

Principles of Anatomy and Physiology
14th Edition
Gerard J. Tortora / Bryan Derrickson
WILEY

CHAPTER 28
The Reproductive System

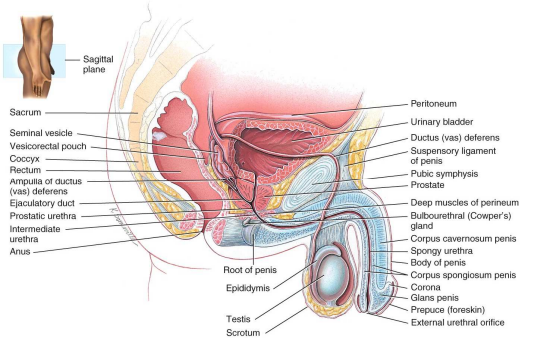
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Male Reproductive System

Organs include: **testes, ductus deferens, epididymis, ejaculatory ducts, urethra, seminal vesicles, prostate, bulbourethral glands, scrotum and penis.**

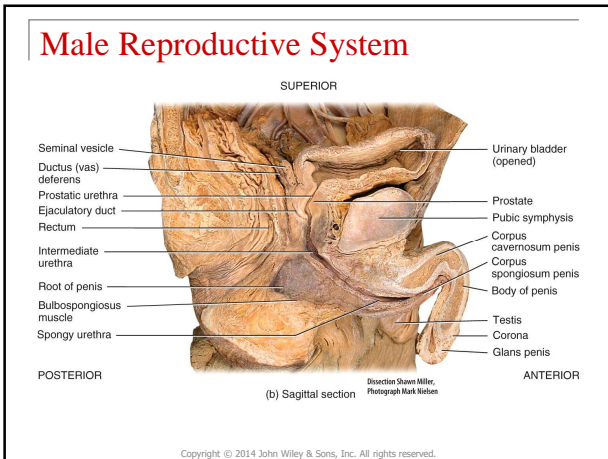
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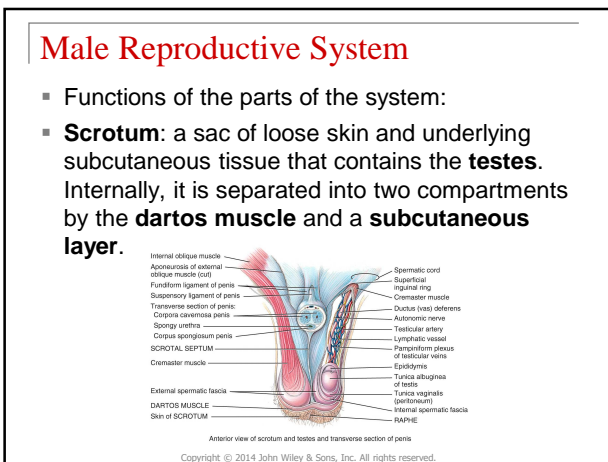
Male Reproductive System

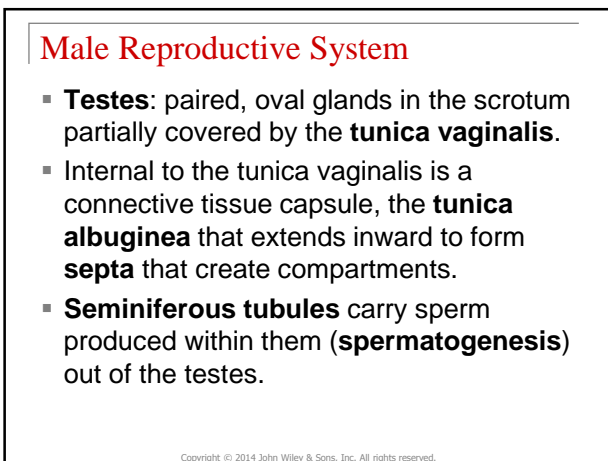


(a) Sagittal section

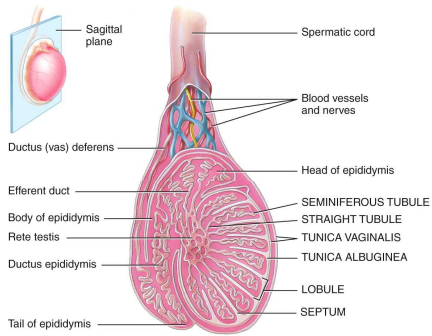
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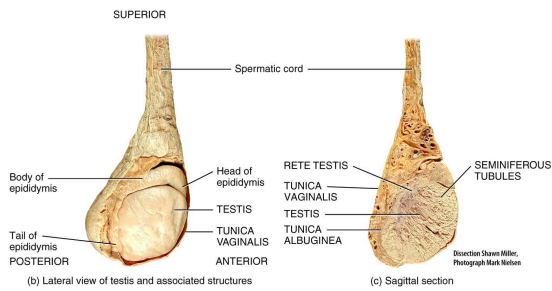
Male Reproductive System



(a) Sagittal section of testis showing seminiferous tubules

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Male Reproductive System



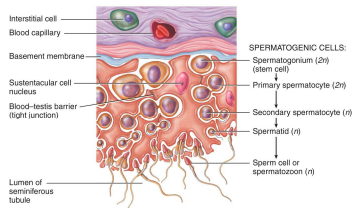
(b) Lateral view of testis and associated structures

(c) Sagittal section

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Male Reproductive System

Spermatogenesis begins with spermatogonia (diploid stem cells) that differentiate into diploid primary spermatocytes.



Transverse section of part of seminiferous tubule

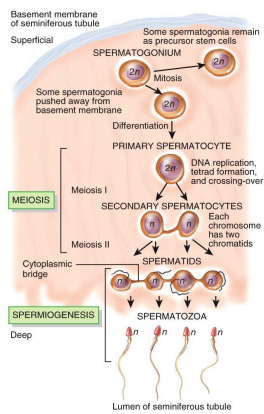
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Male Reproductive System

- The primary spermatocyte undergoes **meiosis I** to become two **secondary spermatocytes (haploid)**.
- **Meiosis II** takes place and the secondary spermatocytes become four **spermatids**.

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Male Reproductive System

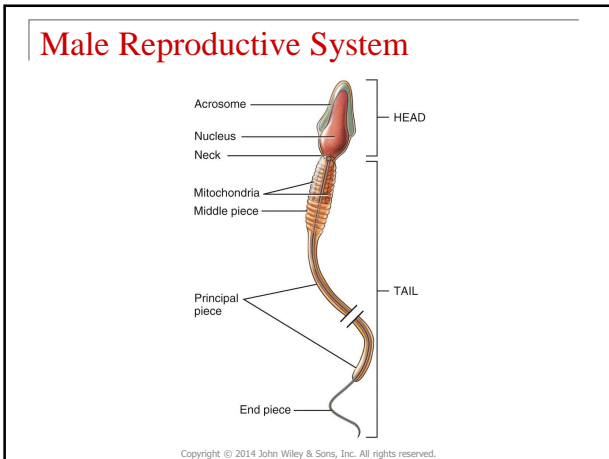


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Male Reproductive System

- **Sperm:** designed to reach and penetrate the **secondary oocyte** in order to achieve fertilization and create a zygote.
- The **head** contains a **nucleus** with 23 chromosomes.
- The **acrosome** covers the head and contains **enzymes** to help with penetration.
- The **neck** contains **centrioles** that form the microtubules that make up the rest of the **tail**.
- The **middle piece** contains **mitochondria** that make ATP for **locomotion** of the sperm.
- The **principal piece** and **end piece** make up the tail used for movement.

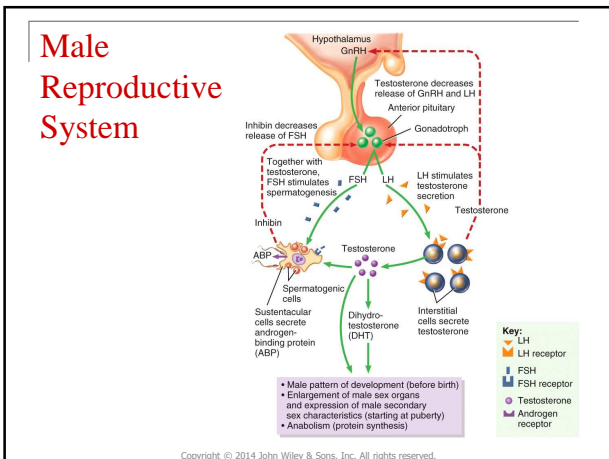
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Male Reproductive System

- **Hormones** control testicular function. At **puberty gonadotropin releasing hormone (GnRH)** stimulates cells in the **anterior pituitary gland** to produce **luteinizing hormone (LH)** and **follicle stimulating hormone (FSH)**.
- **LH** stimulates cells in the **testes** to produce **testosterone**.
- **FSH** stimulates **spermatogenesis**.

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Male Reproductive System

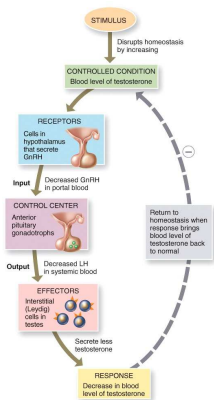
Testosterone and **dihydrotestosterone** produce several effects:

- Prenatal development
- Development of male sexual characteristics
- Development of sexual function
- Stimulation of anabolism

A negative feedback system controls the blood level of testosterone.

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Male Reproductive System



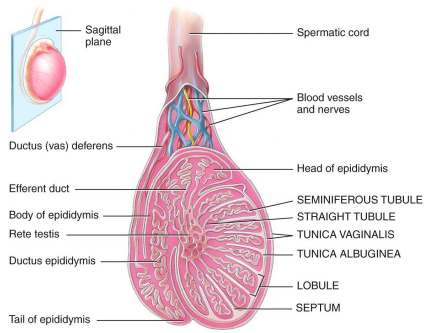
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Male Reproductive System

- There is a system of **ducts** in the male reproductive system. Sperm and fluid travel from the seminiferous tubules to **straight tubules** and then to a network of ducts, the **rete testis**.
- **Efferent ducts** carry the sperm to the **epididymis**. **Sperm mature** here and degenerated sperm are reabsorbed.
- The epididymis propels sperm into the **ductus (vas) deferens**.

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Male Reproductive System



(a) Sagittal section of testis showing seminiferous tubules

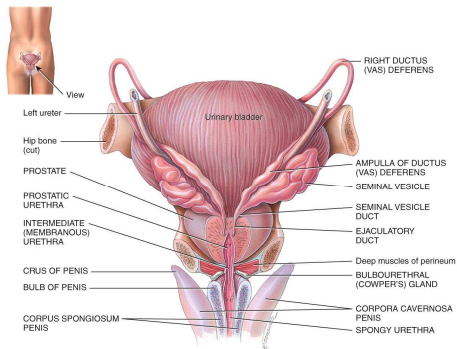
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Male Reproductive System

The **ductus (vas) deferens** exits the tail of the epididymis and ascends through the **spermatic cord** into the into the pelvis. It loops over the ureter and passes over the side and down the posterior surface of the **urinary bladder**.

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Male Reproductive System



(a) Posterior view of male accessory organs of reproduction

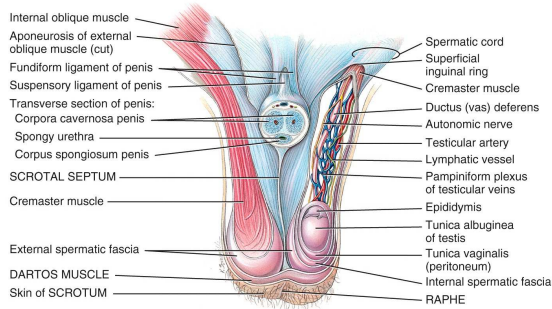
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Male Reproductive System

- The **spermatic cord** ascends out of the **scrotum** and contains the **ductus deferens, testicular artery, veins draining the testes, autonomic nerves, lymphatic vessels** and the **cremaster muscle**.
- The spermatic cord and **ilioinguinal nerve** pass through the **inguinal canal** which originates at the **deep inguinal ring** and ends at the **superficial inguinal ring**.

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Male Reproductive System



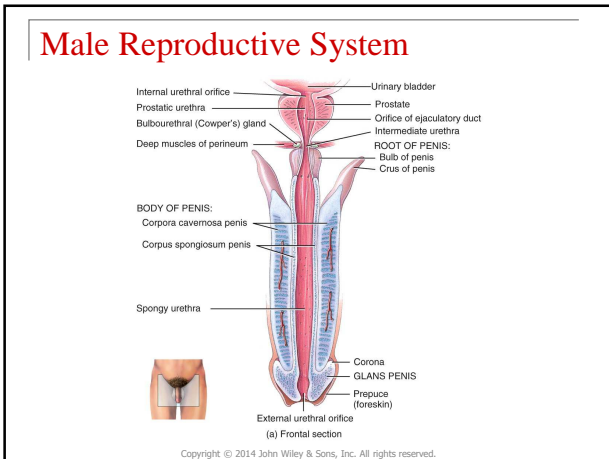
Anterior view of scrotum and testes and transverse section of penis

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Male Reproductive System

- The **ejaculatory ducts** arise from the junction of the **duct from the seminal vesicle** and the **ampulla of the ductus deferens**.
- The **urethra** is the duct shared by the reproductive and urinary systems. Both **semen** and **urine** pass through it. It passes through the **prostate gland (prostatic urethra)**, **deep muscles of the perineum (intermediate or membranous urethra)** and the **penis (spongy urethra)**.

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Male Reproductive System

- **Accessory glands** include:
 - **Seminal vesicles (glands)**—secrete an alkaline, viscous fluid containing fructose, prostaglandins and clotting proteins.
 - **Prostate:** a single, donut-shaped gland that secretes a milky, slightly acidic fluid containing citric acid, proteolytic enzymes, acid phosphatase and seminalplasmin.

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Male Reproductive System

Bulbourethral (Cowper's) glands: secrete an alkaline fluid during sexual arousal that neutralizes acids from urine and mucus for lubrication.

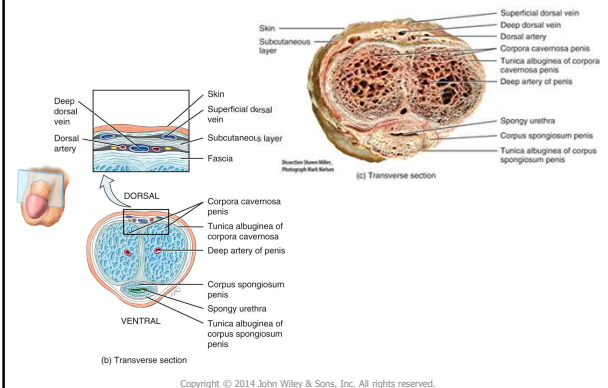
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Male Reproductive System

- **Semen:** a mixture of **sperm** and **seminal fluid**.
- The volume of an average ejaculate is 2.5-5 ml. with 50–150 million sperm per ml.
- The **pH** is **7.2–7.7**
- **Penis:** containing the urethra it is a passageway for semen and urine.
- Composed of 3 cylindrical masses: 2 **corpora cavernosa**, 1 **corpus spongiosum** (all erectile tissues).
- **Glans:** Head of penis covered by the **prepuce (foreskin)**.

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Male Reproductive System



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Male Reproductive System

- The penis is supported by the **fundiform and suspensory ligaments**.
- An **erection** is brought about by **parasympathetic innervation** leading to **vasodilation of arterioles in erectile tissue**.
- Large amounts of blood enter the tissue into **dilated blood sinuses**.
- **Ejaculation** is the powerful release of semen due to **sympathetic stimulation**. The **bulbospongiosus, ischiocavernosus** and **superficial transverse perineal muscles** contract to force the semen out.

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Male Reproductive System

Interactions Animation:

- [Hormonal Control of Male Reproductive Function](#)

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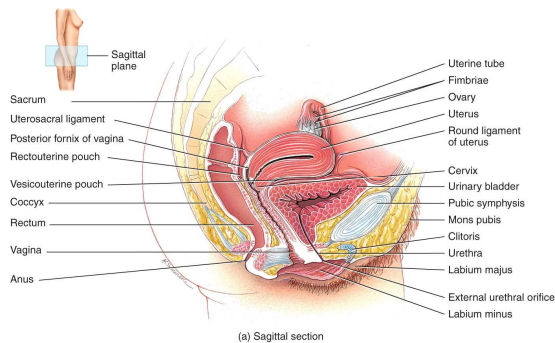
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Female Reproductive System

Organs include: **ovaries, uterine (fallopian) tubes (oviducts), the uterus, the vagina and external organs.**

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Female Reproductive System



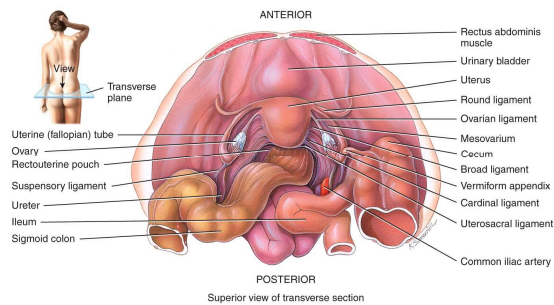
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Female Reproductive System

- **Ovaries:** paired glands homologous to the testes. They produce **gametes (mature into ova)** and **hormones (progesterone, estrogens, inhibin, relaxin)**.
- They are supported by the **broad ligament, ovarian ligament** and **suspensory ligament**.

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Female Reproductive System



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Female Reproductive System

- Histologically, ovaries consist of:
- The **germinal epithelium**—covers the surface
- The **tunica albuginea**—capsule of dense irregular connective tissue below the germinal epithelium
- The **ovarian cortex**—below the tunica albuginea. Consists of **ovarian follicles** and **stromal cells**.
- The **ovarian medulla**—connective tissue, blood vessels, lymphatic vessels and nerves.

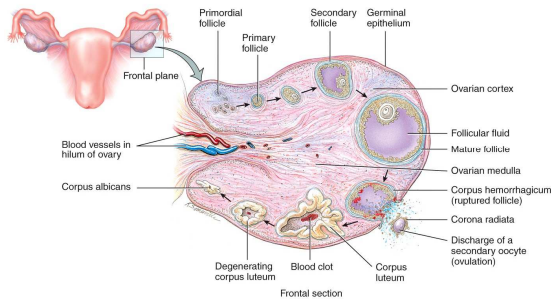
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Female Reproductive System

- **Ovarian follicles**—contain **oocytes** in various stages of development, **follicular cells** and **granulosa cells**.
- A **mature (graafian) follicle** is ready to rupture and expel the **secondary oocyte**.
- A **corpus luteum** develops after ovulation when the empty follicle produces **progesterone, estrogens, inhibin** and **relaxin**.

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Female Reproductive System



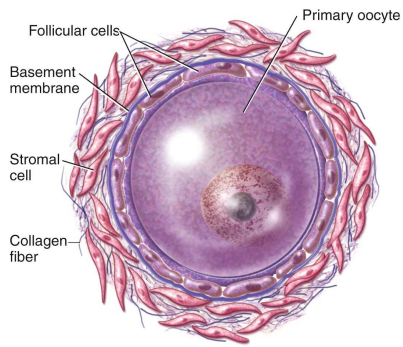
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Female Reproductive System

- Formation of gametes in the ovaries is **oogenesis**. It begins before a female is born with the process of meiosis.
- When **primordial germ cells** migrate from the **yolk sac** to the ovaries during fetal development, they differentiate into **oogonia**.
- Oogonia divide into **germ cells**, some of which become **primary oocytes**. Each is surrounded by **follicular cells** forming a **primordial follicle**.

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Female Reproductive System



(a) Primordial follicle

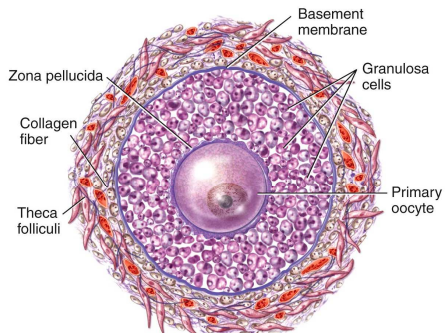
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Female Reproductive System

Each month after puberty, FSH and LH stimulate the development of the primordial follicles. Only one usually reaches maturity. A few start to grow, developing into **primary follicles**.

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Female Reproductive System



(b) Late primary follicle

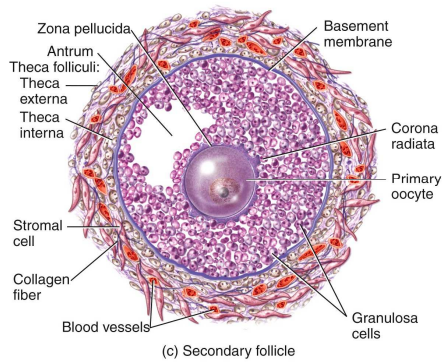
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Female Reproductive System

- In later stages of development, the primary oocyte is surrounded by several layers of **cuboidal and low-columnar cells (granulosa cells)**.
- The glycoprotein **zona pellucida** forms between the primary oocyte and the granulosa cells.
- As maturation continues, the primary follicle develops into a **secondary follicle**.
- The **theca folliculi** forms from **stromal cells**.

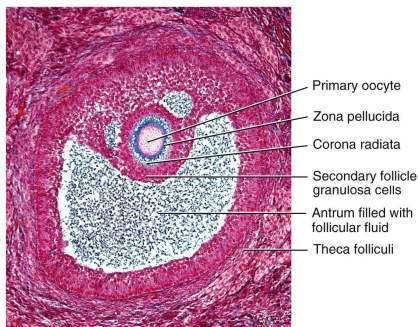
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Female Reproductive System



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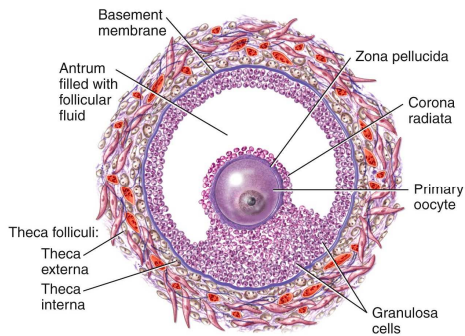
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Female Reproductive System

- In a **secondary follicle** the **theca** differentiates into the **theca interna** and **theca externa**.
- The innermost layer of granulosa cells becomes the **corona radiata**.
- The secondary follicle becomes a **mature (graafian) follicle**.

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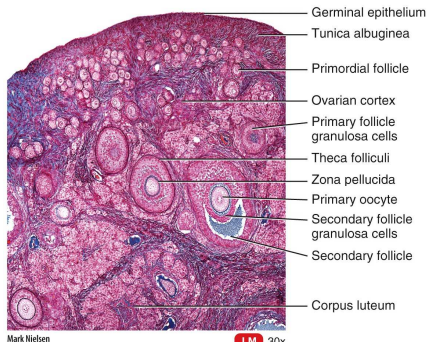
Female Reproductive System



(d) Mature (graafian) follicle

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Female Reproductive System



(e) Ovarian cortex

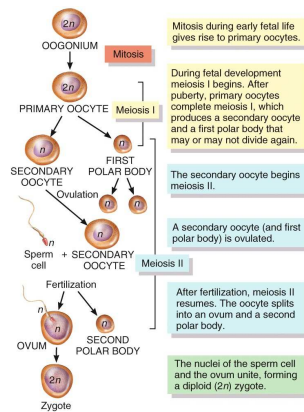
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Female Reproductive System

- While in the mature follicle, the diploid primary oocyte completes meiosis I producing a **haploid secondary oocyte** (with the majority of the cytoplasm) and a haploid **first polar body**.
- At ovulation, both cells and the corona radiata enter the uterine tube. If sperm are present and **fertilization** takes place, the secondary oocyte continues into **meiosis II**.
- An ovum and a **second polar body** form. The ovum becomes a **zygote** when it unites with the sperm.

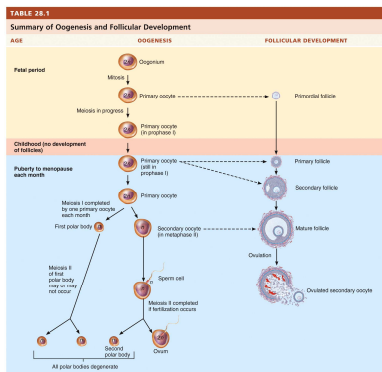
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Female Reproductive System



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Female Reproductive System



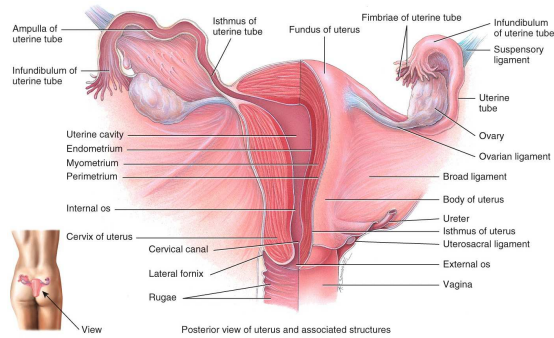
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Female Reproductive System

- Females have two **uterine (fallopian) tubes** (oviducts) that extend from the **uterus**.
- The tubes are the pathway for the sperm to reach the ovum and for the secondary oocytes and fertilized ova to travel to the uterus.
- The end of the tube is the **infundibulum**.
- **Fimbriae** project from it.
- The **ampulla** is the widest portion of the tube.

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Female Reproductive System



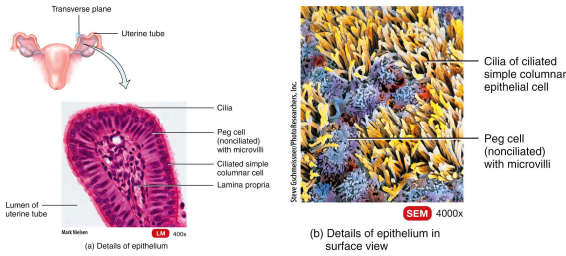
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Female Reproductive System

- The uterine tubes have 3 layers: **mucosa**, **muscularis** and **serosa**.
- The **simple ciliated columnar epithelium** of the mucosa contains **cilia** that move the fertilized ovum or secondary oocyte towards the uterus.
- **Peg cells** in the tube secrete a fluid providing nourishment for the ovum.

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Female Reproductive System



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Female Reproductive System

- The **uterus** is part of the pathway for sperm deposited in the vagina to reach the uterine tube.
- It is the site of **implantation of the fertilized ovum, development of the fetus during pregnancy and labor.**
- The top of the uterus is the **fundus**.
- The central portion is the **body**.
- The inferior extension into the vagina is the **cervix**.
- The **isthmus** is between the body and the cervix.

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Female Reproductive System

- The interior of the body is the **uterine cavity**.
- The interior of the cervix is the **cervical canal**.
- The opening of the canal into the uterus is the **internal os**.
- The opening of the canal into the vagina is the **external os**.

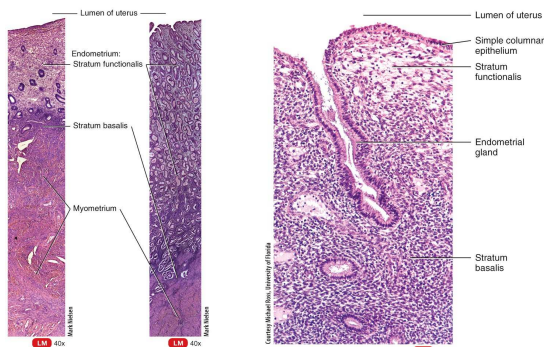
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Female Reproductive System

- Histologically, there are **three layers** to the uterus.
- The **perimetrium (serosa)** is the outermost layer.
- The middle layer is the **myometrium** consisting of **three layers of smooth muscle**.
- The **endometrium** is the inner layer. Its **stratum functionalis** layer is shed each month during menstruation.
- The **stratum basalis** layer is permanent and gives rise to a new stratum functionalis after each menstruation.

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Female Reproductive System



(a) Transverse section through the uterine wall: second week of menstrual cycle (left) and third week of menstrual cycle (right)

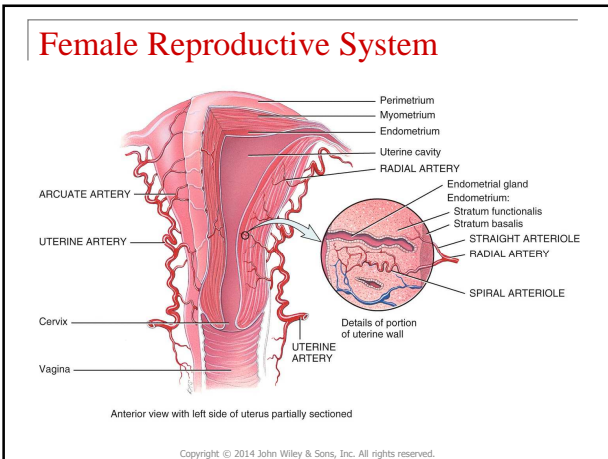
(b) Details of endometrium

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Female Reproductive System

- Branches of the **internal iliac artery** called **uterine arterioles** supply blood to the uterus.
- Uterine arteries give rise to **arcuate arteries** that feed the myometrium.
- These branch into **radial arteries** that go deep into the myometrium.
- **Straight arterioles** supply the **stratum basalis**.

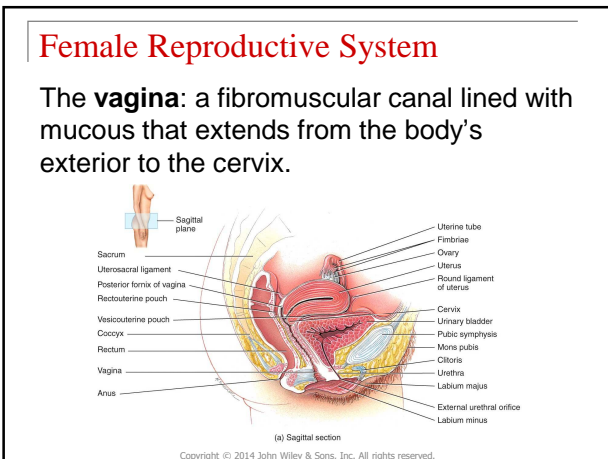
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Female Reproductive System

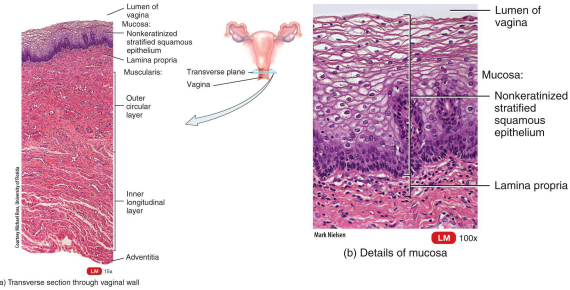
- Secretory cells of the cervix produce **cervical mucus** which is chemically **more hospitable to sperm during ovulation** because it is **less viscous and more alkaline**.
- It helps nourish sperm
- It may aid in **capacitation—functional changes in sperm that allow them to fertilize a secondary oocyte**.

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Female Reproductive System

The mucosa of the vagina is continuous with that of the uterus.



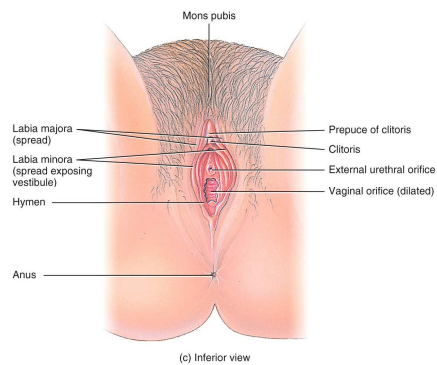
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Female Reproductive System

- The epithelium and areolar connective tissue of the vagina lie in a series of transverse folds called **rugae**.
- The **muscularis** is composed of an **outer circular layer** and **inner longitudinal layer** of **smooth muscle**.
- This allows the vagina to stretch during intercourse and childbirth.
- The **hymen** is a thin fold of vascularized mucous membrane that partially closes the inferior end of the vagina.

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Female Reproductive System



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Female Reproductive System

The **vulva (pudendum)** refers to the external genitalia of the female. It includes:

- The **mons pubis**
- **Labia minora**
- **Labia majora**
- **Clitoris**
- **Vestibule** (hymen, vaginal orifice, external urethral orifice, openings of ducts of several glands)

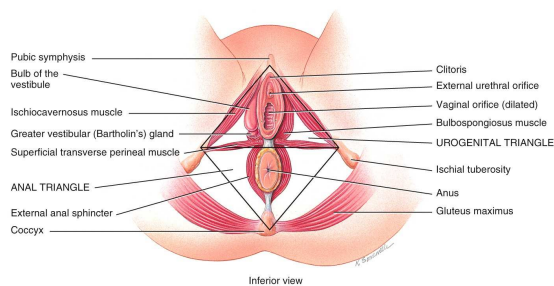
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Female Reproductive System

- **Paraurethral (Skene's) glands** secrete mucous and are embedded in the wall of the urethra. They are homologous to the prostate.
- **Greater vestibular (Bartholin's) glands** produce mucous during sexual arousal to provide lubrication. They are homologous to the bulbourethral gland.
- The **bulb of the vestibule** has two masses of erectile tissue that engorges during sexual arousal to narrow the vaginal orifice applying pressure to the penis during intercourse. It is homologous to the erectile tissues of the penis.

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Female Reproductive System



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Female Reproductive System

TABLE 28.2

Summary of Homologous Structures of the Female and Male Reproductive Systems

FEMALE STRUCTURES	MALE STRUCTURES
Ovaries	Testes
Ovum	Sperm cell
Labia majora	Scrotum
Labia minora	Spongy urethra
Vestibule	Intermediate urethra
Bulb of vestibule	Corpus spongiosum penis and bulb of penis
Clitoris	Glans penis and corpora cavernosa
Paraurethral glands	Prostate
Greater vestibular glands	Bulbourethral glands

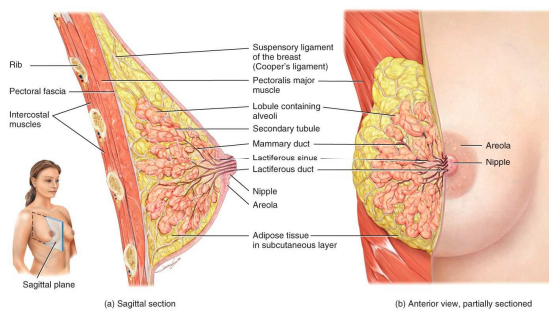
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Female Reproductive System

- The **mammary glands** are located in each of the two **breasts**. They are modified **sudoriferous (sweat) glands** that produce milk.
- Mammary glands contain **15–30 lobes**.
- Each lobe has lobules containing milk secreting glands called **alveoli**.
- Each breast has a **nipple** containing **lactiferous ducts** where milk emerges.
- The skin around the nipple is the **areola**.

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Female Reproductive System



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The Female Reproductive Cycle

- Nonpregnant females experience **cyclical changes** in the **ovaries** and **uterus**. Each cycle takes approximately one month.
- The cycle involves **oogenesis and preparation by the uterus to receive a fertilized ovum**.
- The **ovarian cycle** includes changes that occur during and after **maturation of the oocyte**.
- The **uterine cycle** involves changes in the **endometrium** that prepare it for implantation of the developing embryo.

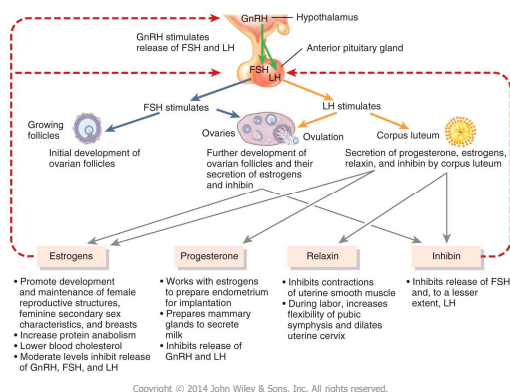
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The Female Reproductive Cycle

Gonadotropin-releasing hormone (GnRH) from the hypothalamus controls both the ovarian and uterine cycles.

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The Female Reproductive Cycle



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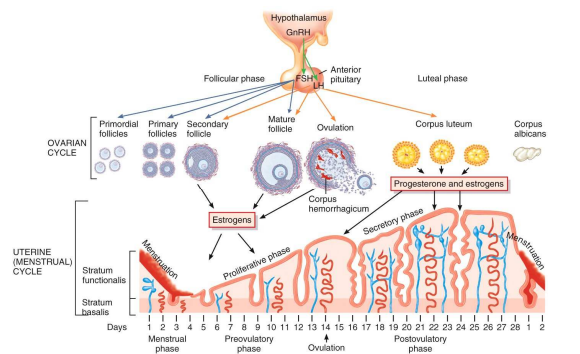
The Female Reproductive Cycle

Phases: The cycle generally ranges from **24–36 days**. It is divided into 4 phases:

1. Menstrual
2. Preovulatory
3. Ovulation
4. Postovulatory

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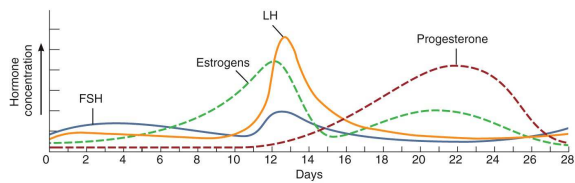
The Female Reproductive Cycle



(a) Hormonal regulation of changes in the ovary and uterus

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The Female Reproductive Cycle



(b) Changes in concentration of anterior pituitary and ovarian hormones

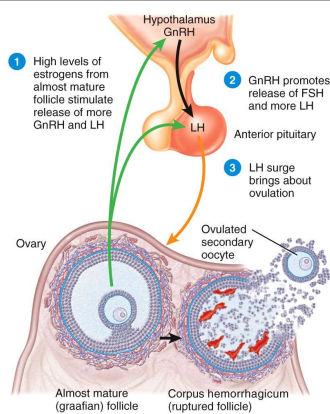
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The Female Reproductive Cycle

- **Feedback** is important in regulating hormonally controlled cycles.
- The high levels of **estrogens** during the last part of the preovulatory phase have a **positive feedback** effect on cells secreting LH and GnRH thus bringing about **ovulation**.
- There are many **hormonal interactions** between the ovarian and uterine cycles.

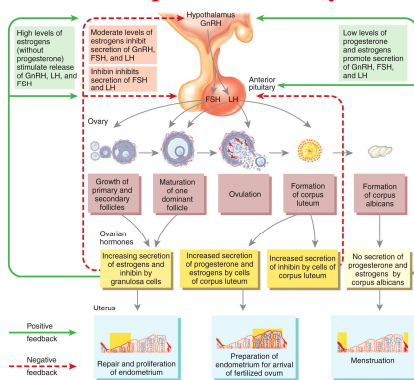
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The Female Reproductive Cycle



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The Female Reproductive Cycle



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The Female Reproductive System

Interactions Animation:

- [Phases of the Female Reproductive Cycle](#)

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Birth Control Methods and Abortion

- **Birth control methods** are designed to limit the number of children produced by **preventing conception**.
- **Complete abstinence** is the only 100% reliable method.
- Other methods include: **Surgical sterilization**
- **Hormonal methods**
- **Periodic abstinence**
- Other than complete abstinence, all methods have different failure rates.

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Birth Control Methods and Abortion

METHOD	FAILURE RATES* (%)	
	PERFECT USE*	TYPICAL USE
Complete abstinence	0	0
Surgical sterilization		
Vasectomy	0.10	0.15
Tubal ligation	0.5	0.5
Non-incisional sterilization (Essure [®])	0.2	0.2
Hormonal methods		
Oral contraceptives		
Combined pill (Yasmin [®])	0.3	1–2
Extended cycle birth control pill (Seasonale [®])	0.3	1–2
Minoxipill (Micronor [®])	0.5	2
Non-oral contraceptives		
Contraceptive skin patch	0.1	1–2
Vaginal contraceptive ring	0.1	1–2
Emergency contraception	25	25
Hormone injections	0.3	1–2

*Defined as percentage of women having an unintended pregnancy during the first year of use.
*Failure rate when the method is used correctly and consistently.

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Birth Control Methods and Abortion

TABLE 28.3
Failure Rates for Several Birth Control Methods

METHOD	FAILURE RATES* (%)	
	PERFECT USE [†]	TYPICAL USE
Intrauterine devices (Copper T 380A [®])	0.6	0.8
Spermicides (alone)	15	29
Barrier methods		
Male condom	2	15
Vaginal pouch	5	21
Diaphragm (with spermicide)	6	16
Cervical cap (with spermicide)	9	16
Periodic abstinence		
Rhythm method	9	25
Sympto-thermal method (STM)	2	20
No method	85	85

*Defined as percentage of women having an unintended pregnancy during the first year of use.
[†]Failure rate when the method is used correctly and consistently.

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Birth Control Methods and Abortion

- **Surgical sterilization:** surgical intervention to render an individual incapable of reproduction.
- **Vasectomy** is used in males by removing a portion of the **vas deferens**.
- **Tubal ligation** is used in females to tie closed and then cut the **uterine (fallopian) tubes**.
- **Non-incisional sterilization** employs the insertion of a coil made of plastic and metal into each uterine tube. **Scar tissue** grows and blocks the tubes.

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Birth Control Methods and Abortion

- **Hormonal methods** include **oral contraceptives** that are designed to prevent pregnancy by inhibiting ovulation.
- There are several types of oral hormonal methods of contraception.
- **Combined oral contraceptives (COC)** contain **progestin** and **estrogens**.

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Birth Control Methods and Abortion

- **Extended cycle birth control pills** contain progestin and estrogen. Menstruation occurs every 13 weeks.
- **Minipills** contain progestin only.
- **Progestin** thickens cervical mucous.

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Birth Control Methods and Abortion

Non-oral methods include:

- **Contraceptive skin patch**
- **Vaginal contraceptive ring**
- **Emergency contraception (EC)** (oral method, but only 2 pills are taken—one within 72 hours of unprotected intercourse; the x = second is taken 12 hours after the first).

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Birth Control Methods and Abortion

Barrier methods employ a physical barrier to block sperm from gaining access to the uterine cavity and tubes. These include:

- Male condom
- Vaginal pouch (female condom)
- Diaphragm
- Cervical cap

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Birth Control Methods and Abortion

- **Periodic abstinence** is employed when the couple has knowledge of the physiological changes that take place during the female cycle.
- The first method used was the **rhythm method**. The couple abstains from intercourse when **ovulation is likely to occur**.
- The **sympto-thermal method** may be used to avoid or achieve pregnancy. It uses normally fluctuating physiological markers such as temperature and the production of clear, sticky cervical mucous that is produced at ovulation.

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Birth Control Methods and Abortion

- **Abortion** is the **premature expulsion of the products of conception from the uterus**. There are several methods employed.
- **Mifepristone (RU 486)** is a hormone used in pregnancies 9 weeks or less. It blocks progesterin thus blocking the action of progesterone. Menstruation occurs.
- **Vacuum aspiration (suction)** uses suction to remove the embryo or fetus, placenta and uterine lining.

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Birth Control Methods and Abortion

- **Dilation and evacuation** are used together to dilate the cervix and employ suction and a forceps to remove the fetus, placenta and uterine lining.
- **Late-stage abortion** employs similar methods to dilation and evacuation or uses a **saline solution** or **surgical methods** to induce abortion.

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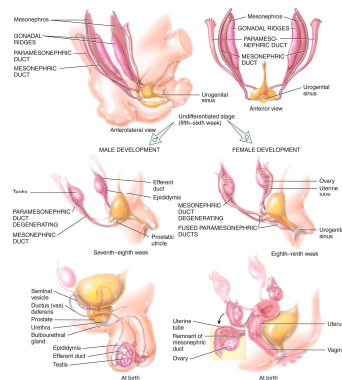
Development of the Reproductive Systems

The reproductive systems develop from several structures and require several chemical substances.

- Gonads develop from **intermediate mesoderm** that gives rise to **gonadal ridges**.
- **Mesonephric (Wolffian) ducts** develop into the male reproductive system.
- **Paramesonephric (Mullerian) ducts** develop into the female reproductive system.

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Development of the Reproductive Systems



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Development of the Reproductive Systems

- **Mullerian-inhibiting substance (MIS)** causes apoptosis of cells in the Mullerian ducts in developing males. So, no structures develop from the ducts in male reproductive systems.
- **Testosterone in developing males** secreted by interstitial cells in the testes stimulates the development of the mesonephric ducts into the **epididymis, vas deferens, ejaculatory duct and seminal vesicles**.

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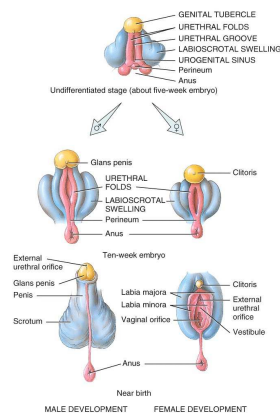
Development of the Reproductive Systems

Before differentiation, all embryos have:

- Urethral (urogenital) folds
- Urethral groove
- Genital tubercle
- Labioscrotal swelling

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Development of the Reproductive Systems



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Aging and the Reproductive Systems

- The **first decade**: reproductive system in juvenile state
- **Age 10**: hormone-directed changes leading to **puberty**
- **Puberty**: males begin to produce sperm, females enter **menarche** (beginning of menstruation).
- With age, fertility declines. Between **30–40**, ovarian follicles become exhausted. Estrogen levels decline.

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Aging and the Reproductive Systems

- In males, reproduction is still possible into the eighties or nineties.
- At around **age 55**, testosterone levels decline, sperm levels drop, sexual desire wanes.
- Most males **over 60** experience **benign prostatic hypertrophy** where the prostate enlarges to two to four times its normal size.

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FOCUS on HOMEOSTASIS

CONTRIBUTIONS OF THE REPRODUCTIVE SYSTEMS FOR ALL BODY SYSTEMS

- INTEGUMENTARY SYSTEMS**
 - Androgens promote the growth of body hair
 - Estrogens stimulate the deposition of fat in the breasts, abdomen, and hips
 - Mammary glands produce milk
 - Skin thickens during pregnancy as the fetus enlarges
- SKELLETAL SYSTEM**
 - Androgens and estrogens stimulate the growth and maintenance of bones of the skeletal system
- MUSCULAR SYSTEM**
 - Androgens stimulate the growth of skeletal muscles
- NERVOUS SYSTEM**
 - Androgens influence libido (sex drive)
 - Estrogens may play a role in the development of mature regions of the brain in males
- ENDOCRINE SYSTEM**
 - Testosterone and estrogens exert feedback effects on the hypothalamus and anterior pituitary gland
- CARDIOVASCULAR SYSTEM**
 - Estrogens lower blood cholesterol level and may reduce the risk of coronary artery disease in women under age 50
- LYMPHATIC SYSTEMS and IMMUNITY**
 - The presence of an antibiotic-like chemical in semen and the acidic pH of vaginal fluid provide innate immunity against micro-organisms in the reproductive tract
- RESPIRATORY SYSTEM**
 - Sexual arousal increases the rate and depth of breathing
- DIGESTIVE SYSTEM**
 - The presence of the fetus during pregnancy crowds the digestive organs, which leads to heartburn and constipation
- URINARY SYSTEM**
 - In males, the portion of the urethra that extends through the prostate and penis is a passageway for urine as well as semen

FOR ALL BODY SYSTEMS

- The male and female reproductive systems produce gametes (sperm and ova) that fuse to form embryos and fetuses, which contain cells that divide and differentiate to form all of the organ systems of the body

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End of Chapter 28

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