CHAPTER 5

# Gynecologic Anatomy and Physiology

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The women's health movement encourages women to be knowledgeable about their bodies, to appreciate the unique form and function of the female body, and to take responsibility for caring and making decisions about their bodies that will positively affect their health. This chapter reviews female anatomy and physiology in terms of how they directly affect gynecologic health and well-being.

Female anatomy and physiology are often referred to as reproductive anatomy and physiology. Gynecology is defined as the branch of medicine dealing with the study of diseases and treatment of the female reproductive system. Regardless of whether a woman is pregnant or ever intends to reproduce, her gynecologic care has historically focused on reproduction. This example of naming provides insight into why women often continue to be essentialized to reproductive functions by clinicians.

The authors of this chapter assume the reader has had basic human anatomy and physiology content. Readers requiring a more in-depth discussion are referred to general anatomy and physiology references.

## PELVIC ANATOMY

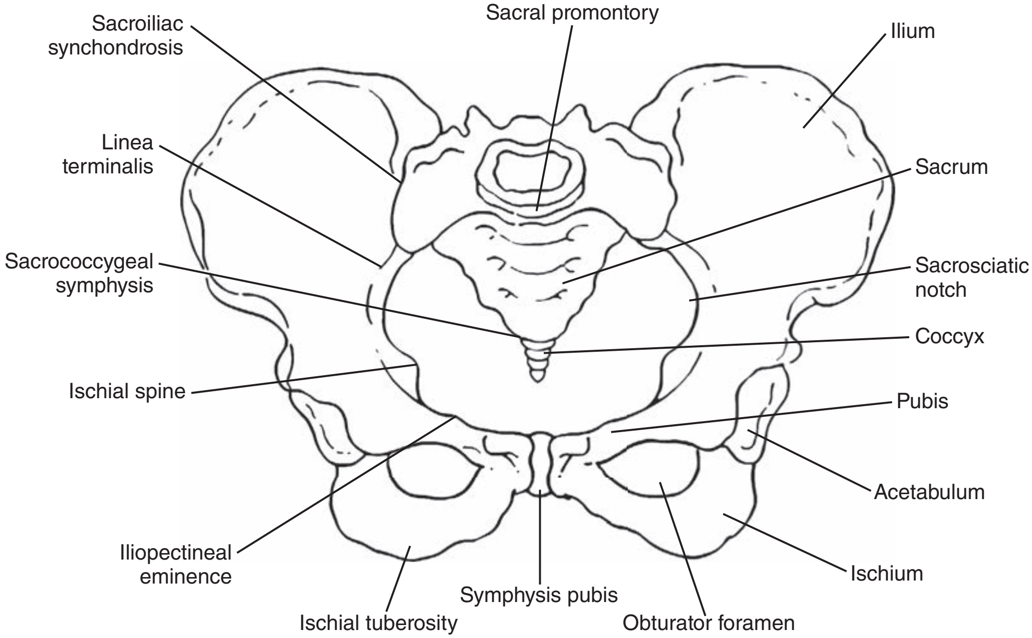
### Pelvic Bones and Pelvic Joints

The pelvis is composed of (1) two hip bones called the innominate bones (also known as *ox coxae*), (2) the sacrum, and (3) the coccyx. The innominate bones consist of the pubis, the ischium, and the ilium, all of which are fused together at the acetabulum (Corton, 2012). The ilium comprises the posterior and upper portion of the innominate bone, forming what is known as the iliac crest. It articulates with the sacroiliac joint posteriorly, and together with its ligaments is the major contributor to pelvic stability. The pubic bones articulate anteriorly with the symphysis pubis and, with their inferior angles from the descending rami, form the important bony landmark of the pubic arch (**Figure 5-1**). The ischial spines are bony prominences that are clinically important because they are used as landmarks when performing pudendal blocks and in other medical procedures such as sacrospinous ligament suspension (Anderson & Gendry, 2007). The ischial spines are also used to assess progression of fetal descent during childbirth.

The sacrum and the coccyx shape the posterior portion of the pelvis. The sacrum is formed by the fusion of the five sacral vertebrae, which includes the important bony landmark of the sacral promontory, and joins the coccyx at the sacrococcygeal symphysis. The coccyx is formed by the fusion of four rudimentary vertebrae, is usually movable, and is itself a key bony landmark. The true pelvis constitutes the bony passageway through which the fetus must maneuver to be born vaginally.

The best-known classification of the female pelvis is the Caldwell–Moloy (1933) classification,

FIGURE 5-1 **Bones of the female pelvis.**



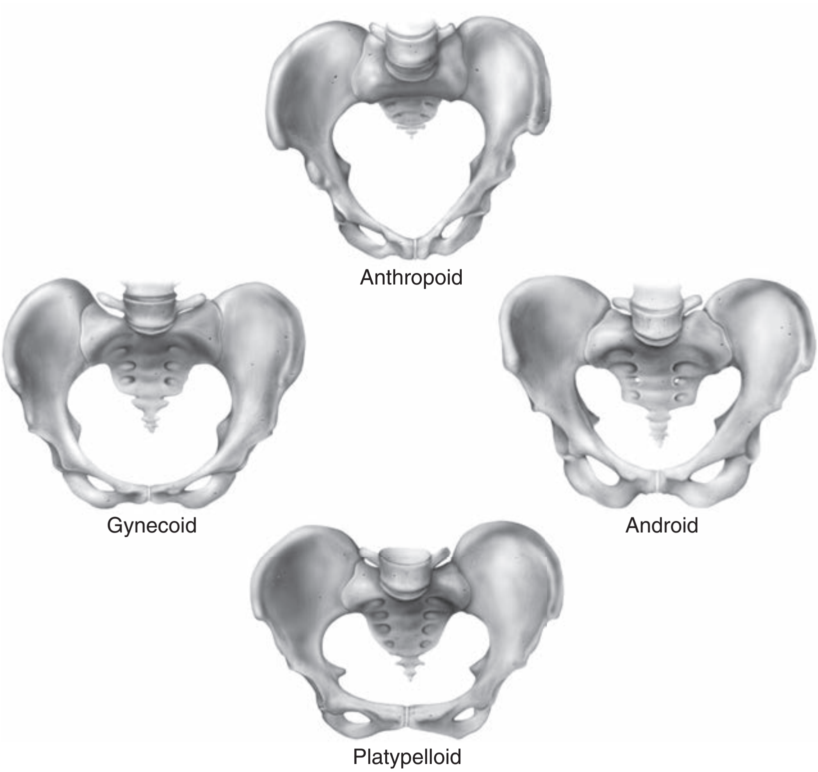

which includes four basic pelvic types: gynecoid, android, anthropoid, and platypelloid (**Figure 5-2**). Each pelvic type is classified in accordance with the characteristics of the posterior segment of the inlet. The development of this classification resulted in the realization that most pelves are not pure types but rather a mixture of types (Kolesova & Vetra, 2012).

## Pelvic Support

Pelvic support structures include not only the muscles and connective tissue of the pelvic floor, but also the fibromuscular tissue of the vaginal wall and endopelvic connective tissue (Richter & Varner, 2007). The piriformis and obturator internus muscles and their fasciae form part of the walls of the pelvic cavity. The piriformis muscle originates at the front of the sacrum, near the third and fourth sacral foramina. This muscle leaves the pelvis by passing laterally through the greater sciatic foramen and inserts in the upper border of the greater trochanter of the femur. The origin of the obturator internus muscle includes the pelvic surfaces of the ilium and ischium and the obturator membrane. It exits the pelvis through the lesser sciatic foramen, where it attaches to the greater trochanter of the hip, enabling it to function in external hip rotation (Anderson & Gendry, 2007; Corton, 2012).

The deep perineal space is a pouch that lies superiorly to the perineal membrane (**Figure 5-3**). This deep space is continuous with the pelvic cavity and contains the compressor urethrae and urethrovaginal sphincter muscles, the external urethral sphincter, parts of the urethra and vagina, branches of the pudendal artery, and the dorsal nerve and vein of the clitoris (Corton, 2012). The perineal membrane (also known as the urogenital diaphragm, although this label is a misnomer) is a sheet made up of dense

**FIGURE 5-2** **Caldwell–Moloy classification of pelves.**

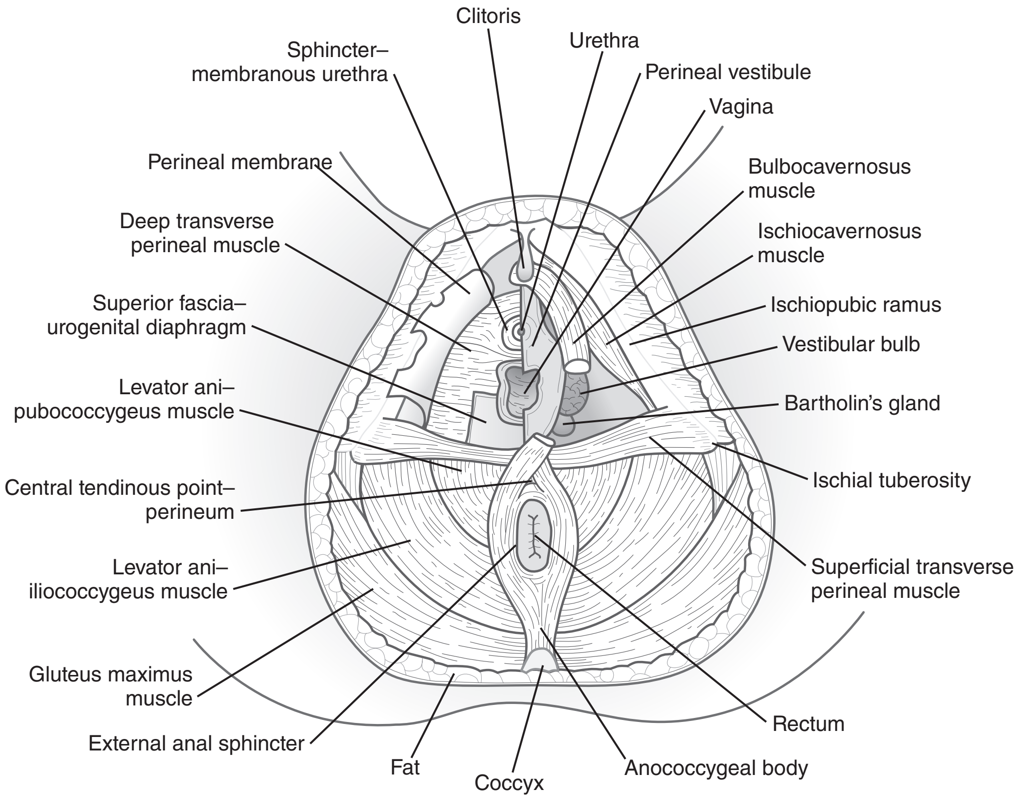



fibrous tissue that spans the opening of the anterior pelvic outlet. The perineal membrane attaches to the side walls of the vagina and provides support to the distal vagina and urethra by attaching these structures to the bony pelvis (Corton, 2012).

The levator ani muscle is a critical component of pelvic support; indeed, it is often considered the most important muscle of the pelvic floor (Corton, 2012). Normally this muscle is in a constant state of contraction, providing support for all of the abdominopelvic contents against intra-abdominal pressures. The levator ani muscle is actually a complex unit of several muscles with different origins, insertions, and functions. The pubococcygeus, puborectalis, and iliococcygeus are the primary components making up this muscle. The pubococcygeus is further divided into the pubovaginalis, puboperinealis, and puboanalis.

The levator ani and coccygeus muscles form the pelvic floor, and the related fascia form a supportive sling for the pelvic contents. The muscle fibers insert at various points in the bony pelvis and form functional sphincters for the vagina, rectum, and urethra. The origin of the levator ani muscle is the pubic bone and the adjacent fascia of the obturator internus muscle. Various portions of this muscular sheet insert on the coccyx (the anococcygeal rapine) and the perineal body, which is a fibrous band lying between the vagina and the rectum. The different sections of the levator ani muscular sheet are subdivided based on the exact origin and insertion of the fibers:

FIGURE 5-3 **Superficial musculature of the perineum.**




- The levator prostatae or sphincter vaginae fibers form the sling around the vagina and originate from the posterior surface of the pubis; they insert in the perineal body.
- The puborectalis fibers are important in maintaining fecal continence; they originate from the posterior surface of the pubis and form a sling around the rectum.
- The pubococcygeus fibers originate from the posterior surface of the pubis and insert into the anococcygeal rapine.
- The iliococcygeus fibers originate from the obturator internus fascia and the ischium and insert into the anococcygeal rapine.

The fan-shaped coccygeus muscle lies anterior to the sacrospinous ligament, originates from the ischial spine, inserts into the lower part of the sacrum and coccyx, and works synergistically to aid the levator ani muscle. The transverse perinei are small straplike muscles that help support the pelvic viscera. They originate from the ischial tuberosity, pass by the genitalia, and insert in the central tendon at the midline. The bulbocavernosus muscles aid in strengthening the pelvic diaphragm and in constricting the urinary and vaginal openings. Their muscle fibers originate in the perineal body and surround the vaginal openings as the muscle fibers pass forward to insert into the pubis. The ischiocavernous muscle contracts to cause erection of the clitoris during sexual arousal. Its muscle fibers originate in the tuberosities of the ischium and continue at an angle to insert next to the bulbocavernosus muscle (Anderson & Gendry, 2007; Corton, 2012).

## FEMALE GENITALIA

Dr. Nelson Soucasaux, a Brazilian gynecologist, has devoted much of her writing to the traditionally typical and symbolic aspects of women's sexual organs, and the importance these views have in influencing our understanding of women's nature. According to Soucasaux (1993a, 1993b), historically it was believed that the key to understanding the female psyche was having a deeper understanding of woman's genital functions. By tradition, a woman's uterus was considered "the fundamental organ" and was synonymous with her genital organs. This conception depicted a woman's wholeness to be totally related to her genitals, of which the most important was her uterus. Consequently, there was little appreciation for female genitalia.

This section describes the multiple organs and anatomic structures that constitute a woman's gynecologic anatomy, which are shown in a midsagittal view in **Figure 5-4** and **Color Plate 1**. Equally important to the discussion of women's gynecologic anatomy are the multiple nongenital peripheral anatomic structures involved in female sexual responses, such as salivary and sweat glands, cutaneous blood vessels, and breasts.

### External Genital Anatomy

#### *Vulva*

The vulva is the externally visible outer genitalia (**Figure 5-5** and **Color Plate 2**). It includes the mons pubis, labia minora, labia majora, clitoris, urinary meatus, vaginal opening, and corpus

FIGURE **5-4** **Midsagittal view of a woman's pelvic organs.**

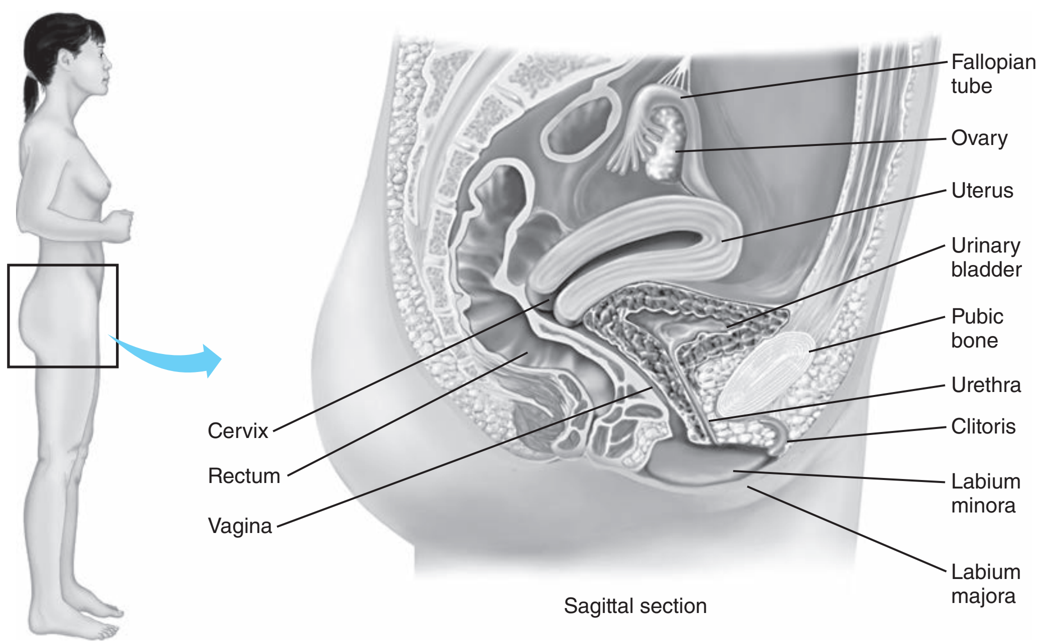
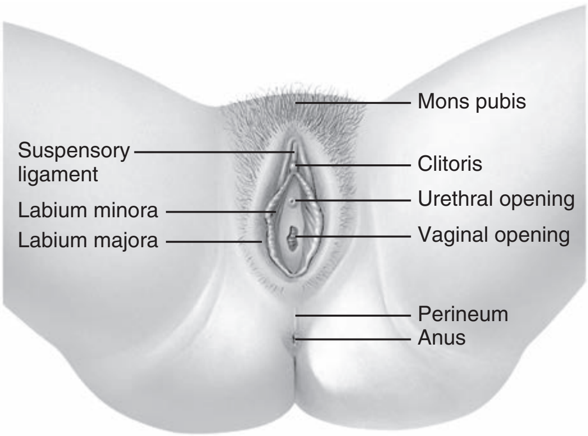


FIGURE 5-5 **Female external genitalia.**




spongiosum erectile tissue (vestibular bulbs) of the labia minora and perineum. The vestibule is inside the labia minora and outside the hymen. On each side of the vestibule is a Bartholin's gland, which secretes lubricating mucus into the introitus during sexual excitement. The mons pubis is the mound-like fatty tissue that covers and protects the symphysis pubis. During puberty, genital hair growth covers this pad of tissue.

The labia majora are fused anteriorly with the mons veneris, or anterior prominence of the symphysis pubis, and posteriorly with the perineal body or posterior commissure. They assist in keeping the vaginal introitus closed, which in turn helps prevent infection. The labia minora are surrounded by the labia majora and are smaller, nonfatty folds covered by non-hair-bearing skin laterally and by vaginal mucosa on the medial aspect. The anterior aspect of the labia minora forms the prepuce of the clitoris and also assists in enclosing the opening of the urethra and the vagina.

Women's vulva vary in size, related to the amount of adipose tissue, length, and pigment color of the labia minora or majora, which may be light pink, dark pink, shades of gray, peach, brown, or black. There is also considerable variation in the size of the labia minora in women of reproductive age. The labia minora are usually more prominent in children and women who are postmenopausal (Katz, 2012).

### Clitoris

The clitoris is a sensitive organ that is typically described as the female homologue of the penis in the male, particularly in terms of its erogenous function (Puppo, 2013). During the early 1800s, a respected English gynecologist, Isaac Baker Brown, theorized that habitual clitoral stimulation was the cause of the majority of women's diseases because it caused an overexcitement of a woman's nervous system. As a result, clitorectomy came into favor as a means to rid women of ailments believed to be caused by clitoral stimulation (Duffy, 1963; Hall, 1998). Fortunately, this theory has long been refuted, and the practice of clitorectomy in the Western world is rare.

Anatomically, the clitoris is formed from the genital tubercle (Bradshaw, 2012; Martini, Timmons, & Tallitsch, 2011). It is 1.5 to 2 cm in length, consists of two crura and two corpora cavernosa, and is covered by a sensitive rounded tubercle known as the glans (Anderson & Gendry, 2007; Katz, 2012).

The clitoris is a small, sensitive organ that consists of two paired erectile chambers and is located at the superior portion of the vestibule (Katz, 2012). These chambers are composed of endothelial-lined lacunar spaces, trabecular smooth muscle, and trabecular connective tissue; they are surrounded by a fibrous sheath, the tunica albuginea. The paired corpus spongiosum (bilateral vestibular bulbs) unite ventrally to the urethral orifice to form a thin strand of spongiosus erectile tissue connection (pars intermedia) that ends in the clitoris as the glans (Martini et al., 2011). The clitoris is capped externally by the glans, which is covered by a clitoral hood formed in part by the fusion of the upper part of the two labia minora.

The clitoris has numerous nerve endings and contains tissue that fills with blood when the woman is sexually aroused. The blood supply to this organ includes the dorsal and clitoral cavernosal arteries, which arise from the iliohypogastric pudendal bed. The autonomic efferent motor innervation occurs via the cavernosal nerve of the clitoris arising from the pelvic and hypogastric plexus (Bradshaw, 2012; Katz, 2012).

The labia minora, together with the clitoris, play a critical role in sexual activity. Because of their rich nerve and vascular supply, they are easily sensitized and become engorged with blood during sexual arousal. This vascular erectile tissue is capable of becoming significantly enlarged and tense during sexual excitement. In addition to the great quantity of erectile tissue in the clitoris, erectile tissue is found inside the labia majora and minora, around the vulvovaginal opening, and along the lower third of the vagina. A very small quantity of this tissue can also be found in the vaginal walls and along the urethra. Age-associated female sexual dysfunction from decreased clitoral sensitivity may be associated with histologic changes in clitoral cavernosal erectile tissue (Katz, 2012).

### *Periurethral Glands*

Two Skene's (paraurethral) glands open directly into the vulva and are adjacent to the distal urethra (Katz, 2012). The Skene's glands, which release mucus, form a triangular area of mucous membrane surrounding the urethral meatus from the clitoral glans to the vaginal upper rim or caruncle (Martini et al., 2011).

### *Bartholin's or Greater Vestibular Glands*

The pea-sized Bartholin's glands are located at about the 4 and 8 o'clock positions in the vulvovaginal area, just beneath the fascia. Each gland has an approximately 2-cm duct that opens into a groove between the labia minora and hymen. The glands, which are made of columnar cells that secrete clear or whitish mucus, are stimulated during sexual arousal (Corton, 2012). If the Bartholin's ducts are blocked, infection can occur, resulting in cyst formation that can lead to the development of an abscess requiring surgical incision and drainage.

## Internal Genital Anatomy

### *Urethra*

The urethra is a short conduit, approximately 3 to 5 cm long, extending from the base of the bladder and exiting externally to the vestibule (Katz, 2012). The urethral mucosa is composed of stratified transitional epithelium near the urinary bladder; the rest of this structure is lined by a stratified squamous epithelium (Katz, 2012; Martini et al., 2011). In women, the urethra passes through the urogenital diaphragm, which is a circular band of skeletal muscle that forms the sphincter urethrae, better known as the external urethral sphincter (Martini et al., 2011). For a woman to urinate, this sphincter must be voluntarily relaxed—its typical state is contraction.

### *Ovaries*

The paired ovaries resemble a large almond in terms of their size and configuration; they are located near the lateral walls of the pelvic cavity (Katz, 2012; Martini et al., 2011) Each ovary measures approximately 1.5 cm × 2.5 cm × 4 cm and weighs 3 to 6 gm (Katz).

The ovaries produce gametes (also known as ova) and the sex hormones known as estrogen and progesterone. The color and texture of these organs change with a woman's age and reproductive stage. The ovaries in a nulliparous woman are situated on a shallow depression called the ovarian fossa, located on either side of the uterus in the upper pelvic cavity. Several ligaments support the ovaries. The broad ligament is the principal supporting membrane of a woman's internal genital organs, including the fallopian tubes and uterus.

The remaining ligaments include the mesovarium, a posterior extension of the broad ligament; the ovarian ligament, which is anchored to the uterus; and a suspensory ligament, which is attached to the pelvic wall. The outermost layer of the ovary is composed of a thin layer of cuboidal epithelial cells called the germinal epithelium. Immediately below this epithelial layer is the tunica albuginea, which is made up of collagenous tissue (Katz, 2012).

The ovaries comprise three parts:

- An outer cortical region (cortex), which contains germinal epithelium with oogonia and ovarian follicles that number approximately 400,000 at the initiation of puberty (Halvorson, 2012a)
- The medullary region (medulla), which consists of connective tissue, myoid-like contractile cells, and interstitial cells
- A hilum, which is the point of entrance for all of the ovarian vessels and nerves (Halvorson, 2012b; Katz, 2012)

Two ovarian arteries that arise from the aorta descend in the retroperitoneal space and cross in front of the psoas muscles and internal iliac vessels (Katz, 2012). They enter the infundibulopelvic ligaments, finally reaching the mesovarium found in the broad ligament. The ovarian blood supply enters through the hilum, and venous return occurs through a venous plexus, which collects blood from the adnexal region and drains into the vena cava on the right and the renal vein on the left.

Innervation of the ovaries is accomplished by sympathetic and parasympathetic fibers of the ovarian plexus that descend along the ovarian vessels. These nerves supply the ovaries, broad ligaments, and uterine tube. The parasympathetic fibers in the ovarian plexus arise from the vagus nerves. The nerve fibers to the ovaries innervate only the vascular networks, and not the stroma (Katz, 2012). Because the ovaries and surrounding peritoneum are sensitive to pain and pressure, it is important to take great care when examining the ovaries during the bimanual examination.

### Fallopian Tubes

The fallopian tubes (also known as the oviducts) are paired narrow muscular tubes that extend approximately 10 cm from each cornu of the body of the uterus, outward to their openings near the ovaries. Each fallopian tube includes four segments:

- The pars interstitialis (intramural portion) penetrates the uterine wall. It contains the fewest mucosal folds, with the myometrium contributing to its muscularis.
- The isthmus, the narrow segment adjacent to the uterine wall, contains few mucosal folds.
- The middle segment, known as the ampulla, is the widest and longest segment. It contains extensive branched mucosal folds and is the most common site of fertilization.
- The infundibulum, the funnel-shaped distal segment, opens near the ovary but is not attached to it (Katz, 2012). Very fine fingerlike fronds of its mucosal folds, known as fimbriae, project from the opening toward the ovary to help direct the oocyte into the lumen of the fallopian tube.

The inner surface of each fallopian tube is covered by fine hairlike structures called cilia that help to move ova, when they are released from the ovaries, along the tube and into the cavity of the uterus. The fallopian tube extends medially and inferiorly from the infundibulum into the superior-lateral cavity of the uterine opening (Katz, 2012).

The wall of the fallopian tube is composed of three layers: mucosa, muscularis, and serosa. The internal mucosa includes the lamina propria and ciliated columnar epithelium, which consists primarily of two main cell types. On the surface, the abundant ciliated columnar cells beat in waves toward the uterus, aiding in egg transport. Shorter, mucus-secreting peg cells are interspersed among the ciliated cells. These cilia propel the film they produce toward the uterus, help transport the ovum, and hinder bacterial access to the peritoneal cavity. The muscularis—the middle layer of the fallopian tube wall—contains both inner circular and outer longitudinal smooth muscle layers. Its wavelike contractions move the ovum toward the uterus. The outer covering of the fallopian tubes is the serosa; this lubricative layer is part of the visceral peritoneum (Corton, 2012; Katz, 2012).

The ovarian and uterine arteries supply blood to the fallopian tubes. The uterine veins, which parallel the path of the arteries, provide the venous drainage from this area. Sympathetic and parasympathetic innervation to the fallopian tubes from the hypogastric plexus and pelvic splanchnic nerves regulates the activity of the smooth muscles and blood vessels (Corton, 2012).

### *Uterus*

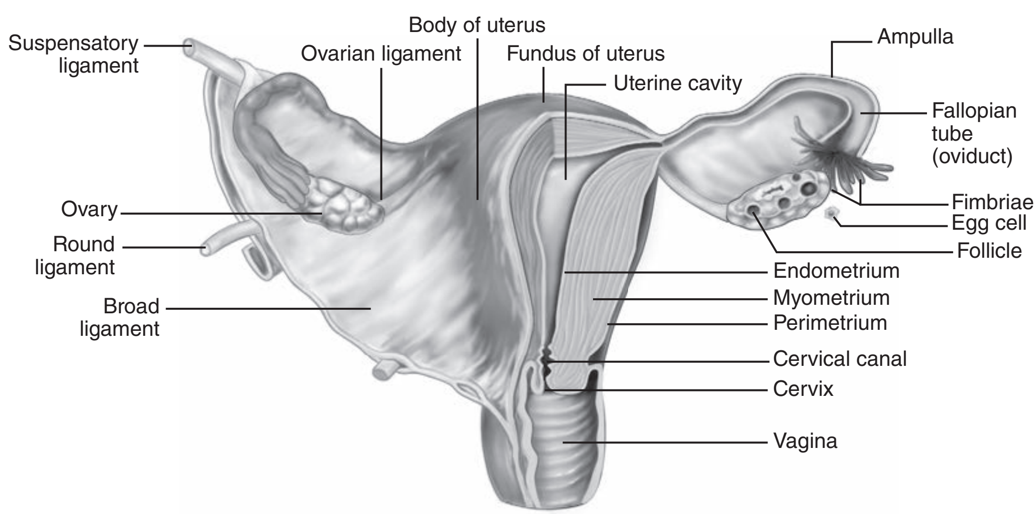
The uterus is a muscular, inverted, pear-shaped, hollow, thick-walled organ that opens to the vagina at the cervix and then widens toward the top where the uterine tubes enter. Its anatomic regions include the fundus, body, and cervix (**Figure 5-6** and **Color Plate 3**). The fundus is the uppermost dome-shaped extension of the uterine body, located above the point of entry of the fallopian tubes. The body is the enlarged main portion. The cervix is the downward constricted extension of the uterus that opens into the vagina.

The uterus is located anteriorly between the urinary bladder and posteriorly between the sigmoid colon and the rectum. When the bladder is empty, the uterus angles forward over the bladder. As the bladder fills, the uterus is lifted dorsally and may become retroflexed, pressing against the rectum. The nulliparous uterus is approximately 8 cm long, 5 cm wide, and 2.5 cm thick, and weighs approximately 40 to 50 gm (Katz, 2012).

The uterine wall of the fundus and body consists of three layers: the endometrium, the myometrium, and the serosa (also known as the adventitia). The uterine mucosa layer consists of simple columnar epithelium supported by a lamina propria. Simple tubular glands extend from the luminal surface into the lamina propria. The stratum functionale is the temporary layer at the luminal surface that responds to ovarian hormones by undergoing cyclic thickening and shedding. The stratum basale is the deeper, thinner, permanent layer that contains the basal portions of the endometrial glands; this layer is retained during menstruation. The epithelial cells lining these glands divide and cover the raw surface of exposed endometrium that occurs during menstruation.

The endometrium receives a double blood supply. In the middle of the myometrium, a pair of uterine arteries branch to form the arcuate arteries. These arteries then bifurcate into two sets

**FIGURE 5-6** **An anterior view of the female internal genital anatomy showing the relationships of the ovaries, fallopian tubes, uterus, cervix, and vagina.**



of arteries: straight arteries to the stratum basale and coiled arteries to the functionalis. The double blood supply to the endometrium is important in the cyclic shedding of the functionalis; the straight arteries are retained during this process, while the coiled arteries are lost (Anderson & Gendry, 2007).

The myometrium is composed of four poorly defined layers of smooth muscle that are thickest at the top of the uterus. The middle layers contain the abundant arcuate arteries. The outer layer of the uterus consists of two types of outer coverings: A cap of serosa covers the fundus, and the body is surrounded by an adventitia of loose connective tissue (Anderson & Gendry, 2007).

Structurally, the cervix is made mostly of dense connective tissue, is usually 2.5 to 3 cm in length, and is covered interiorly by a mucus-secreting ciliated epithelium at the upper regions and by stratified squamous epithelium at the vaginal end. The opening of the cervix into the vagina occurs at almost a right angle to the long axis of the vagina. Uterine blood supply is provided via the uterine and ovarian arteries, with venous return traveling via the uterine veins. The hypogastric and ovarian nerve plexuses supply sympathetic and parasympathetic fibers as well as carry uterine afferent sensory fibers on their way to the spinal cord at T11 and T12 (Anderson & Gendry, 2007; Katz, 2012).

### *Vagina*

The vagina is a thin-walled tube extending from the external vulva to the cervix. Its walls are normally in apposition and flattened, but can extend (stretch) greatly, as observed during childbirth. The length of the vaginal walls varies greatly but on average the anterior vaginal length is 6 to 9 cm and the posterior vaginal length is 8 to 12 cm (Corton, 2012; Katz, 2012). The upper portion of the vagina encircles the vaginal portion of the cervix. The vagina touches the empty bladder on the ventral and superior surface. Inferiorly, it adheres to the posterior wall of the urethra and opens adjacent to the labia minora.

The internal mucosal layer of the vagina contains traverse folds, known as rugae. This muscular canal extends from the midpoint of the cervix to its opening located between the urethra and the rectum. The mucous membrane lining the vagina and musculature is continuous with the uterus. The vaginal walls can be easily separated because their surfaces are normally moist, lubricated by a basal vaginal fluid.

The vaginal wall is composed of three layers: mucosa, muscle, and adventitia. Vaginal epithelium is stratified squamous epithelium supported by a thick lamina propria. The lamina propria has many thin-walled blood vessels that contribute to diffusion of vaginal fluid across the epithelium. The lamina propria of the mucosa contains many elastic fibers as well as a dense network of blood vessels, lymph nodes, and nerve supply. To a much lesser degree than seen in the skin, this epithelium undergoes hormone-related cyclic changes, including slight keratinization of the superficial cells during the menstrual cycle (Corton, 2012). The epithelium has no glands, so it does not secrete mucus. Release of estrogen causes the epithelium to thicken, differentiate, and accumulate glycogen. Vaginal bacteria metabolize the glycogen to lactic acid, causing the typically low pH of the vaginal environment.

Loose connective tissue containing many elastic fibers is found underneath the vaginal epithelium, which has a subdermal layer rich in capillaries. This rich vascular supply is the source for vaginal moisture during sexual stimulation (Soper, 2007).

Within the epithelium lie the smooth muscles of the muscularis, which are oriented longitudinally on the outer layer and as circular bundles on the inner layer. The outer layer—the adventitia—consists of dense connective tissue with many elastic fibers, which provides structural support for the vagina. It also contains an extensive nerve supply and venous capillaries. The adventitia is elastic and rich in collagen, provides structural support to the vagina, and allows for expansion of the vagina during intercourse and childbirth.

The upper two-thirds of the vagina receives efferent innervation through the uterovaginal plexus, which contains both sympathetic and parasympathetic fibers. The pelvic splanchnic nerves provide the parasympathetic efferent input to the uterovaginal plexus. The proximal two-thirds of the vagina is innervated via the uterovaginal plexus. The lower vagina receives autonomic efferent innervation from the pudendal nerve. The distal one-third of the vagina has primarily somatic sensation; this innervation arises from the pudendal nerve and is carried to the sacral spinal cord (Katz, 2012).

## BREAST ANATOMY AND PHYSIOLOGY

In Western society, it often seems that a woman's breasts have two functions or roles: one that is sexual, and one that is maternal. The breasts are visible social sex symbols, and they are often a key source of a woman's anxiety about her body. Breasts often define women in both the public and private eye.

The breasts—that is, the mammary glands—are large, modified sebaceous glands contained within the superficial fascia of the chest wall located over the pectoral muscles (Katz & Dotters, 2012). Each consists of a nipple, lobes, ducts, and fibrous and fatty tissue (**Color Plate 4**). Each breast is composed of 12 to 20 lobes of glandular tissue. The number of lobes is not related to the size of the breast. The lobes branch to form 10 to 100 lobules per lobe, which are in turn subdivided into many secretory alveoli. These glands are connected together by a series of ducts. The alveoli produce milk and other substances during lactation. Each lobe empties into a single lactiferous duct that travels out through the nipple. As a result, there are 15 to 20 passages through the nipple, resulting in just as many openings in the nipple.

Fatty and connective tissues surround the lobes of glandular tissue. The amount of fatty tissue depends on many factors, including age, the percentage of body fat relative to total body weight, and heredity. Cooper's ligaments connect the chest wall to the skin of the breast, giving the breast its shape and elasticity (Katz & Dotters, 2012). The size of the nonpregnant breasts reflects the amount of adipose tissue in the breast rather than the amount of glandular tissue. The secretory nature of the breasts develops during pregnancy.

The nipple and areola are located near the center of each breast; the areola is the pigmented area surrounding the nipple. These areas usually have a color and texture that differ from those of the adjacent skin. Notably, the color of the nipple–areolar complex varies and darkens during pregnancy and lactation. The consistency of the nipple and areola may range from very smooth to wrinkled and bumpy. The size of the nipples and areolae also varies a great deal from woman to woman, and some size variation between a woman's breasts is normal. The nipple and areola are made of smooth muscle fibers and feature a thick network of nerve endings.

The areola is populated by numerous oil-producing Montgomery's glands. These glands may form raised bumps and be responsive to a woman's menstrual cycle. They protect and lubricate the nipple during lactation.

The nipple usually protrudes out from the surface of the breast. Some nipples project inward or are flat with the surface of the breast. Neither flat nor inverted nipples appear to negatively affect a woman's ability to breastfeed.

Reproductive hormones are vital to the development of the breast during puberty and lactation. Prolactin (PRL) and growth hormone (GH) from the anterior lobe of the pituitary stimulate mammary gland development. These hormones are aided by human placental lactogen from the placenta, which stimulates the mammary gland ducts to become active during pregnancy. Estrogen promotes the growth of the gland and ducts, while progesterone stimulates the development of milk-producing cells. Prolactin, which is released from the anterior pituitary, stimulates milk production. Oxytocin, which is released from the posterior pituitary in response to suckling, causes milk ejection from the lactating breast.

The lymphatic system in the breast is abundant and empties the breast tissue of excess fluid. Lymph nodes along the pathway of drainage monitor for foreign bodies such as bacteria or viruses. Although the main flow moves toward the axilla and anterior axillary nodes, lymph drainage has been shown to pass in all directions from the breast (Martini et al., 2011).

## MENSTRUAL CYCLE PHYSIOLOGY

The initiation of menstruation, called menarche, usually happens between the ages of 12 and 15. Menstrual cycles typically continue to age 45 to 55, when menopause occurs. Many women find themselves reluctant to discuss the existence and normality of menstruation. The word *menstruation* has been replaced by a variety of euphemisms, such as *the curse*, *my period*, *my monthly*, *my friend*, *the red flag*, or *on the rag*.

Most women experience deviations from the average menstrual cycle during their reproductive years. As a result, it is not uncommon for women to display certain preoccupations regarding their menstrual bleeding, not only in relation to the regularity of its occurrence, but also in regard to the characteristics of the flow, such as volume, duration, and associated signs and symptoms. Unfortunately, society has encouraged the notion that a woman's normalcy is based on her ability to bear children. This misperception has understandably forced women to worry over the most miniscule changes in their menstrual cycles. Indeed, changes in menstruation are one of the most frequent reasons why women visit their clinician.

Numerous patterns in the secretion of estrogens and progesterone are possible; in fact, it is difficult to find two cycles that are exactly the same. Studies that include women of different ethnicities, occupations, genetics, nutritional status, and age have demonstrated that the length and duration of the menstrual cycle vary widely (Assadi, 2013; Johnson et al., 2013; Karapanou & Papadimitriou, 2010).

Menarche is the most readily evident external event that indicates the end of one developmental stage and the beginning of a new one. It is now believed that body composition is critically important in determining the onset of puberty and menstruation in young women (Ferin & Lobo, 2012). The ratio of total body weight to lean body weight is probably the most relevant factor, and individuals who are moderately obese (i.e., 20–30% above their ideal body weight) tend to have an earlier onset of menarche (Johnson et al., 2013). Widely accepted standards for distinguishing what are regular versus irregular menses, or normal versus abnormal menses, are generally based on what is considered average and not necessarily typical for every woman. According to these standards, the normal menstrual cycle is 21 to 35 days with a menstrual flow lasting 4 to 6 days, although a flow for as few as 2 days or as many as 8 days is still considered normal (Ferin & Lobo, 2012).

The amount of menstrual flow varies, with the average being 50 mL; nevertheless, this volume may be as little as 20 mL or as much as 80 mL. Generally, women are not aware that anovulatory cycles and abnormal uterine bleeding (changes in bleeding outside of normal; see Chapter 24) are common after menarche and just prior to menopause (Ferin & Lobo, 2012; Fritz & Speroff, 2011). Menstrual cycles that occur during the first 1 to 1.5 years after menarche are frequently irregular due to the immaturity of the hypothalamic–pituitary–ovarian axis (Fritz & Speroff, 2011).

## The Hypothalamic–Pituitary–Ovarian Axis

### *Hypothalamus*

The hypothalamus controls anterior pituitary functions via the secretion of releasing and inhibiting factors. Together with the pituitary, it manages the production of hormones that serve as chemical messengers for the regulation of the gynecologic system. The hypothalamus initially releases gonadotropin-releasing hormone (GnRH) in a pulsatile manner. On average, the frequency of GnRH secretion is once per 60 to 100 minutes during the early follicular phase, increases to once per 60 to 70 minutes during the middle of the menstrual cycle, and then decreases during the luteal phase (McCartney & Marshall, 2014). The release of GnRH stimulates the pituitary gland to produce follicle-stimulating hormone (FSH) and luteinizing hormone (LH). Two other hormones necessary for gynecologic health, estrogen and progesterone, are secreted by the ovaries at the command of FSH and LH.

### *Pituitary Gland*

The oval-shaped, pea-sized pituitary gland is located in a small depression in the sphenoid bone of the skull. It is controlled by the hypothalamus, which secretes releasing factors into a special blood vessel network (hypothalamic–hypophyseal portal system) that feeds the pituicytes (McCartney & Marshall, 2014). These releasing factors either stimulate or inhibit the release of pituitary hormones that travel via the circulatory system to target organs.

The anterior pituitary synthesizes seven hormones:

- Growth hormone (GH)
- Thyroid-stimulating hormone (TSH)
- Adrenocorticotropin (ACTH)
- Melanocyte-stimulating hormone (MSH)
- Prolactin (PRL)
- Follicle-stimulating hormone (FSH)
- Luteinizing hormone (LH)

FSH and LH (both gonadotropins) are responsible for regulating gynecologic organ activities. FSH targets the ovaries, where it stimulates the growth and development of the primary follicles and results in the production of estrogen and progesterone. The release of FSH from the pituitary is governed by a negative feedback mechanism involving these steroids. In contrast, LH targets the developing follicle within the ovary; it is responsible for ovulation, corpus luteum formation, and hormone production in the ovaries. Prolactin is responsible for preparing the mammary gland for lactation and brings about the synthesis of milk (McCartney & Marshall, 2014; Molitch, 2014).

### *Ovaries and Uterus*

Complex changes occur in the ovaries and the endometrium as a result of the cyclic fluctuations of gonadotropic hormones. The endometrium emulates the activities of the ovaries; thus whatever happens in the uterus during the menstrual cycle is precisely correlated with whatever is occurring in the ovaries. The objective of the ovarian cycle is to produce an ovum, while the objective of the endometrial cycle is to prepare a site to nourish and maintain the ovum if it becomes fertilized. The ovarian cycle includes three distinct phases: the follicular phase, ovulation, and the luteal phase. The endometrial cycle can be divided into the proliferative phase, the secretory phase, and menstruation (Fritz & Speroff, 2011).

## Hormonal Feedback System

The menstrual cycle is influenced by a complex interaction of hormones. In particular, the monthly rhythmic functioning of the menstrual cycle depends on the changing concentrations of gonadotropic hormones. The release of LH and FSH from the pituitary depends on the secretion of GnRH from the hypothalamus, which is modulated by the feedback effects of estrogen and progesterone. The hormones LH and FSH, in turn, play important roles in stimulating secretion of estrogen and progesterone.

Almost all hormones are released in short pulses at intervals of 60 to 90 minutes throughout most of the menstrual cycle, with these pulses decreasing in frequency closer to menstruation. Steroid hormones modulate the frequency and amplitude of the pulse, which varies throughout the cycle (Fritz & Speroff, 2011); see **Color Plate 5**.

As noted earlier, under normal physiologic conditions, GnRH pulses stimulate the release of FSH and LH. As a result of this gonadotropic hormone stimulation, the ovarian follicles develop and produce estrogen. As the amount of estrogen in the circulation increases and reaches the pituitary gland, it affects the amount of FSH and LH secreted, albeit without significantly affecting the pulse frequency (negative feedback).

When the estrogen level becomes high enough, the negative feedback effect on the pituitary is reversed. Now estrogen causes a midcycle positive feedback effect on the pituitary, which results in a surge of LH and FSH and causes ovulation. Under LH influence, the ruptured follicle becomes the corpus luteum and secretes progesterone. Although the presence of progesterone reduces the frequency of the hypothalamic GnRH pulses, the amount of LH released from the pituitary is proportionally increased to sustain the corpus luteum and the production of progesterone. In the absence of pregnancy, the corpus luteum degenerates, progesterone levels decline, and menstruation occurs. The GnRH pulses return to the frequency associated with the beginning of the follicular phase and a new cycle begins (Ferin & Lobo, 2012).

## The Ovarian Cycle

The ovarian cycle comprises three phases: follicular, ovulatory, and luteal.

### *Follicular Phase*

The follicular phase is characterized by the development of ovarian follicles and usually lasts from day 1 (first day of menses) to day 14 of the ovarian cycle. Folliculogenesis begins during the last few days of the previous menstrual cycle and continues until the release of the mature follicle at ovulation. The decrease in estrogen production by the corpus luteum and the dramatic fall of inhibin levels allow the FSH level to rise during the last few days of the menstrual cycle. During days 1 through 4 of the menstrual cycle, a cohort of primary follicles is recruited from a pool of nonproliferating follicles in response to the increased concentration of FSH (Fritz & Speroff, 2011). Follicles that have enough granulosa cells will develop receptors for estrogen and FSH on the cells of the granulosa layers, and LH receptors on the theca cells. The primary role of FSH is to induce the development of increased receptors on the granulosa cells and thereby stimulate estrogen production. The preliminary role of LH is to stimulate the cells' production of androgen that will be converted to estrogen by the granulosa layers.

Between cycle days 5 and 7, only one dominant follicle from the cohort of recruited follicles is destined to ovulate during the next menstrual cycle. As menses progresses, FSH levels decline due to the negative feedback of estrogen and the negative effects of the peptide hormone inhibin, which is secreted by the granulosa and theca cells of the developing follicle (Fritz & Speroff, 2011; Halvorson, 2012b). The decrease in FSH level promotes a more androgenic microenvironment within the adjacent follicles. By the eighth day of the cycle, the dominant follicle (Graafian follicle) is producing more estrogen than the total amount produced by the other developing follicles. In response to the dominant follicle's combined production of estrogen and FSH, LH receptors develop on its outermost granulosa layers. The dominant follicle continues to flourish and gradually moves toward the surface of the ovary (see **Color Plate 6**). The Graafian follicle contains the ovum and is surrounded by a layer of granulosa cells, which are themselves surrounded by the specialized theca interna and theca externa cells.

An oocyte maturation inhibitor (OMI) in the follicular fluid suppresses the final maturation of the dominant follicle until the time of ovulation. The OMI's suppressive effects end hours before the LH surge that causes ovulation (Halvorson, 2012b).

### *Ovulatory Phase*

Ovulation is the process whereby the mature ovum is released from the follicle (Halvorson, 2012b). It occurs approximately 10 to 12 hours after the LH peak—that is, when the highest level of LH is attained. Ovulation and the subsequent conversion of the follicle to the corpus luteum are dependent on an increased level of estrogen and the LH surge, which marks the beginning of the rapid rise of LH. During the mid-follicular phase, the dominant follicle's FSH levels diminish, but estrogen levels continue to increase. At the end of the follicular phase, estrogen reaches a blood level of approximately 200 picograms per milliliter (pg/mL); this concentration may be maintained for as long as 50 hours (Fritz & Speroff, 2011; Halvorson, 2012b). At this critical time, the high estrogen level initiates a positive feedback of LH, generating the preovulatory LH surge. The LH surge, which begins 34 to 36 hours prior to ovulation and provides a relatively accurate predictor for timing ovulation, is responsible for many changes in the follicle selected for rupture.

Initially the nuclear membrane around the oocyte breaks down, the chromosomes progress through the rest of the first meiotic division, and the egg moves on to the secondary stage. Meiosis ceases at this time and will be initiated again only if the ovum is fertilized. The LH surge stimulates luteinization of the granulosa cells as well as synthesis of progesterone. Progesterone, in turn, enhances the positive feedback effect of estrogen on the LH surge and is responsible for promoting enzyme activity in the follicular fluid capable of digesting the follicle wall. High levels of LH and progesterone cause the synthesis of prostaglandins and proteolytic enzymes such as collagenase and plasmin. Although the exact mechanism underlying this process is unknown, the activated proteolytic enzymes and prostaglandins digest collagen in the follicular wall, leading to an explosive release of the ovum (oocyte), along with the zona pellucida and corona radiate surrounding it. At ovulation, the ovum is expelled and drawn up by the ciliated fimbriae of the fallopian tube to initiate its migration through the oviduct (Ferin & Lobo, 2012; Fritz & Speroff, 2011).

New information about the timing of the LH surge and ovulation is available now because of the amount of data collected by many clinicians during in vitro fertilization. The LH surge has a tendency to occur around 3 a.m. in more than two-thirds of women, and ovulation has been found to occur primarily in the morning during the spring months and primarily during the evening during autumn and winter (Fritz & Speroff, 2011). In the Northern Hemisphere, from July to February, approximately 90% of women will ovulate between 4 and 7 p.m. During the spring, 50% of women will ovulate between midnight and 11 a.m. (Fritz & Speroff, 2011, p. 228).

### *Luteal Phase*

Under the influence of LH, the follicle's granulosa cells that are left in the ruptured follicle become enlarged, undergo luteinization, and form the corpus luteum. The corpus luteum continues to function for approximately 8 days after ovulation. It secretes increased progesterone and some estrogen that start the negative feedback loop to the hypothalamus and pituitary gland, preventing further ovulation within the current cycle. In the absence of a fertilized ovum, luteal cells degenerate, causing a decline in estrogen and progesterone levels, and the corpus luteum regresses to become the corpus albicans. As a result of the regression of the corpus luteum, estrogen and progesterone levels decrease rapidly, removing the negative feedback effect. FSH and LH then begin to increase once again to initiate the next menstrual cycle (Ferin & Lobo, 2012; Fritz & Speroff, 2011).

## The Endometrial Cycle

The endometrial cycle has three phases: proliferative, secretory, and menstrual.

### *Proliferative Phase*

The proliferative phase is influenced by estrogen and entails the regrowth of endometrium after the menstrual bleed. It starts on about the fourth or fifth day of the cycle and usually lasts approximately 10 days, ending with the release of the ovum. The proliferative phase involves changes in the endometrium, myometrium, and ovaries. These cyclic changes, which result from fluctuations in gonadotropin and estrogen levels, are characterized by progressive mitotic growth of the deciduas functionalis in response to increasing levels of estrogen secreted by the ovary. They occur in preparation for implantation of the fertilized ovum.

At the beginning of the proliferative phase, the endometrium is relatively thin and the endometrial glands are straight, narrow, and short. As the phase progresses, the glands become long and tortuous. The endometrium becomes thicker as a result of the glandular hyperplasia and growth of the stroma. The endometrium proliferates from 4 to 12 mm in height and increases eightfold in thickness in preparation for implantation of the fertilized ovum (Ferin & Lobo, 2012).

### *Secretory Phase*

The secretory phase begins at ovulation. When part of a 28-day cycle, it usually lasts from day 15 (the day after ovulation—the exact cycle day will vary with cycle length) to day 28. This phase does not take place if ovulation has not occurred. It tends to be the most constant phase, in terms of time.

During the secretory phase, the glands of the endometrium become more tortuous and dilated and fill with secretions, primarily as a result of increased progesterone production. The endometrium becomes thick, cushiony, and nutritive in preparation for implantation of the fertilized ovum. In the absence of implantation, the corpus luteum shrinks, and progesterone and estrogen levels subsequently decrease. The endometrium begins to regress toward the end of the secretory phase. By days 25 to 26, progesterone and estrogen withdrawal results in increased tortuous coiling and constriction of the spiral arterioles in the thinning layer.

Until the last decade, it was believed that decreased blood flow to the superficial endometrial layers resulted in tissue ischemia and resulting menses. The end of menses was believed to be caused "by longer and more intense waves of vasoconstriction, combined with coagulation mechanisms activated by vascular stasis and endometrial collapse, aided by rapid re-epithelization mediated by estrogen from the emerging new follicular cohort" (Fritz & Speroff, 2011, p. 595). Newer studies do not support the theory that menstruation results from vascular events. Rather, the current theory suggests that menstruation is initiated by enzymatic autodigestion of the functional layer of the endometrium, which is triggered by estrogen–progesterone withdrawal (Fritz & Speroff, 2011). As estrogen and progesterone levels fall during the days prior to menses, lysosomal membranes become destabilized, such that the enzymes within them are released into the cytoplasm of the epithelial, stromal, and endothelial cells and into the intercellular space. These enzymes are proteolytic: They digest the cells surrounding them as well as surface membranes. Their actions result in platelet deposition, release of prostaglandins, vascular thrombosis, extravasation of red blood cells, and tissue necrosis in the vascular endothelium (Ferin & Lobo, 2012). Enzymatic action progressively degrades the endometrium and eventually disrupts the capillaries and venous system just under the endometrial surface, causing interstitial hemorrhage and dissolution of the surface membrane and allowing blood to escape into the endometrial cavity (Fritz & Speroff, 2011). This degeneration continues and extends to the functional layer of the endometrium, where rupture of the basal arterioles contributes to the bleeding. The concepts about how the menstrual flow ceases remain unchanged.

### Menstrual Phase

The menstrual phase begins with the initiation of menses and lasts 4 to 6 days. Prostaglandins initiate contractions of the uterine smooth muscle and sloughing of the degraded endometrial tissue, leading to menstruation. The composition of menstrual fluid comprises desquamated endometrial tissue, red blood cells, inflammatory exudates, and proteolytic enzymes. Because some of the clotting factors ordinarily found in blood are lysed by lysosomal enzymes in the uterus, menstrual blood does not clot (Ferin & Lobo, 2012; Fritz & Speroff, 2011). For 3 to 5 days, 20 to 80 mL (on average) of blood loss occurs. Approximately 2 days after the start of menstruation, estrogen stimulates the regeneration of the surface endometrial epithelium, while concurrent simultaneous endometrial shedding is occurring.

## Changes in Organs Due to Cyclic Changes

### Cervix

After menstruation, the cervical mucus is scant and viscous. During the late follicular phase, it becomes clear, copious, and elastic. The quantity of cervical mucus increases 30-fold compared to the early follicular phase and can stretch to at least 6 cm (Ferin & Lobo, 2012; Fritz & Speroff, 2011). The cervical mucus during this time is clear and stretchable (spinnbarkeit). It displays a characteristic ferning appearance during the ovulatory period if observed under a microscope.

After ovulation, when progesterone levels are high, the cervical mucus once again becomes thick, viscous, opaque, and decreased in amount. This thick mucus is hostile and impenetrable to the sperm. The increased viscosity also reduces the risk of ascending infection at the time of possible implantation.

Increased estrogen levels promote stromal vascularization and edema and relax the myometrial fibers that supply the cervix. Activated collagenase causes the tightly bound collagen bundles to form a loose matrix, triggering the cervix to become softer a few days prior to and at ovulation. The external cervical os everts prior to ovulation. Progesterone causes the cervical muscle to retract, the collagen matrix to tighten, and the cervix to become firmer (Fritz & Speroff, 2011; Halvorson, 2012b).

### Fallopian Tube Mobility

Estrogen stimulates epithelial cell activity, resulting in increased cilia movement and secretions in the uterine tubes. These special effects assist ovum mobility along the fallopian tube following ovulation. Progesterone reverses these effects, thereby inhibiting the peristaltic activity of the fallopian tube smooth muscle.

### Vagina

The changes in hormonal levels of estrogen and progesterone have characteristic effects on the vaginal epithelium. This information becomes important when cervical cells are examined under the microscope, as their morphologic differences can be related to specific stages of the menstrual cycle. During the early follicular phase, exfoliated vaginal epithelial cells have vesicular nuclei and are basophilic. They appear flatter than the corresponding cells in the later phases owing to the influence of progesterone, which causes them to become folded and clumped. The pH of the vagina responds to cyclical changes as estrogen stimulates the growth of lactobacilli. Lactobacilli metabolize glycogen from cervical secretions, producing lactic acid that decreases the vaginal pH to a level that assists in protecting the gynecologic tract against opportunistic pathogens (Fritz & Speroff, 2011; Halvorson, 2012b).

# References

Anderson, J., & Gendry, R. (2007). Anatomy and embryology. In J. Berek (Ed.), *Berek and Novak's gynecology* (14th ed., pp. 75–127). Philadelphia, PA: Lippincott Williams & Wilkins.

Assadi, S. N. (2013). Is being a health-care worker a risk factor for women's reproductive system. *International Journal of Preventive Medicine, 4*(7), 852–857.

Bradshaw, K. (2012). Anatomic disorders. In B. L. Hoffman, J. O. Schorge, J. I. Schaffer, L. M. Halvorson, K. D. Bradshaw, F. G. Cunningham, & L. E. Calver (Eds.), *Williams gynecology* (2nd ed., pp. 481–505). New York, NY: McGraw-Hill.

Caldwell, W. E., & Moloy, H. C. (1933). Anatomical variations in female pelvic bones and their effect on labor with a suggested classification. *American Journal of Obstetrics & Gynecology, 26*, 479–482.

Corton, M. (2012). Anatomy. In B. L. Hoffman, J. O. Schorge, J. I. Schaffer, L. M. Halvorson, K. D. Bradshaw, F. G. Cunningham, & L. E. Calver (Eds.), *Williams gynecology* (2nd ed., pp. 918–947). New York, NY: McGraw-Hill.

Duffy, J. (1963). Masturbation and clitoridectomy. *Journal of the American Medical Association, 186*(3), 246–248. doi:10.1001/jama.1963.63710030028012

Ferin, M., & Lobo, R. (2012). Reproductive endocrinology. In G. Lentz, R. Lobo, D. Gershenson, & V. Katz (Eds.), *Comprehensive gynecology* (6th ed., pp. 67–95). Philadelphia, PA: Mosby Elsevier.

Fritz, M., & Speroff, L. (2011). *Clinical gynecologic endocrinology and infertility*. Philadelphia, PA: Lippincott Williams & Wilkins.

Hall, L. A. (1998). The other in the mirror: Sex, Victorians, and historians. Retrieved from http://www.lesleyahall.net/sexvict.htm

Halvorson, L. M. (2012a). Amenorrhea. In B. L. Hoffman, J. O. Schorge, J. I. Schaffer, L. M. Halvorson, K. D. Bradshaw, F. G. Cunningham, & L. E. Calver (Eds.), *Williams gynecology* (2nd ed., pp. 440–459). New York, NY: McGraw-Hill.

Halvorson, L. M. (2012b). Reproductive endocrinology. In B. L. Hoffman, J. O. Schorge, J. I. Schaffer, L. M. Halvorson, K. D. Bradshaw, F. G. Cunningham, & L. E. Calver (Eds.), *Williams gynecology* (2nd ed., pp. 400–439). New York, NY: McGraw-Hill.

Johnson, W., Choh, A., Curran, J., Czerwinski, S. A., Bellis, C., Dyer, T. D., & Demerath, E. (2013). Genetic risk for earlier menarche also influences peripubertal body mass index. *American Journal of Physical Anthropology, 150,* 10–20.

Karapanou, O., & Papadimitriou, A. (2010). Determinants of menarche. *Reproductive Biology and Endocrinology, 5*(1), 115–123.

Katz, V. (2012). Reproductive anatomy. In V. Katz, G. Lentz, R. Lobob, & D. Gershenson (Eds.), *Comprehensive gynecology* (6th ed., pp. 39–65). Philadelphia, PA: Mosby Elsevier.

Katz, V., & Dotters, D. (2012). Breast diseases. In V. Katz, G. Lentz, R. Lobo, & D. Gershenson (Eds.), *Comprehensive gynecology* (6th ed., pp. 301–334). Philadelphia. {A: Mosby Elsevier.

Kolesova, O., & Vetra, J. (2012). Female pelvic types and age differences in their distribution. *Papers on Anthropology, 21,* 147–154.

Martini, F., Timmons, M. J., & Tallitsch, R. (2011). *Human anatomy* (7th ed.). San Francisco, CA: Benjamin Cummings.

McCartney, C. R., & Marshall, J. C. (2014). Neuroendocrinology of reproduction. In J. F. Strauss & R. L. Barbien (Eds.), *Reproductive endocrinology: physiology, pathophysiology, and clinical management* (7th ed., pp. 3–26.) Philadelphia, PA: Saunders.

Molitch, M. (2014). Prolactin in human reproduction. In J. F. Strauss & R. L. Barbien (Eds.), *Reproductive endocrinology: physiology, pathophysiology, and clinical management* (7th ed., pp. 45–65). Philadelphia, PA: Saunders.

Puppo, V. (2013). Anatomy and physiology of the clitoris, vestibular bulbs, and labia minora with a review of the female orgasm and the prevention of female dysfunction. *Clinical Anatomy, 26*(1), 134–152.

Richter, H., & Varner, R. (2007). Pelvic organ prolapse. In J. Berek (Ed.), *Berek and Novak's gynecology* (14th ed., pp. 897–934). Philadelphia, PA: Lippincott Williams & Wilkins.

Soper, D. (2007). Genitourinary infections and sexually transmitted diseases. In J. Berek (Ed.), *Berek and Novak's gynecology* (14th ed., pp. 541–559). Philadelphia, PA: Lippincott Williams & Wilkins.

Soucasaux, N. (1993a). Archetypal aspects of the female genitals. *Museum of Menstruation & Women's Health*. Retrieved from http://www.mum.org/sougenit.htm

Soucasaux, N. (1993b). Psychosomatic and symbolic aspects of menstruation. *Museum of Menstruation & Women's Health*. Retrieved from http://www.mum.org/psychos.htm