Chapter 28: The Reproductive System

Chapter Objectives

MALE REPRODUCTIVE SYSTEM

1. List the major components of the male reproductive system and their general functions.
2. Explain the structure of the testes.
3. Explain the functions of the seminiferous tubules, sustentacular cells and interstitial cells.
4. Explain the structure and functions of the scrotum in its role of protection and temperature regulator.
5. List the structures found in the spermatic cord.
6. Explain the structure and functions of the penis.
7. List the parts of the autonomic nervous system that control erections and ejaculation.
8. Explain the structure and functions of the epididymis.
9. Explain the structure and functions of the ductus (vas) deferens.
10. Explain the structure and functions of the ejaculatory ducts.
11. Explain the structure and functions of the urethra.
12. Explain the structure and function of the seminal vesicles.
13. Explain the structure and function of the prostate gland.
14. Explain the structure and function of the bulbourethral gland.
15. Describe the origins as well as cellular and chemical characteristics of semen.
17. Describe and explain the events of spermatogenesis and spermiogenesis.
18. Explain the difference between spermatogenesis, spermiogenesis and spermiation.
19. Discuss hormones that control the production of sperm, with emphasis on the actions of each type of hormone with the different types of cells in the testes.
20. Describe the structure of a mature sperm.

FEMALE REPRODUCTIVE SYSTEM

21. Describe the general location and functions of the ovaries, uterine (Fallopian) tubes, uterus, vagina, vulva, and mammary glands.
22. Describe the external accessory structures that hold the ovaries in place.
23. Discuss the histology of the ovaries.
24. Describe the uterine tubes' general and epithelial structure, in addition to their operation in transport of the secondary oocyte after ovulation.
25. Identify the anatomical subdivisions of the uterus.
26. Discuss the three histological layers of the uterus.
27. Provide a detailed histological description of the endometrium.
28. Discuss the composition of the cervical mucosa and correlate the changes in the cervical mucosa to its effects on the sperm.
29. Name the anatomic structures of the vagina.
30. Differentiate the functions of the distinct external structure of the vulva: the Labia majora, Labia minora, Clitoris, and Bulb of Vestibule.
31. Describe the location, anatomy and function of the mammary glands.
32. Follow the steps of oogenesis.
33. Trace the formation and development of the ovarian follicles.
34. Relate the timing of oogenesis to follicle development.

**FEMALE REPRODUCTIVE CYCLE**
35. Describe the difference between the uterine and ovarian cycles.
36. Discuss the hormones that control the female reproductive cycle. Describe each hormone’s function.
37. Note the normal time span for each of the four phases of the female reproductive cycle.
38. Portray the events occurring with the follicles in the ovaries and the tissue changes in the endometrium during the menstrual phase.
39. Discuss the changes in hormone levels during the preovulatory phase
40. Discuss the changes in hormonal levels that initiate ovulation.
41. Explain the consistency of the postovulatory interval and course of development of the corpus luteum and endometrium depending on whether fertilization does or does not occur.

**Chapter Lecture Notes**

**Introduction**

Male and female reproductive systems are a series of glands and tubes that produce and nurture sex cells, and transport them to the site of fertilization.

**Organs of the Male Reproductive System**

Testes – primary sex organ of the male reproductive system (Fig 28.1, 28.3 & 28.4)

Testes or testicles - ovoid glands (gonads) suspended by a spermatic cord in the scrotum

Tunica Vaginalis
Piece of peritoneum that descended with testes into scrotal sac
Facilitates movement of testes within scrotum

Structure of the Testes

Tunica Albuginea - dense white capsule on the outside
lobules contain highly coiled seminiferous tubules and are separated by connective tissue
Seminiferous tubules - lined with stratified epithelium that gives rise to sperm cells
Sertoli cells or sustentacular cells – large cells embedded among the spermatogenic
cells in the seminiferous tubules
blood-testis barrier - tight junctions between sustentacular cells prevent an
immune response against the spermatogenic cells
nourish spermatocytes, spermatids, and spermatozoa

Organs of the Male Reproductive System
mediate the effects of testosterone and follicle stimulating hormone on
spermatogenesis
phagocytose excess spermatids cytoplasm as development proceeds
control movements of spermatogenic cells and the release of spermatozoa into the
lumen of the seminiferous tubule
secrete fluid for sperm transport
secrete the hormone inhibin, which slows sperm production by inhibiting FSH

Interstitial cells (Leydig cells) - produce the male hormones (testosterone)

Channels leading from the seminiferous tubules carry sperm to the epididymis and ductus
(vas) deferens

Scrotum - a pouch of skin and subcutaneous tissue that houses the testes (Fig 28.1 & 28.2)

Temperature regulation of testes
sperm survival requires 3 degrees lower temperature than core body temperature
skin contains dartos muscle which causes wrinkling
when warm, muscle is relaxed to increase surface area for cooling
wrinkles when cold to conserve heat
cremaster muscle in spermatic cord
elevates testes on exposure to cold & during arousal
warmth reverses the process

Spermatic cord - a supporting structure of the male reproductive system, consisting of (Fig 28.2)
cremaster muscle
ductus (vas) deferens
testicular artery
veins and lymphatic vessels
autonomic nerves

Penis - contains the urethra and is a passageway for the ejaculation of semen (Fig 28.10)
Four anatomical parts
root
    bulb
    crura (pl), crus (s)
body
glans penis

Body contains three erectile tissue masses
    paired corpora cavernosa penis (1 & 2)
    unpaired corpus spongiosum penis (3)
    filled with blood sinuses
    lined by endothelial cells
    surrounded by smooth muscle and elastic connective tissue

Erection
    parasympathetic reflex causes erection
sexual stimulation → dilation of arteries supplying the penis

nitric oxide mediates local vasodilation

erectile dysfunction drugs increase vasodilation

veins become compressed, and blood is trapped

**Ejaculation**

sympathetic reflex

muscle contractions close sphincter at base of bladder

peristaltic contractions in the vas deferens, seminal vesicles, ejaculatory ducts and prostate propel semen into the penile portion of the spongy urethra

blood flow is restricted to penis and small muscles around the erectile tissue masses

forces blood out of the penis and the penis will become flaccid again

**Male Duct System**

Epididymis - a tightly coiled tube lying adjacent to the testis and leading from the testis to the vas deferens (Fig 28.3)

Site of sperm maturation and storage

sperm may remain in storage here for at least a month, after which they are either expelled or degenerated and reabsorbed

Ductus (Vas) Deferens (seminal duct) – a muscular tube 45 centimeters in length leading from the epididymus up into the body cavity (Fig 28.1 & 28.3)

unites with the ejaculatory duct and empties its contents into the urethra

lined with pseudostratified columnar epithelium & covered with heavy coating of muscle

conveys sperm along through peristaltic contractions

Ejaculatory duct - union of the ducts from the seminal vesicles and ductus deferens (Fig 28.1)

function to eject spermatozoa into the prostatic urethra

Male urethra - shared terminal duct of the reproductive and urinary systems (Fig 28.1)

serves as a passageway for semen and urine
male urethra is subdivided into three portions:

- Prostatic urethra (through prostate gland)
- Intermediate urethra (through deep muscles of perineum)
- Penile (spongy) urethra (through corpus spongiosum)

Accessory Sex Glands

Seminal Vesicle - a saclike structure attached to the vas deferens near the base of the urinary bladder (Fig 28.1 & 28.9)

secretes a alkaline fluid that neutralizes acid in the male urethra and female reproductive tract

fluid also contains

- fructose - nourishes sperm
- prostaglandins - cause muscular contractions in the female tract to help propel sperm to the egg cell
- semenogelin - causes coagulation of semen after ejaculation

Prostate Gland - a chestnut-shaped structure surrounding the urethra at the base of the urinary bladder (Fig 28.1 & 28.9)

secretes a milky, slightly acidic fluid that contains:

- citric acid, which can be used by sperm for ATP production
- acid phosphatase enzymes
  - prostate-specific antigen (PSA)
  - pepsinogen
  - lysozyme
  - amylase
  - hyaluronidase - liquefies coagulated semen
Bulbourethral (Cowper’s) Glands - small structures located inferior to the prostate (Fig 28.1 & 28.9)

secrete mucus to lubricate the tip of the penis during sexual arousal

secrete an alkaline substance that neutralizes acid

Semen - a combination of sperm cells and the secretions of the seminal vesicles, prostate gland, and bulbourethral glands

120 million sperm/milliliter of semen

Spermatogenesis

Spermatogenesis – sperm production (Fig 28.4 & 28.5)

Spermatogonia – undifferentiated spermatogenic cells that contain 46 chromosomes

spermatogonia enlarge, undergo mitosis and become primary spermatocytes

Primary spermatocytes – spermatogenic cells that are in Meiosis I and still have 46 chromosomes

complete first meiotic division to become secondary spermatocyte

Secondary spermatocytes - spermatogenic cells that are in Meiosis II and are haploid with 23 chromosomes

complete second meiotic division to become spermatids

Spermatids – four haploid cells produced from one primary spermatocyte

Spermiogenesis - maturation of the spermatids into sperm

the final stage of spermatogenesis

Spermiation - the release of a sperm from its connection to a Sertoli cell

Hormonal Control of Spermatogenesis (Fig 28.7)

Puberty

hypothalamus increases its stimulation of anterior pituitary by secreting GnRH

anterior pituitary increases secretion LH & FSH

LH stimulates Leydig cells to secrete testosterone
an enzyme in prostate & seminal vesicles converts testosterone into dihydrotestosterone

(DHT is more potent)

FSH stimulates spermatogenesis

with testosterone, stimulates Sertoli cells to secrete androgen-binding protein (keeps hormones levels high)

Testosterone (Fig 28.8)

stimulates final steps spermatogenesis

controls the growth, development, functioning, and maintenance of sex organs

stimulates bone growth, protein anabolism, and sperm maturation

stimulates development of male secondary sex characteristics

Negative feedback systems regulate testosterone production

Inhibin - produced by Sertoli cells

Inhibits secretion of FSH

helps to regulate the rate of spermatogenesis

decreases sperm production when sperm production is sufficient

when sperm production is proceeding too slowly less inhibin is released by the Sertoli cells, more FSH will be secreted and sperm production will be increased

Sperm

morphology (shape) (Fig 28.6)

head contains DNA

acrosome – cap on the head which contains hyaluronidase and proteinase enzymes

midpiece contains mitochondria to form ATP

tail is flagellum used for locomotion

produced at the rate of about 300 million per day

once ejaculated sperm have a life expectancy of 48 hours within the female reproductive tract

Organs of the Female Reproductive System
Ovaries - primary sex organ of the female reproductive system (Figs 28.11, 28.12 & 28.16)

Ovaries - solid, ovoid structures located within the lateral pelvic cavity maintained in position by a series of ligaments

- Broad ligament suspends uterus from side wall of pelvis
- Mesovarium attaches ovaries to broad ligament
- Ovarian ligament anchors ovary to uterus
- Suspensory ligament covers blood vessels to ovaries
- Round ligament attaches uterus to inguinal canal

Ovary Structure (Fig 28.13)

- Germinal epithelium – simple cuboidal epithelium that covers the surface of the ovary but does not give rise to ova
- Tunica albuginea – dense irregular connective tissue
- Ovarian cortex - contains ovarian follicles
- Ovarian medulla - contains blood vessels, lymphatics, and nerves

Female Internal Accessory Organs

Uterine Tubes (oviducts, Fallopian tubes) - suspended by the broad ligament and lead to the uterus (Fig 28.16 & 28.17)

- infundibulum – funnel shaped portion near each ovary
- fimbriae – fringe of finger-like projections
- cells lining the tubes have cilia, which beat in unison, drawing the egg cell into the uterine tube

Uterus (Fig 28.16)

Gross anatomy

- fundus – dome shaped portion superior to uterine tubes
- body – central portion of uterus
- isthmus – constricted portion of uterus between body and cervix
cervix – inferior portion that opens to vagina

Histology

Endometrium

simple columnar epithelium

lamina propria of connective tissue with uterine (endometrial) glands penetrating into layer

stratum functionalis – superficial layers of endometrium that are shed during menstruation

stratum basalis – deep layer of endometrium that replaces stratum functionalis each month

Myometrium

3 layers of smooth muscle

Perimetrium

visceral peritoneum

Cervical mucus - a mixture of water, glycoprotein, serum-type proteins, lipids, enzymes, and inorganic salts produced by the secretory cells of the mucosa of the cervix

when thin, is more receptive to sperm

when thick, forms a cervical plug that physically impedes sperm penetration

mucus supplements the energy needs of the sperm

serves as a sperm reservoir which protects the sperm from the hostile environment of the vagina, and protects sperm from phagocytes

Vagina - a fibromuscular tube that extends from the uterus to the outside (Fig 28.20)

Histology - three layers

mucosal layer

stratified squamous epithelium & areolar connective tissue
large stores of glycogen breakdown to produce acidic pH which set up a hostile acid environment for sperm

muscularis layer - smooth muscle allows for considerable stretch

adventitia - areolar connective tissue that binds it to other organs

Female External Reproductive Organs

Vulva (pudendum) - external genitalia of the female (Fig 28.20)

Labia majora (labium major) - enclose and protect the other external reproductive organs

correspond to the scrotum of the male

Labia minora (labium minus) - flattened, longitudinal folds between the labia majora that

form a hood around the clitoris

Many blood vessels cause the labia minora to appear pink

corresponds to the spongy urethra of the male

Clitoris - a mass of erectile tissue at the anterior end of the vulva between the labia minora

corresponds to the penis

Vestibule - a space enclosed by the labia minora into which the vagina opens posteriorly

corresponds to the membranous urethra of the male

A pair of vestibular glands lie on either side of the vaginal opening; these correspond to bulbourethral glands

Mammary Glands

Mammary glands - modified sudoriferous (sweat) glands that lie over the pectoralis major and serratus anterior muscles (Fig 28.22)

alveoli - milk-secreting cells that are clustered in lobules within the breasts

Functions of the mammary glands

synthesis of milk

lactation - secretion and ejection of milk

Follicular Development
Oogenesis – egg cell development (Fig 28.15 & Table 28.1)

Germ cells migrate to ovary & become oogonia

Oogonia – female diploid stem cells that divide by mitosis to produce millions of oocytes in the female fetus

Atresia – process by which most germ cells degenerate before birth

Primary oocyte – stem cell that has entered Meiosis I and stops in Prophase I

process halts and does not resume until puberty

200,000 to 2 million are present at birth

40,000 remain at puberty, but only 400 mature during a woman’s life

Secondary oocyte – haploid stem cell that continues Meiosis and stops at Metaphase II produced starting at puberty

monthly hormonal changes trigger maturation

Penetration by the sperm causes the final stages of meiosis to occur

Follicle Maturation (Fig 28.14 & Table 28.1)

Ovarian follicles - oocytes and support cells in various stages of development

Primordial follicle - a primary oocyte surrounded by a single layer of squamous follicular cells formed during prenatal development

Primary follicle - a primary oocyte surrounded by cuboidal follicular cells

form at puberty

the follicle enlarges and the follicular cells proliferate into granulosa cells and theca cells

zona pellucida – glycoprotein layer around primary oocyte

corona radiata – single layer of follicular cells attached to the zona pellucida

Secondary follicle – a follicle that has a fluid-filled cavity (antrum)

Mature follicle - contains a secondary oocyte and a large antrum

Ovulation – release of the secondary oocyte from the surface of the ovary (Fig 28.13)
cumulus oophorus – follicular cells outside of the corona radiata that leave the ovary with the ovulated secondary oocyte

If the secondary oocyte is not fertilized shortly after its release, it will degenerate

Corpus hemorrhagicum – ruptured follicle
Corpus luteum – reorganized follicle after ovulation that is yellow in color
fills in with hormone-secreting cells
Corpus albicans - white scar left after corpus luteum regresses

Female Reproductive Cycle

Ovarian cycle
changes in ovary during & after maturation of oocyte

Uterine (menstrual) cycle
involves changes in the endometrium
preparation of uterus to receive fertilized ovum
if implantation does not occur, the stratum functionalis is shed during menstruation

Cyclical changes in the breasts and the cervix

Hormonal Regulation of the Female Reproductive Cycle

GnRH controls the female reproductive cycle (Fig 28.23)

stimulates the release of FSH and LH

FSH initiates growth of follicles that secrete estrogen and inhibin
LH stimulates ovulation & promotes formation of the corpus luteum which secretes estrogens, progesterone, relaxin & inhibin

Estrogen
 maintains reproductive organs
promotes secondary sex characteristics and the breasts
prepares the endometrium for implantation
prepares the mammary glands for milk synthesis
inhibits the release of GnRH and secretion of LH and FSH

Progesterone

prepares uterus for implantation
prepares the mammary glands for milk synthesis

Relaxin relaxes the uterus for implantation

Inhibin inhibits the secretion of FSH

Phases of the Female Reproductive Cycle

The female reproductive cycle may be divided into four phases (Fig 28.24 & 28.26)

Menstrual cycle (menstruation) - lasts for approximately the first 5 days of the cycle

In the ovary

several follicles begin to develop into secondary follicles

In the uterus

the stratum functionalis layer of the endometrium is shed, discharging blood, tissue fluid, mucus, and epithelial cells

Preovulatory Phase - days 6-13

In the ovary (follicular phase)

the secondary follicles increase their estrogen and inhibin production

inhibin slows the secretion of FSH

increasing estrogen increases the secretion of LH

a dominant follicle continues to develop into a mature ovarian (Graafian) follicle

by day 14, the Graafian follicle has enlarged & bulges at surface of the ovary

In the uterus (proliferative phase)

endometrial repair occurs

this time between menstruation and ovulation is more variable in length than the other phases

Ovulation usually occurs on day 14 in a 28-day cycle (Fig 28.25)
high levels of estrogen during the last part of the pre-ovulatory phase exert positive feedback on both LH and GnRH to cause ovulation

FSH levels depressed by increase in inhibin

a LH surge brings about the ovulation

Following ovulation, the vesicular ovarian follicle collapses to become the corpus hemorrhagicum and reorganizes to become the corpus luteum

Stimulated by LH, the corpus luteum secretes estrogens, progesterone, relaxin and inhibin

Postovulatory - days 15-28

Time between ovulation and onset of the next menstrual period

Most constant timeline = lasts 14 days

In the ovary (luteal phase)

both estrogen and progesterone are secreted in large quantities by the corpus luteum

if fertilization does not occur, then the corpus albicans is formed

as estrogen and progesterone levels drop, secretion of GnRH, FSH & LH rise

if fertilization does occur, then the developing embryo secretes human chorionic gonadotropin (hCG) which maintains health of corpus luteum & its hormone secretions

In the uterus (secretory phase)

hormones from corpus luteum promote thickening of endometrium to 12-18 mm

formation of more endometrial glands & vascularization

if no fertilization occurs, menstrual phase will begin