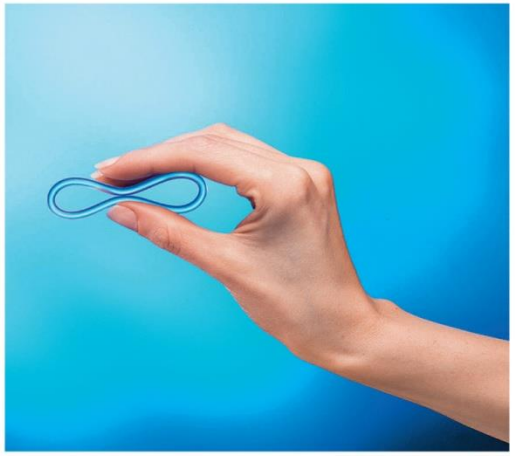
Male condom

Female condom

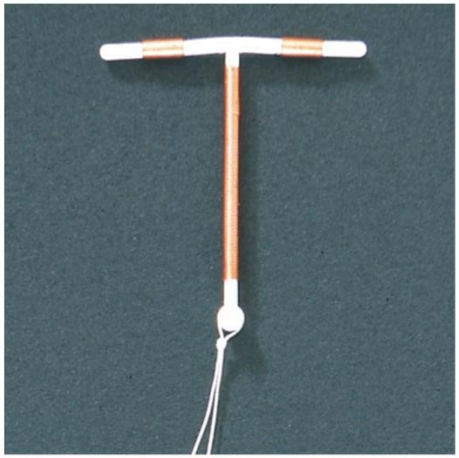
Diaphragm with contraceptive jelly

Contraceptive foam with vaginal applicator

Birth-control pills



NuvaRing



Intrauterine device (IUD)

Figure 28.22

Methods of Contraception

- **Contraception**—any procedure or device intended to prevent pregnancy
- **Behavioral methods**
  - Abstinence
  - Rhythm method (periodic abstinence)
  - Withdrawal (coitus interruptus)
- **Barrier and spermicidal methods**
  - Male and female condom, diaphragm, sponge
  - Spermicides: foams, creams, jellies

Methods of Contraception

- **Hormonal methods**
  - Most hormonal methods prevent ovulation
  - “The pill” (estrogen and progestin), patch, injection, or vaginal ring
    - Ovarian follicles do not mature as FSH, LH are inhibited
  - “Morning after pills” = emergency contraceptive pills
    - High dose of estrogen and progestin or progestin alone
    - Induce menstruation if implantation has not occurred
    - Inhibit ovulation, inhibit movement of sperm and egg, inhibit implantation
  - RU-486: progesterone antagonist
    - Induces abortion up to 2 months into pregnancy

Methods of Contraception

- **Intrauterine device (IUD)**
  - Springy device that is left in place for extended period of time
  - Irritates uterine lining and interferes with implantation
- **Surgical sterilization**
  - Clamping or cutting the genital ducts (uterine tubes or ductus deferens)

Methods of Contraception

Failure Rates of Contraceptive Methods

Method	Rate of Failure (Pregnancies per 100 Users)	
	Perfect Use	Typical Use
No protection	85	85
Rhythm method	3–5	25
Withdrawal	4	27
Spermicide alone	18	26
Condom alone (male or female)	2–5	15–21
Diaphragm with spermicide	6	16
Vaginal sponge	9–20	16–32
Birth-control pill, patch, or NuvaRing	0.3–0.5	8
Medroxyprogesterone	0.3	3
Intrauterine device	0.2–0.6	0.2–0.8
Vasectomy	0.10	0.15
Tubal ligation	0.5	0.5

[50] *ligat* = to tie