

## Reproductive System

- **Primary sex organs (gonads) - testes and ovaries**
  - Produce **gametes** (sex cells) – sperm & ova
  - Secrete steroid **sex hormones**
    - Androgens (males)
    - Estrogens and progesterone (females)
- **Accessory reproductive organs** - ducts, glands, and external genitalia

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## Reproductive System

- Sex hormones play roles in
  - Development and function of reproductive organs
  - Sexual behavior and drives
  - Growth and development of many other organs and tissues

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## Male Reproductive System

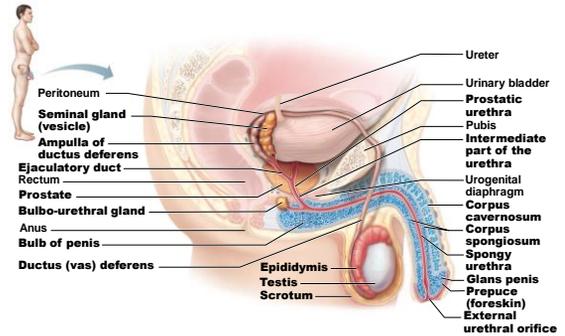
- **Testes** (within *scrotum*) produce sperm
- Sperm delivered to exterior through system of ducts
  - *Epididymis* → *ductus deferens* → *ejaculatory duct* → *urethra*

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## Male Reproductive System

- Accessory sex glands
  - Seminal glands
  - Prostate
  - Bulbo-urethral glands
  - Empty secretions into ducts during ejaculation

Figure 27.1 Reproductive organs of the male, sagittal view.



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## The Scrotum

- Sac of skin and superficial fascia
  - Hangs outside abdominopelvic cavity
  - Contains paired testes
    - 3°C lower than core body temperature
    - Lower temperature necessary for sperm production

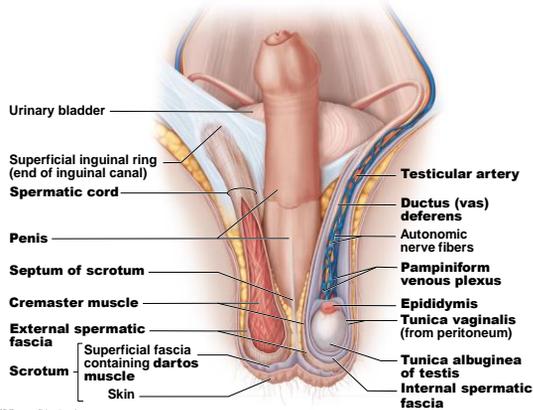
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## The Scrotum

- Temperature kept constant by two sets of muscles
  - **Dartos muscle** - smooth muscle; wrinkles scrotal skin; pulls scrotum close to body
  - **Cremaster muscles** - bands of skeletal muscle that elevate testes

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Figure 27.2 Relationships of the testis to the scrotum and spermatic cord.



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## The Testes

- Each surrounded by two tunics
  - **Tunica vaginalis** – outer layer derived from peritoneum
  - **Tunica albuginea** – inner layer; fibrous capsule
- Septa divide testis into ~250 *lobules*, each containing 1–4 **seminiferous tubules** - site of sperm production

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## Seminiferous Tubules

- **Interstitial endocrine cells** in soft tissue surrounding seminiferous tubules
- Produce androgens, e.g., testosterone
  - Secrete it into interstitial fluid

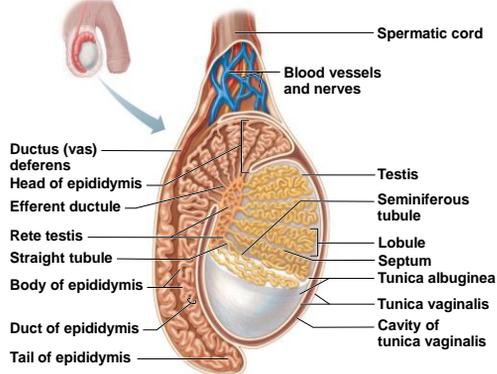
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## The Testes

- Blood supply
  - Testicular arteries arise from abdominal aorta
  - Testicular veins arise from **pampiniform venous plexus** surrounding each testicular artery
    - Cooler; absorb heat from testicular arteries
    - Keep testes cool
- **Spermatic cord** encloses nerve fibers, blood vessels, and lymphatics that supply testes

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Figure 27.3a Structure of the testis.



(a)

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## The Penis

- Penis consists of
  - Root and shaft that ends in **glans penis**
  - **Prepuce**, or foreskin—cuff of loose skin covering glans
  - **Crura**
    - Proximal ends of corpora cavernosa surrounded by ischiocavernosus muscle; anchors penis to pubic arch

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## Circumcision

- Surgical removal of foreskin
- 60% newborn boys in US circumcised
  - 15% in other parts of world
  - Some claim medically unnecessary
  - Studies show
    - 60% reduction in HIV risk
    - Reduced risk for other reproductive system infections

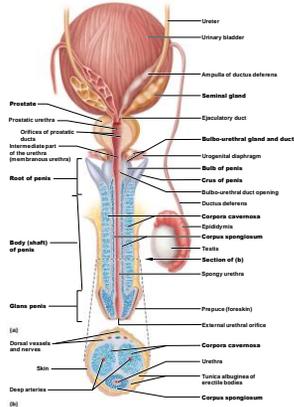
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## The Penis: Internally

- Spongy urethra and three cylindrical bodies of *erectile tissue* (spongy network of connective tissue and smooth muscle with vascular spaces)
  - **Corpus spongiosum** - surrounds urethra and expands to form glans and bulb
  - **Corpora cavernosa** - paired dorsal erectile bodies
- *Erection* - erectile tissue fills with blood, causing penis to enlarge and become rigid

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Figure 27.5 Male reproductive structures.



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## The Male Duct System

- Ducts carry sperm from testes to body exterior
  - **Epididymis**
  - **Ductus deferens**
  - **Ejaculatory duct**
  - **Urethra**

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## Epididymis

- **Head** - contains efferent ductules; superior aspect of testis; **body** and **tail** on posterolateral area of testis
- **Duct of the epididymis** ~ 6 m in length
  - Microvilli (stereocilia) absorb testicular fluid and pass nutrients to stored sperm
- Nonmotile sperm enter, pass slowly through (~ 20 days), become motile; can be stored several months
- During ejaculation epididymis contracts, expelling sperm into ductus deferens

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## Ductus Deferens and Ejaculatory Duct

- **Ductus deferens** (vas deferens) ~ 45 cm
  - Passes through inguinal canal to pelvic cavity
  - Expands to form **ampulla**; joins duct of seminal vesicle to form **ejaculatory duct**
- Smooth muscle in walls propels sperm from epididymis to urethra
- **Vasectomy** - cutting and ligating ductus deferens; nearly 100% effective form of birth control

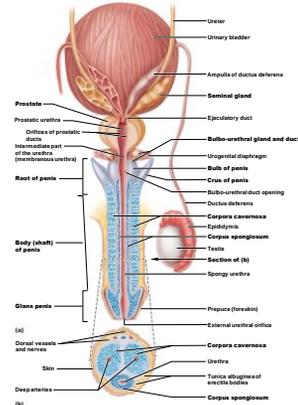
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## Urethra

- Conveys both urine and semen (at different times)
- Has three regions
  - **Prostatic urethra** – surrounded by prostate
  - **Intermediate part of the urethra (membranous urethra)** – in urogenital diaphragm
  - **Spongy urethra** – runs through penis; opens at *external urethral orifice*

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Figure 27.5 Male reproductive structures.



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## The Male Accessory Glands

- Paired **seminal glands (seminal vesicles)**
- Paired **bulbo-urethral glands**
- **Prostate**
- Produce bulk of **semen**
  - Remainder - sperm from testes

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## Accessory Glands: Seminal Glands

- On posterior bladder surface; smooth muscle contracts during ejaculation
- Produces viscous alkaline seminal fluid
  - Fructose, citric acid, coagulating enzyme (vesiculase), and prostaglandins
  - Yellow pigment fluoresces with UV light
  - 70% volume of semen
- Duct of seminal gland joins ductus deferens to form ejaculatory duct

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### Accessory Glands: Prostate

- Encircles urethra inferior to bladder; size of peach pit; smooth muscle contracts during ejaculation
- Secretes milky, slightly acid fluid
  - Contains citrate, enzymes, and prostate-specific antigen (PSA)
  - Role in sperm activation
  - Enters prostatic urethra during ejaculation
- 1/3 semen volume

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### Prostate Disorders

- **Prostatitis** – inflammatory disorders
  - Bacterial infection; acute and chronic; treated with antibiotics
- **Benign prostatic hyperplasia**
  - May be age-related; distorts urethra; treated with surgery, microwaves, drugs, balloon compression, radio-frequency radiation

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### Prostate Disorders

- **Prostate cancer**
  - Second most common cause of cancer death in males
  - Digital exam screening, PSA levels
    - Biopsy if abnormal
  - Treated with surgery and sometimes radiation; castration; drugs
  - In clinical trials - cryosurgery, chemotherapy, ultrasound, proton beam therapy

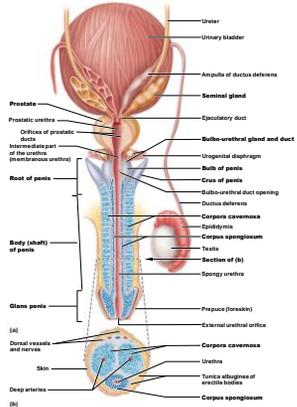
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### Accessory Glands: Bulbo-Urethral Glands (Cowper's Glands)

- Pea-sized glands inferior to prostate
- Produce thick, clear mucus during sexual arousal
  - Lubricate glans penis
  - Neutralize traces of acidic urine in urethra

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Figure 27.5 Male reproductive structures.



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## Semen

- Milky-white mixture of sperm and accessory gland secretions
  - 2–5 ml semen ejaculated, contains 20–150 million sperm/ml
- Contains fructose for ATP production; protects and activates sperm; facilitates sperm movement
- Alkaline → neutralizes acidity of male urethra and female vagina → enhanced motility

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## Semen Functions

- Prostaglandins decrease viscosity of mucus in cervix; stimulate reverse peristalsis in uterus
- Hormone relaxin, enzymes → sperm motility
- Contains ATP for energy
- Suppresses female immune response
- Antibacterial action
- Clotting factors coagulate semen initially to prevent draining out; then liquefied by fibrinolysin → sperm begin journey

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## Male Sexual Response

- **Erection**
  - Arterioles normally constricted
  - Sexual excitement causes CNS activation of *parasympathetic* neurons
  - → nitric oxide (NO) release → local vascular smooth muscle relaxation
  - → arterioles dilate → corpora cavernosa expands, retards venous drainage
  - → engorgement of erectile tissues with blood
  - → enlargement and stiffening of penis

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## Male Sexual Response

### • Ejaculation

- Propulsion of semen from male duct system
- *Sympathetic* spinal reflex
  - Bladder sphincter muscle constricts, preventing expulsion of urine
  - Ducts and accessory glands contract and empty their contents
  - Bulbospongiosus muscles undergo rapid series of contractions → expulsion of semen at ~ 500 cm/s (close to 11 mph)
- Ejaculatory event – **climax (orgasm)**

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## Homeostatic Imbalance

### • Erectile dysfunction

- Parasympathetic nerves of penis release too little NO
- Causes – alcohol, drugs, hormones, blood vessel or nervous system problems, incompetent venous valves fail to retain blood in penis
- New drugs (Viagra, Cialis) potentiate existing NO effects

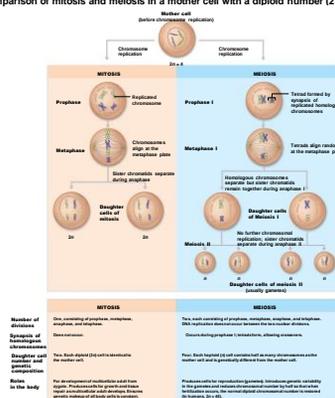
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## Spermatogenesis

- **Sperm (spermatozoa)** production in seminiferous tubules
- Most body cells have 46 chromosomes - **diploid chromosomal number (2n)**
  - Two sets (23 pairs) of chromosomes
    - One maternal, one paternal – **homologous chromosomes**
  - Gametes have 23 chromosomes - **haploid chromosomal number (n)**
    - Only one member of homologous pair

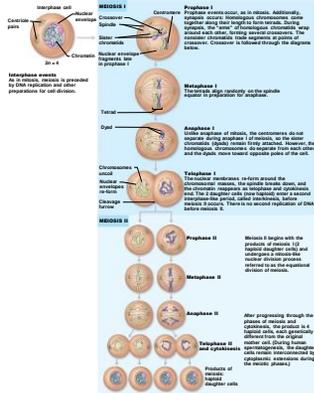
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Figure 27.6 Comparison of mitosis and meiosis in a mother cell with a diploid number (2n) of 4.



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Figure 27.7 Meiosis.



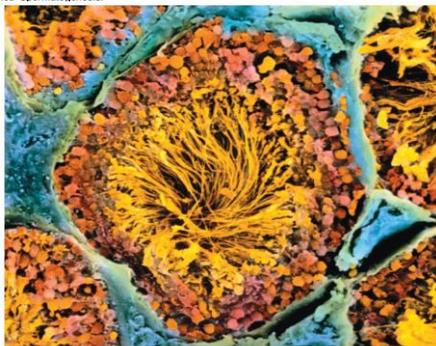
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## Spermatogenesis

- **Spermatogenic cells** give rise to sperm
  - Mitosis of spermatogonia (stem cell) forms two spermatocytes
  - Meiosis
    - Spermatocytes → secondary spermatocytes → spermatids
  - **Spermiogenesis**
    - Spermatids become sperm

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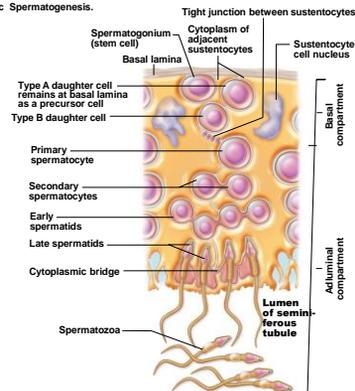
Figure 27.8a Spermatogenesis.



**(a) Scanning electron micrograph of a cross-sectional view of a seminiferous tubule (165x)**

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Figure 27.8c Spermatogenesis.



**(c) A portion of the seminiferous tubule wall, showing the spermatogenic cells surrounded by sustentocytes (colored gold)**

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### Mitosis of Spermatogonia

- Spermatogenesis begins at puberty
- **Spermatogonia**
  - Stem cells in contact with epithelial basal lamina
  - Each mitotic division → one **type A daughter cell** and one **type B daughter cell**

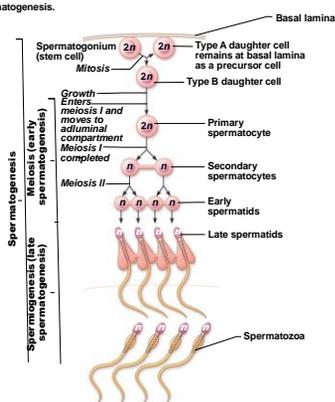
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### Mitosis of Spermatogonia

- Type A cells maintain germ cell line at basal lamina
- Type B cells move toward lumen and develop into primary spermatocytes

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Figure 27.8b Spermatogenesis.

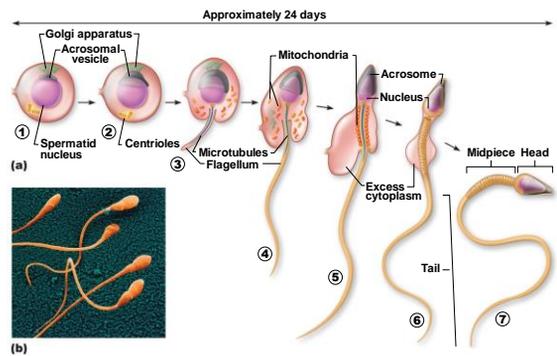


(b) Events of spermatogenesis, showing the relative position of various spermatogenic cells

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Figure 27.9 Spermiogenesis: transformation of a spermatid into a functional sperm.

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## Spermatogenesis

- Takes 64 – 72 days if conditions hospitable
- Pressure of testicular fluid pushes immotile sperm into epididymis → motility and fertilizing power

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## Homeostatic Imbalance

- Infertility
  - Gradual decline in male fertility past 50 years
  - *Xenobiotics* (alien molecules) may be cause
    - Environmental toxins, PVCs, phthalates, pesticides, herbicides, compounds with estrogenic effects, antibiotics, radiation, lead, marijuana
  - Also, lack of selenium, excessive alcohol, lack of specific  $Ca^{2+}$  channel, anatomical obstructions, hormonal imbalances, oxidative stress, fevers, hot tubs

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## Hormonal Regulation of Male Reproductive Function

- Sequence of hormonal regulatory events involving hypothalamus, anterior pituitary gland, and testes
  - Hypothalamic-pituitary-gonadal (HPG) axis
  - Regulates production of gametes and sex hormones through 3 interacting sets of hormones
    - GnRH indirectly stimulates testes via FSH & LH
    - FSH & LH directly stimulate testes
    - Testosterone & inhibin – negative feedback on hypothalamus and anterior pituitary

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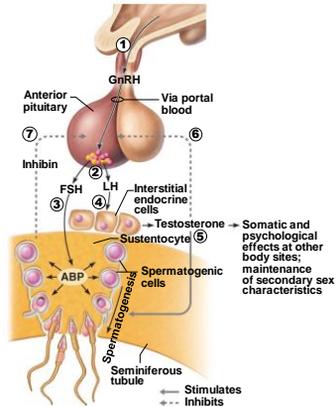
## HPG Axis

- Testosterone → sex organ maturation, development/maintenance secondary sex characteristics, libido
- Rising testosterone levels → feedback inhibition on hypothalamus to inhibit GnRH and on pituitary to inhibit gonadotropin release
- **Inhibin** (released when sperm count high) – inhibits GnRH and FSH release

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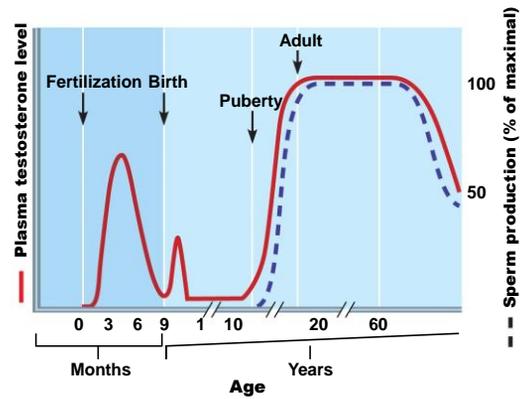
Figure 27.10 Hormonal regulation of testicular function, the hypothalamic-pituitary-gonadal (HPG) axis.

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Figure 27.11 Plasma testosterone and sperm production levels versus age in male humans.



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## Female Reproductive Anatomy

- **Ovaries - female gonads**
  - Produce female gametes (ova)
  - Secrete female sex hormones, **estrogen** (estradiol, estrone, estriol) and **progesterone**
- Accessory ducts include
  - **Uterine tubes**
  - **Uterus**
  - **Vagina**

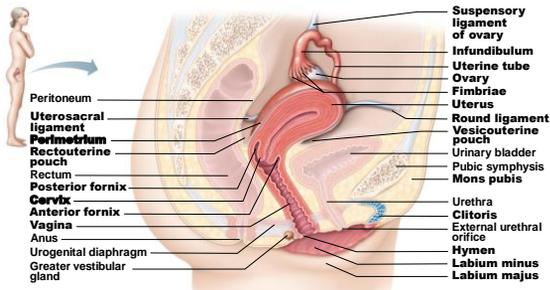
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## Female Reproductive Anatomy

- **Internal genitalia** – in pelvic cavity
  - **Ovaries**
  - **Uterine tubes**
  - **Uterus**
  - **Vagina**
- **External genitalia**
  - External sex organs

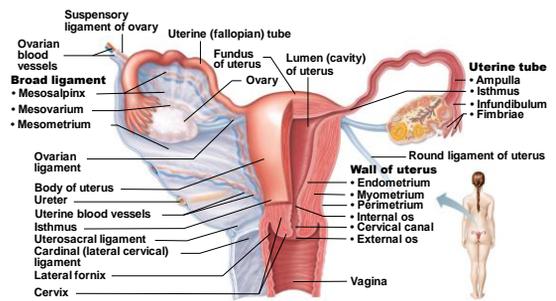
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Figure 27.12 Internal organs of the female reproductive system, midsagittal section.



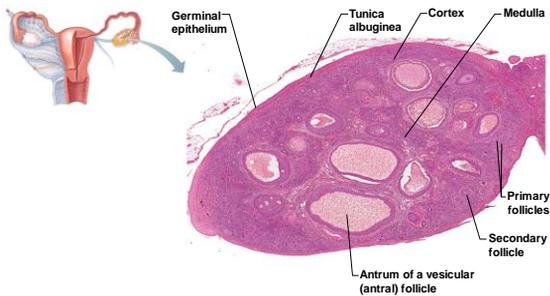
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Figure 27.14 Internal reproductive organs of a female, posterior view.



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Figure 27.13 Photomicrograph of a mammalian ovary showing follicles in different developmental phases.



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## Female Duct System

- Ducts have no contact with ovary
  - Oocyte cast into peritoneal cavity; some lost there
- Uterine (fallopian) tubes or oviducts
- Uterus
- Vagina

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## Homeostatic Imbalance

- **Ectopic pregnancy**
  - Oocyte fertilized in peritoneal cavity or distal uterine tube begins developing there
    - Normally abort naturally with substantial bleeding
- **Pelvic inflammatory disease (PID)**
  - Spread of infection from reproductive tract to peritoneal cavity
    - May cause scar tissue → infertility

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## Homeostatic Imbalance

- **Cervical cancer**
  - 450,000 women worldwide each year – killing half
  - Most common between 30 – 50
  - Risks – frequent cervical inflammations, STIs, multiple pregnancies
  - Papanicolaou (Pap) smear for detection
    - Every two years 21 – 30; every year > 30; discontinue at 65 if negative for 10 years

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## Homeostatic Imbalance

- Pap smear results inconclusive
  - Test for human papillomavirus – cause of most cervical cancers
- Gardasil – three-dose vaccine; protects against HPV
  - Recommended for 11- and 12-year-old girls

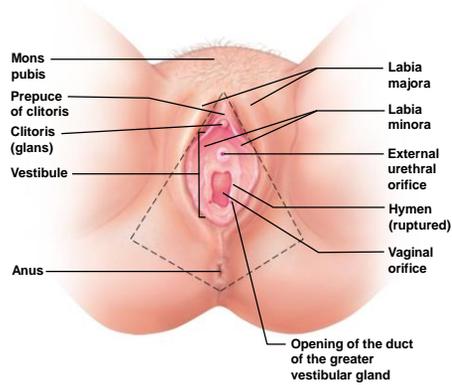
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## Vagina

- Layers of wall
  - Fibroelastic *adventitia*
  - Smooth muscle *muscularis*
  - Stratified squamous *mucosa* with rugae
- Dendritic cells in mucosa may provide route for HIV transmission
- Mucosa near vaginal orifice forms incomplete partition called **hymen** – ruptures with intercourse
- **Vaginal fornix** - upper end of vagina surrounding cervix

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Figure 27.16a The external genitalia (vulva) of the female.



(a)

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## External Genitalia (Vulva or Pudendum)

- **Mons pubis** - fatty area overlying pubic symphysis
- **Labia majora** - hair-covered, fatty skin folds
  - Counterpart of male scrotum
- **Labia minora** - skin folds lying within labia majora
  - Join at posterior end of vestibule → **fourchette**
  - Vestibule - recess within labia minora

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## External Genitalia

- **Greater vestibular glands**
  - Flank vaginal opening
  - Homologous to bulbo-urethral glands
  - Release mucus into vestibule for lubrication

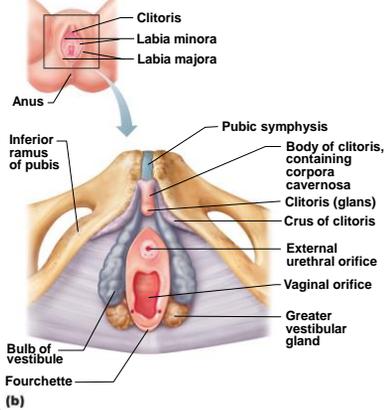
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## External Genitalia

- **Clitoris** – anterior to vestibule
  - **Glans of the clitoris** - exposed portion
  - **Prepuce of the clitoris** – hoods glans
  - Counterpart of penis
- **Perineum**
  - Diamond-shaped region between pubic arch and coccyx
  - Bordered by ischial tuberosities laterally

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Figure 27.16b The external genitalia (vulva) of the female.



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## Mammary Glands

- Modified sweat glands consisting of 15–25 **lobes**
- Function in milk production
- **Areola** - pigmented skin surrounding **nipple**
- **Suspensory ligaments** – attach breast to underlying muscle
- Lobules within lobes contain glandular **alveoli** that produce milk

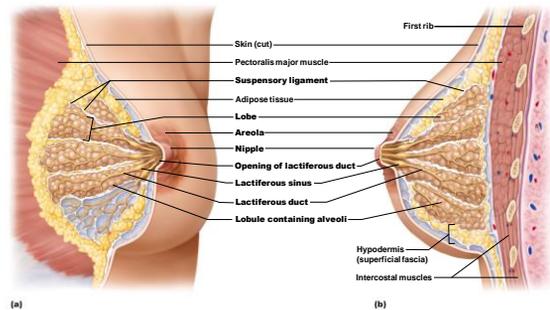
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## Mammary Glands

- Milk → **lactiferous ducts** → **lactiferous sinuses** → open to outside at nipple
- Breast size due to amount of fat deposits

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Figure 27.17 Structure of lactating mammary glands.



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## Breast Cancer

- Invasive breast cancer most common malignancy, second most common cause of cancer death in U.S. women
- 13% will develop condition

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## Breast Cancer

- Usually arises from epithelial cells of smallest ducts; eventually metastasize
- Risk factors include
  - Early onset of menstruation and late menopause
  - No pregnancies or first pregnancy late in life
  - No or short periods of breast feeding
  - Family history of breast cancer
- 70% of women with breast cancer have no known risk factors

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## Breast Cancer

- 10% due to hereditary defects, including mutations to genes BRCA1 and BRCA2
  - 50 – 80% develop breast cancer
  - Greater risk of ovarian cancer as well

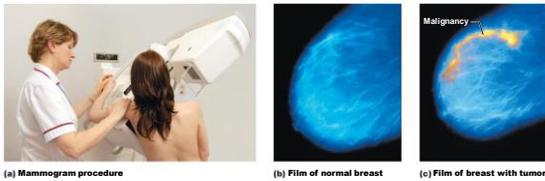
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## Breast Cancer: Treatment

- **Radical mastectomy** – removes breast, all underlying muscles, fascia, associated lymph nodes
- **Lumpectomy** – excises only cancerous lump
- **Simple mastectomy** – removes only breast tissue, sometimes some axillary lymph nodes
- Some have breast reconstruction

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Figure 27.18 Mammograms.



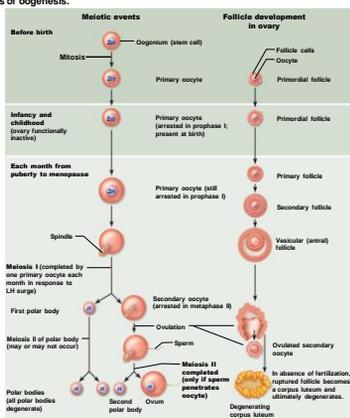
### Physiology of the Female Reproductive System

- Always assumed females total supply of eggs determined at birth
- New evidence stem cells can arise from epithelial cells at ovary surface
- May overturn previous assumption

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Figure 27.19 Events of oogenesis.



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### Comparison of Oogenesis and Spermatogenesis

- Spermatogenesis → 4 viable sperm
- Spermatogenesis – error rate of 3-4%
- Oogenesis → 1 viable gamete; 3 polar bodies
- Oogenesis – error rate of 20%
- Unequal divisions ensure oocyte has ample nutrients for 6-7 day journey to uterus
- Polar bodies degenerate and die

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## Ovarian Cycle

- Monthly series of events associated with maturation of egg
- Two consecutive phases (in 28-day cycle)
  - **Follicular phase** - period of follicle growth (days 1–14)
  - **Ovulation** occurs midcycle
  - **Luteal phase** - period of corpus luteum activity (days 14–28)

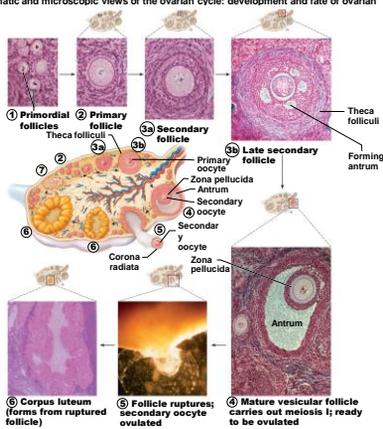
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## Ovarian Cycle

- Only 10 – 15% women have 28-day cycle
- Follicular phase varies
- Luteal phase constant – always 14 days from ovulation to end of cycle

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Figure 27.20 Schematic and microscopic views of the ovarian cycle: development and fate of ovarian follicles.



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**CHAPTER 27**

**The Reproductive System: Part C**

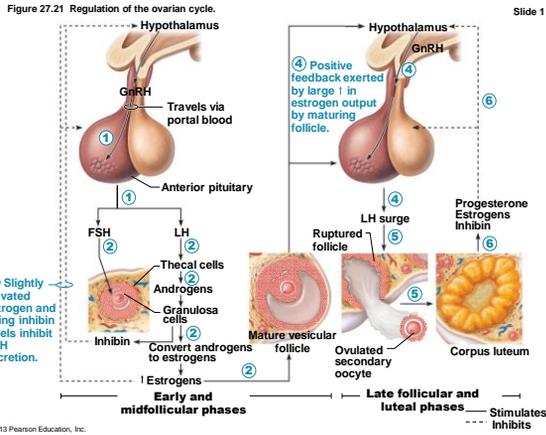
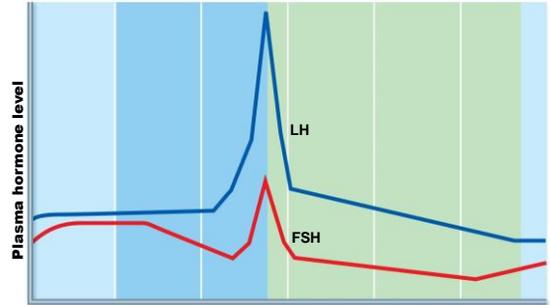


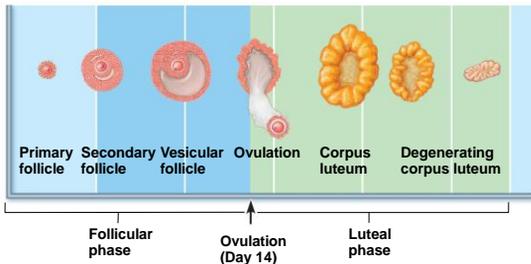
Figure 27.22a Correlation of anterior pituitary and ovarian hormones with structural changes of the ovary and uterus.



(a) Fluctuation of gonadotropin levels: Fluctuating levels of pituitary gonadotropins (follicle-stimulating hormone and luteinizing hormone) in the blood regulate the events of the ovarian cycle.

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Figure 27.22b Correlation of anterior pituitary and ovarian hormones with structural changes of the ovary and uterus.



(b) Ovarian cycle: Structural changes in the ovarian follicles during the ovarian cycle are correlated with (d) changes in the endometrium of the uterus during the uterine cycle.

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## The Uterine (Menstrual) Cycle

- Cyclic changes in endometrium in response to fluctuating ovarian hormone levels
- Three phases
  - Days 1–5 - menstrual phase
  - Days 6–14 - proliferative (preovulatory) phase
  - Days 15–28 - secretory (postovulatory) phase (constant 14-day length)

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## Uterine Cycle

- **Menstrual phase (Days 1 - 5)**
  - Ovarian hormones at lowest levels
  - Gonadotropins beginning to rise
  - Stratum functionalis shed; menstrual flow (blood and tissue) 3 - 5 days
  - By day 5 growing ovarian follicles produce more estrogen

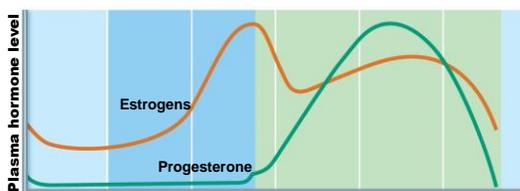
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## Uterine Cycle

- **Proliferative phase (Days 6 - 14)**
  - Rising estrogen levels prompt generation of new stratum functionalis layer; increased synthesis of progesterone receptors in endometrium; glands enlarge and spiral arteries increase in number
  - Normally thick, sticky cervical mucus thins in response to rising estrogen (allows sperm passage)
  - Ovulation occurs at end of proliferative phase

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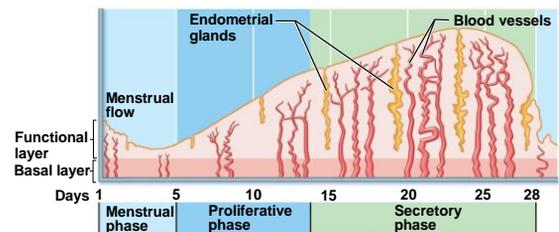
Figure 27.22c Correlation of anterior pituitary and ovarian hormones with structural changes of the ovary and uterus.



(c) **Fluctuation of ovarian hormone levels:** Fluctuating levels of ovarian hormones (estrogens and progesterone) cause the endometrial changes of the uterine cycle. The high estrogen levels are also responsible for the LH/FSH surge in (a).

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Figure 27.22d Correlation of anterior pituitary and ovarian hormones with structural changes of the ovary and uterus.

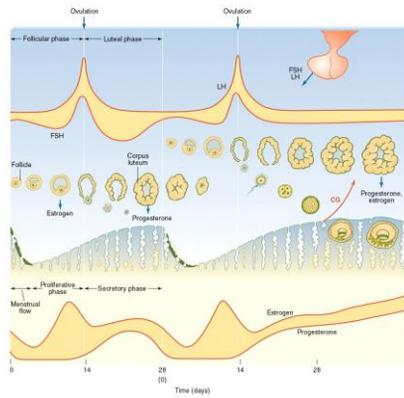


(d) **The three phases of the uterine cycle:**

- **Menstrual:** The functional layer of the endometrium is shed.
- **Proliferative:** The functional layer of the endometrium is rebuilt.
- **Secretory:** Begins immediately after ovulation. Enrichment of the blood supply and glandular secretion of nutrients prepare the endometrium to receive an embryo.

Both the menstrual and proliferative phases occur before ovulation, and together they correspond to the follicular phase of the ovarian cycle. The secretory phase corresponds in time to the luteal phase of the ovarian cycle.

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## Effects of Estrogens

- Promote oogenesis and follicle growth in ovary
- Exert anabolic effects on female reproductive tract
- Support rapid but short-lived growth spurt at puberty

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## Effects of Estrogens

- Induce secondary sex characteristics
  - Growth of breasts
  - Increased deposit of subcutaneous fat (hips and breasts)
  - Widening and lightening of pelvis

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## Effects of Estrogens

- Metabolic effects (not true secondary sex characteristics)
  - Maintain low total blood cholesterol and high HDL levels
  - Facilitate calcium uptake

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## Effects of Progesterone

- Progesterone works with estrogen to establish and regulate uterine cycle
- Promotes changes in cervical mucus
- Effects of placental progesterone during pregnancy
  - Inhibits uterine motility
  - Helps prepare breasts for lactation

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## Sexually Transmitted Infections (STIs)

- Also called sexually transmitted diseases (STDs) or venereal diseases (VDs)
- U.S. – highest rates of infection among developed countries
- Latex condoms help prevent spread
- Single most important cause of reproductive disorders

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## Gonorrhea

- Commonly called "the clap"
- Bacterial infection of mucosae of reproductive and urinary tracts
- Spread by contact with genital, anal, and pharyngeal mucosae
- Number of cases in U.S. declining

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## Gonorrhea

- Signs and symptoms
  - Males
    - Urethritis, painful urination, discharge of pus
  - Females
    - 20% display no signs or symptoms
    - Abdominal discomfort, vaginal discharge, or abnormal uterine bleeding
    - Can result in pelvic inflammatory disease and sterility
- Treatment - antibiotics, but resistant strains becoming prevalent

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## Syphilis

- Bacterial infection transmitted sexually or contracted congenitally
  - Infected fetuses stillborn or die shortly after birth
- Infection asymptomatic for 2–3 weeks
- Painless *chancre* appears at site of infection; disappears in few weeks

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## Syphilis

- If untreated, secondary signs appear several weeks later for 3–12 weeks, then disappear
  - Pink skin rash, fever, and joint pain
- Latent period may or may not progress to tertiary syphilis, characterized by gummas (lesions of CNS, blood vessels, bones, and skin)
- Treatment - penicillin

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## Chlamydia

- Most common bacterial STI in United States
- Responsible for 25–50% of all diagnosed cases of pelvic inflammatory disease
- Symptoms - urethritis; penile and vaginal discharges; abdominal, rectal, or testicular pain; painful intercourse; irregular menses
- Can cause arthritis and urinary tract infections in men; sterility in women; newborns contract in birth canal → trachoma (painful eye infection), respiratory tract inflammation
- Treatment - tetracycline

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## Trichomoniasis

- Most common curable STI in active young women in U.S.
- Parasitic infection; easily, inexpensively treated
- Yellow-green vaginal discharge with strong odor; some symptomless

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## Viral Infections

### • Genital warts

- Caused by human papillomavirus (HPV)
- Second most common STI in United States
- Increased risk of cancers in infected body regions
  - Linked to 80% cases of invasive cervical cancer; most strains do not cause cancer
- Treatment difficult; controversial

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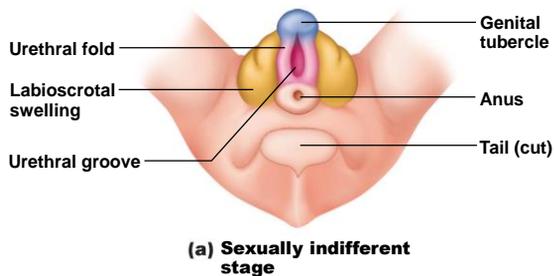
## Viral Infections

### • Genital herpes

- Caused by herpes simplex virus 2
- Characterized by latent periods and flare-ups
  - Congenital herpes can cause malformations of fetus
- Treatment - acyclovir and other antiviral drugs

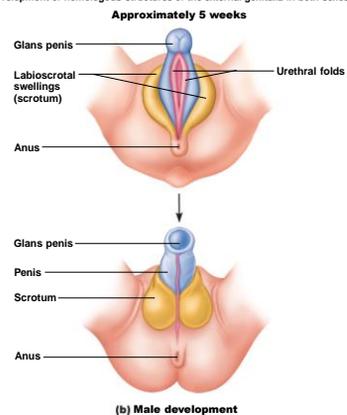
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Figure 27.24a Development of homologous structures of the external genitalia in both sexes.



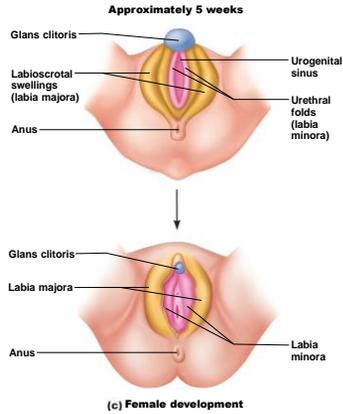
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Figure 27.24b Development of homologous structures of the external genitalia in both sexes.



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Figure 27.24c: Development of homologous structures of the external genitalia in both sexes.



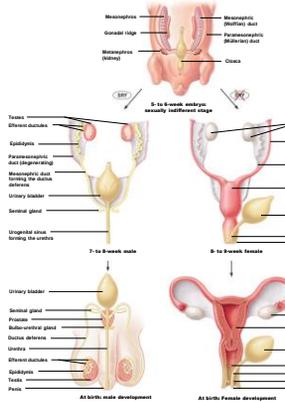
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### Development Aspects: Descent of the Gonads

- About two months before birth
  - Testosterone stimulates migration of testes toward scrotum
- **Gubernaculum** - fibrous cord from each testis to scrotum or from ovary to labium majus; guides descent
- Ovaries also descend, but stopped by broad ligament at pelvic brim

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Figure 27.23 Development of the internal reproductive organs.



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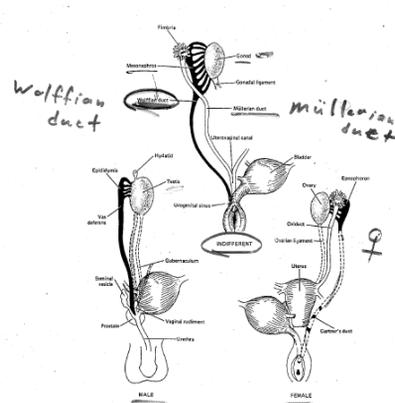


Figure 27-4. Embryonic differentiation of male and female internal genitalia (perineal ducts from Wolffian (male) and Müllerian (female) primordia. (After Chang, H.K., Wilson, L., Eds. and reproduced, with permission, from Van Wijk, F., Grubbels, M.H.; Textbook of Gynecology, 10th ed., Williams & Wilkins, Baltimore, 1974.)

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## Development Aspects: Puberty

- FSH and LH elevated at birth but drop and remain low during prepubertal years
- Reproductive organs grow to adult size and become functional – **puberty**
- Occurs in response to rising levels of gonadal hormones
- Secondary sex characteristics appear
- Earliest time that reproduction is possible

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## Menopause

- Has occurred when menses have ceased for an entire year
- No equivalent to menopause in males
  - Males continue to produce sperm well into eighth decade of life, though numbers and motility decrease

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## Menopause

- Declining estrogen levels →
  - Atrophy of reproductive organs and breasts
  - Irritability and depression in some
  - Hot flashes as skin blood vessels undergo intense vasodilation
  - Gradual thinning of skin and bone loss
  - Increased total blood cholesterol levels and falling HDL

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## Menopause

- Treatment with estrogen-progesterone preparations given for years
  - Women's Health Initiative research reported increased risk of heart disease (51%), invasive breast cancer (24%), stroke (31%), dementia (risk doubled)
  - Smallest dose for shortest time alright to reduce symptoms if no breast cancer or mutated BRCA gene

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## Sperm

- Major regions
  - **Head** - genetic region; nucleus and helmetlike **acrosome** containing hydrolytic enzymes that enable sperm to penetrate egg
  - **Midpiece** - metabolic region; mitochondria → ATP to move tail
  - **Tail** - locomotor region; flagellum

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## Role of Sustentocytes

- Large supporting cells (**Sertoli cells**)
  - Extend through wall of tubule and surround developing cells
  - Provide nutrients and signals to dividing cells
  - Move cells along to lumen
  - Secrete **testicular fluid** into lumen for sperm transport
  - Phagocytize faulty germ cells and excess cytoplasm
  - Produce chemical mediators to regulate spermatogenesis

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## Mechanism and Effects of Testosterone Activity

- Testosterone
  - Synthesized from cholesterol
  - Transformed to exert its effects on some target cells
    - *Dihydrotestosterone* (DHT) in prostate
    - *Estradiol* in some neurons in brain

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## Ovaries

- Held in place by several ligaments
  - **Ovarian ligament** - anchors ovary medially to uterus
  - **Suspensory ligament** - anchors ovary laterally to pelvic wall
  - **Mesovarium** - suspends ovary
- Suspensory ligament and mesovarium part of **broad ligament** – supports uterine tubes, uterus, and vagina

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## Breast Cancer: Diagnosis

- Early detection via self-examination and **mammography**
  - X-ray examination
  - American Cancer Society recommends screening every year for women 40 and over
  - U.S. Prevention Services Task Force on Breast Cancer Screening recommends 50 and over

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## Breast Cancer: Treatment

- Treatment depends upon characteristics of lesion
  - Radiation; chemotherapy; surgery, often followed by radiation or chemotherapy to destroy stray cells
  - Drugs for estrogen-responsive cancers
    - Trastuzumab – for aggressive cancer cells
    - Tamoxifen – improves outcome for premenopausal women with early- or late-stage
    - Letrozole – reduces recurrence

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## Developmental Aspects: Determination of Genetic Sex

- Of 46 chromosomes in fertilized egg, two (one pair) are sex chromosomes
- Two sex chromosomes – **X chromosome** (large); **Y chromosome** (quite small)
- Females are XX; each ovum always has an X chromosome
- Males are XY, so ~50% of sperm contain X, ~50% contain Y

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### Developmental Aspects: Determination of Genetic Sex

- X egg + X sperm → XX (female offspring)
- X egg + Y sperm → XY (male offspring)
- The **SRY gene** on Y chromosome initiates testes development and maleness

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### Developmental Aspects: Sexual Differentiation

- Sexually indifferent stage
  - Gonads begin development in fifth week as **gonadal ridges**
  - **Paramesonephric (Müllerian) ducts** (future female ducts) form lateral to **mesonephric (Wolffian) ducts** (future male ducts); **sexually indifferent stage** - embryo could develop into male or female
  - **Primordial germ cells** migrate to gonadal ridges to provide germ cells destined to become spermatogonia or oogonia
- Gonads begin development in seventh week in males, eighth week in females

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### Developmental Aspects: Development of External Genitalia

- **Genital tubercle** → penis of male; clitoris of female
- **Urethral fold** → spongy urethra of male; labia minora of female
- **Labioscrotal swellings** → scrotum of male; labia majora of female
- If testosterone absent, all embryos develop into females

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