Chapter 28

Human Reproductive System
• Describe the functions of the male and female reproductive systems
Overview of Reproductive System

• **Male reproductive system**
  – produce sperm (testes)
  – sperm = male gamete
  – deliver sperm to female reproductive system

• **Female reproductive system**
  – produce egg (ovaries)
  – egg = female gamete
  – female reproductive system receives sperm
  – provides for the union of the gametes
  – harbors the embryo / fetus (conceptus)
  – nourishes the offspring postpartum
• Describe the following hormones as to site of production, function, and target:

  – Gonadotropin Releasing Hormone
  – Follicle stimulating hormone (FSH)
  – Luteinizing hormone (LH) or interstitial cell stimulating hormone (ICSH)
  – Human chorionic gonadotropin (hCG)
  – Prolactin
  – Oxytocin
  – Estrogen
  – Progesterone
  – Inhibin
  – Testosterone

• Note: Some of these hormones regulate different functions in both female and male physiology
Gonadotropin Releasing Hormone

• GRH produced by nuclei in hypothalamus // delayed nuclei maturation signals beginning of puberty

• Target tissue anterior pituitary (portal delivery)

• Stimulates release of follicle stimulating hormone and luteinizing hormone from anterior pituitary

• Similar function in male and female physiology // timing of maturation for hypothalamic nuclei differs
Follicle Stimulating Hormone (FSH)

- **Females** // FSH produced by anterior pituitary
  - Target tissue = primoidal eggs in ovaries
  - Stimulates growth of follicles
  - Follicles secrete estrogen

- **Males** // FSH produced by anterior pituitary
  - Target tissue = sustentacular cells of seminiferous tubules (located in testis)
  - SC secrete androgen binding protein
  - ABP concentrates testosterone
  - Sustentacular cells may secrete inhibin if sperm are not ejaculated // inhibin stops production of FSH so ABP is not produced – testosterone no longer concentrated in testes and spermatogenesis stops // note: testosterone still produced under influence of LH
Luteinizing hormone (LH) or interstitial cell stimulating hormone (ICSH)

- **Females // LH produced by anterior pituitary**
  - target tissue = mature eggs in ovaries
  - Spike in LH production near day 14 Initiates ovulation
  - Also binds to follicular cells remaining on surface of ovary // converts follicular cells to corpus luteum – secretes inhibin, relaxin, and progesterone
  - Starts luteal phase of the ovarian cycle / second 14 days of ovary cycle

- **Males // LH produced by anterior pituitary**
  - target tissue = interstitial cells of in testes
  - IC secretes testosterone
  - Testosterone concentrated by ABP which is produced by sustentacular cells of the seminiferous tubules (testes) // high concentration of testosterone stimulates spermatogenesis
Human chorionic gonadotropin (hCG)

- Produced by blastocyste
- Target tissue is corpus luteum
- Stimulates CL to continue production of progesterone
- Progesterone required to maintains endometrium (pregnancy)
• Females // Released from anterior pituitary
  – Prolactin target tissue = epithelial glandular cells of the “primed” mammary gland
  – Stimulates the production of milk
Oxytocin

• Females // Released from posterior pituitary // involved in different "neuroendocrine reflexes"
  – Receptors on myometrium, smooth muscle associated with milk producing epithelial cells in mammary gland, and CNS
  – Parturition
  – Milk let down reflex
  – Also receptors in brain // Psychological bonding between mother and baby
Estrogen

- Females // Released from different tissues at different times during the sexual cycle and throughout pregnancy
  - FSH stimulate primordial cells of ovary to produce estrogen
  - Corpus luteum produce both estrogen, progesterone, relaxin, and inhibin after ovulation
  - Placenta produces estrogen
  - Estrogen multiple functions: development of secondary sexual characteristics / tissue growth in mammary glands / follicular phase of ovarian cycle / proliferation phase of the menstrual cycle
**Progesterone**

- Females // Released from different tissues at different times during the sexual cycle and pregnancy
  - Produced by corpus luteum and placenta
  - Maintains endometrium to see if egg is fertilized and placenta established
  - Responsible for secretory phase of the menstrual cycle
  - If placenta formed then it to produces estrogen
  - Estrogen multiple functions: development of secondary sexual characteristics / tissue growth in mammary glands / secretory phase of the menstrual cycle
Inhibin

• Females // Released from corpus luteum
  – Target tissue anterior pituitary
  – Inhibits release of FSH

• Males // Released by sustentacular cells of testes
  – Inhibits FSH release
  – Stopping FSH prevents SC from producing ABP // testosterone not concentrated in testes which stops spermatogenesis
  – LH continues to stimulate interstitial cells production of testosterone so testosterone continues to regulate other functions like muscle growth, hair growth, behavior, and other secondary sexual characteristics
Testosterone

• Males // Produced by interstitial cells of the testes
  – LH receptors on interstitial cells
  – Interstitial cells produce testosterone
  – Testosterone responsible secondary sexual characteristics
  – Testosterone required for spermatogenesis
  – Must be concentrated by ABP within seminiferous tubules
Action of Hormones on Male Physiology
Ampulla
Ureter
Bulb
Crus
Penis
ductus deferens
Glans of penis
Epididymis
Urinary bladder
Prostate gland
Prostatic urethra
Membranous urethra
ductus deferens
Spongy (penile) urethra
Glands of penis
(b) Posterior view

Ureter
Ampulla
Seminal vesicle
Epididymis
Urinary bladder
Prostate gland
Prostatic urethra
Membranous urethra
ductus deferens
Spongy (penile) urethra
Glands of penis

Bulbourethral gland
Ejaculatory duct
Bulb
Crus
Corpus spongiosum
Corpus cavernosum
Testis
(b) Posterior view
Spermatogenesis and Histology of Testis

(a) Interstitial cells, Blood vessel, Germ cells, Sustentacular cell, Tails of spermatozoa

(b) Blood vessel, Seminiferous tubule, Spermatids, Sustentacular cell nuclei, Tubule lumen, Germ cells, Connective tissue wall of tubule, Interstitial cells
Spermatogenesis and Meiosis

• spermatogenesis - process of sperm production in seminiferous tubules

• involves three principal events:
  – remodeling of large germ cells into small, mobile sperm cells with flagella
  – reduction of chromosome number by one-half in sperm cells (unites with egg to return to 46)
  – shuffling of genes so new combinations exist in the sperm that are different from both of the parents

• ensures genetic variation in the offspring

• four sperm cells produced from one germ cell by meiosis (haploid cells)
Spermatogenesis and the Testes

- **Seminiferous Tubules**
  - one to three in each lobule
  - each tubule lined with a thick germinal epithelium for sperm generation

- **Interstitial (Leydig) Cells**
  - between tubules // produce testosterone

- **Sustentacular Cells (also called Sertoli Cells or Nurse Cells)**
  - in between germinal epithelium cells
  - protect the germ cells
  - promote their development
  - germ cells depend on “nurse cells” for their nutrients, waste removal, growth factors, and other needs
Spermatogenesis

• Puberty brings on spermatogenesis
  – spermatogonia lie along the periphery of the seminiferous tubules and divide by mitosis
  – one daughter cell of each division remains in the tubule wall as stem cell - type A spermatogonium
  – other daughter cell migrates slightly away from the wall and is on its way to producing sperm – the type B spermatogonium
Spermatogenesis

1. Type A spermatogonium
2. Type B spermatogonium
3. Meiosis I
4. Meiosis II
5. Spermiogenesis

Cross section of seminiferous tubules

- Lumen of seminiferous tubule
- Sperm
- Spermatid
- Secondary spermatocyte
- Blood–testis barrier
- Primary spermatocyte
- Sustentacular cell
- Tight junction
- Basement membrane of seminiferous tubule
Spermatogenesis and the Blood-Testis Barrier (BTB)

- BTB formed by **tight junctions between sustentacular cells**
  - separating sperm from immune system
  - prevents antibodies and other large molecules in the blood from getting to germ cells
  - germ cells are immunologically different from body cells and would be attacked by immune system
Spermatogenesis and the Blood-Testis Barrier (BTB)

- once the primary spermatocyte undergoes meiosis, it becomes genetically different and needs to be protected from the immune system
- the primary spermatocyte moves towards the lumen of the seminiferous tubule and a new tight junction between sustentacular cells forms behind it
- now protected by the blood-testis barrier closing behind it
Endocrine Control of Puberty

• testes secrete substantial amounts of testosterone in first trimester (3 months) of fetal development in levels about as high as they are in mid-puberty

  – End of first trimester testes becomes dormant until puberty

  – from puberty through adulthood

• reproductive function is regulated by hormonal links between the hypothalamus, pituitary gland, and the gonads

• as hypothalamus matures it produces gonadotropin-releasing hormone (GnRH)

  – This hormone initiates endocrine events associated with reproductive life
Endocrine Control of Puberty

- GnRH stimulates anterior pituitary cells (gonadotropes) to secrete:
  - follicle stimulating hormone (FSH)
    - stimulates sustentacular cells to secrete androgen-binding protein
      - binds testosterone keeping it in the seminiferous tubule lumen
      - stimulate spermatogenesis and raising sperm count
    - luteinizing hormone (LH) sometimes called interstitial cell-stimulating hormone (ICSH)
      - stimulates interstitial cells to produce testosterone
1. GnRH from hypothalamus stimulates the anterior pituitary to secrete FSH and LH.

2. FSH stimulates sustentacular cells to secrete androgen-binding protein (ABP).

3. LH stimulates interstitial cells to secrete testosterone (androgen).

4. In the presence of ABP, testosterone stimulates spermatogenesis.

5. Testosterone also stimulates the libido and the development of secondary sex organs and characteristics.

6. Testosterone has negative feedback effects that reduce GnRH secretion and pituitary sensitivity to GnRH.

7. Sustentacular cells also secrete inhibin, which selectively inhibits FSH secretion and thus reduces sperm production without reducing testosterone secretion.
Response to Excess Testosterone
Male pattern of development (before birth)
- Enlargement of male sex organs and expression of male secondary sex characteristics (starting at puberty)
- Anabolism (protein synthesis)
Action of Hormones on Female Physiology
GnRH stimulates release of FSH and LH

FSH stimulates growth of follicles

FSH stimulates initial development of ovarian follicles

LH stimulates further development of ovarian follicles and their secretion of estrogens and inhibin

FSH stimulates ovulation

LH stimulates secretion of progesterone, estrogens, relaxin, and inhibin by corpus luteum

**Estrogens**
- Promote development and maintenance of female reproductive structures, feminine secondary sex characteristics, and breasts
- Increase protein anabolism
- Lower blood cholesterol
- Moderate levels inhibit release of GnRH, FSH, and LH

**Progesterone**
- Works with estrogens to prepare endometrium for implantation
- Prepares mammary glands to secrete milk
- Inhibits release of GnRH and LH

**Relaxin**
- Inhibits contractions of uterine smooth muscle
- During labor, increases flexibility of pubic symphysis and dilates uterine cervix

**Inhibit**
- Inhibits release of FSH and, to a lesser extent, LH
Note: these secretions regulate both the ovarian and the menstrual cycles. The sexual cycle describes the events that occur if a pregnancy does not occur.
Ovarian Cycle
Follicular & Luteal Phases

(a) Ovarian cycle

Gonadotropin secretion

LH

FSH

Ovarian events

Developing follicles
Primary
Secondary
Tertiary
Ovulation
Corpus luteum
Involution
Corpus albicans
New primordial follicles

Days
1 3 5 7 9 11 13 15 17 19 21 23 25 27 1

Follicular phase

Luteal phase
Note: Inhibin (hormone) secreted by corpus luteum selectively suppresses FSH secretion
1. High levels of estrogens from almost mature follicle stimulate release of more GnRH and LH.

2. GnRH promotes release of FSH and more LH.

3. LH surge brings about ovulation.

Ovary

Almost mature (graafian) follicle

Corpus hemorrhagicum (ruptured follicle)
Menstrual Cycle (four phases)
1\textsuperscript{st} = Menstrual Phase

- blood, serous fluid and endometrial tissue are discharged
• further thickening of endometrium due to secretion and fluid accumulation - not mitosis
• due to progesterone stimulation of glands
Menstrual Cycle // 3rd = Proliferative Phase

- day 6-14 rebuild endometrial tissue // estrogen responsible for hyperplasia // produced by developing follicles // upregulates for progesterone receptors
Menstrual Cycle // 4th = Premenstrual Phase

- day 6-14 rebuild endometrial tissue /// estrogen responsible for hyperplasia /// produced by developing follicles /// upregulates for progesterone receptors
GnRH stimulates release of FSH and LH

Anterior pituitary gland

FSH stimulates growing follicles

Initial development of ovarian follicles

LH stimulates ovulation

Further development of ovarian follicles and their secretion of estrogens and inhibin

Corpus luteum

Secretion of progesterone, estrogens, relaxin, and inhibin by corpus luteum

Estrogens
- Promote development and maintenance of female reproductive structures, feminine secondary sex characteristics, and breasts
- Increase protein anabolism
- Lower blood cholesterol
- Moderate levels inhibit release of GnRH, FSH, and LH

Progesterone
- Works with estrogens to prepare endometrium for implantation
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- Inhibits contractions of uterine smooth muscle
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- Inhibits release of FSH and, to a lesser extent, LH
(a) Hormonal regulation of changes in the ovary and uterus
1. High levels of estrogens from almost mature follicle stimulate release of more GnRH and LH.

2. GnRH promotes release of FSH and more LH.

3. LH surge brings about ovulation.
(a) Hormonal regulation of changes in the ovary and uterus
• Introduction to the essential features of human reproduction

• Primary and secondary sexual organs
The Two Sexes

- Essence of sexual reproduction is that it is **bi-parental**
  - offspring receive “combination” of genes from two parents
  - offspring is therefore not genetically identical to either parent
  - “We will die, but our genes will live on in a different container, our offspring”.
    
    Unknown Author
The Two Sexes

• **Gametes** (sex cells) produced by each parent
  
  – Female produce the egg
  
  – Male produce the sperm

• **Zygote** (fertilized egg) has combination of both parent’s genes
The Gametes

• Only one gamete has motility = sperm (spermatozoon)
  
  • parent producing sperm considered male
  
  • parent with a YX chromosome pair is male (XY)

• The other gamete = egg (also called the ovum)
  
  • parent with XX chromosome pair is female (XX)
  
  • contains nutrients for developing embryo
  
  • parent producing eggs considered female
  
  • in mammals, female is the parent that provides a sheltered internal environment and prenatal nutrition for the embryo
Chromosomal Sex Determination

Human cells contain 23 pairs of chromosomes (or a total of 46 chromosomes!)

- 22 pairs of autosomes plus 1 pair of sex chromosomes
- Sex chromosome option one = XY = males
- Sex chromosome option two = XX = females
- Male gamete carry a Y and a X chromosome
- Female gamete carry two X chromosomes
- In gamete formation (haploid cell division = meiosis) // the sex chromosomes are “split” with each gamete getting only one of the two sex chromosomes from each parent

Note: sperm may contain either an X or a Y chromosome
Chromosomal Sex Determination

Sex of child determined by type of sperm that fertilizes mother’s egg (egg can only provide X)

If X carrying sperm fertilizes the egg – female

If Y carrying sperm fertilizes the egg - male
Gamete Union

- Males have a copulatory organ (the penis) for introducing his gametes into the female reproductive tract.

- Females have a copulatory organ (the vagina) for receiving the sperm.

- Zygote formation occur in the female’s fallopian tube.
Overview of Reproductive System

• Reproductive system consists of primary and secondary sex organs

  – **primary sex organs** (the gonads) // produce gametes (testes or ovaries)

  – **secondary sex organs** // organs other than the gonads that are necessary for reproduction

    – **male** – system of ducts, glands, and penis

    – **female** - uterine tubes, uterus, and vagina
• List the substances found in semen

• Discuss the composition and function of seminal fluid

• About male fertility
Male Duct System & Accessory Glands

- Urinary bladder
- Ampulla
- Seminal vesicle
- Ureter
- Prostate gland
- Membranous urethra
- Ductus deferens
- Testis
- Efferent ductules
- Epididymis
- Spongy (penile) urethra
- Corpus cavernosum
- Crus
- Corpus spongiosum
- Bulbourethral gland
- Bulb
- Ejaculatory duct
- Bulbourethral gland
- Membranous urethra
- Prostatic urethra
- Glans of penis
- Penis
- (b) Posterior view

- Male Duct System
- Accessory Glands
Semen (Seminal Fluid)

- **prostate** // produces a thin, milky white fluid (30% volume)
  - contains calcium, citrate, and phosphate ions
  - a clotting enzyme // and a protein-hydrolyzing enzyme called *serine protease* (prostate-specific antigen)

- **seminal vesicles** // contribute viscous yellowish fluid (60%)
  - contains fructose and other carbohydrates, citrate, prostaglandins
  - protein called *proseminogelin* / converted to *seminogelin* by prostate’s clotting enzyme

- **seminiferous tubules** // located in testes – produce sperm and tubular secretion (10% volume)
Semen

- **stickiness** of semen promotes fertilization

  - clotting enzyme from prostate activates **proseminogelin**
  
  - converts it to a sticky fibrin-like protein – **seminogelin**

  - entangles the sperm // sticks to the inner wall of the vagina and cervix

  - ensures that the semen does not drain out of the vagina

  - promotes uptake of sperm-laden clots of semen into the uterus

  - 20 to 30 minutes after ejaculation, **serine protease** from prostatic fluid breaks down seminogelin, and liquifies the semen

  - sperm then become active (see next slide)

  - **prostaglandins** thin the mucus of the cervix, stimulates peristaltic waves in uterus and uterine tubes
Accessory Glands / Seminal Vesicles

- Pair of glands posterior to bladder
- Empties secretions into ejaculatory duct
- Accounts for 60% of semen volume (2 to 5 ml)
- Fluid expelled during ejaculation phase of orgasm
- Fractional semen volume
  - 60% seminal vesicle fluid
  - 30% prostatic fluid
  - 10% sperm and spermatic duct secretions
- Normal sperm count 50-120 million/mL
- If lower than 20 to 25 million/mL – infertility
Accessory Glands / Prostate Gland

- surrounds urethra and ejaculatory duct just inferior to the bladder
- 30 to 50 compound tubuloacinar glands
- empty through about 20 pores in the prostatic urethra
- Produce thin milky secretion // forms 30% of semen
Accessory Glands / Bulbourethral Glands

– Bulbourethral (Cowper) glands

• near bulb of penis

• during sexual arousal, they produce a clear slippery fluid that lubricates the head of the penis in preparation for intercourse

• protects the sperm by neutralizing the acidity of residual urine in the urethra
Semen / Two Requirements for Sperm Motility

• elevated pH
  – prostatic fluid buffers vaginal acidity from 3.5 to 7.5

• energy source
  – seminal vesicles provide fructose and other sugars
  – sperm’s mitochondria use energy to propel flagella
• Trace the passage of sperm from the point of formation through the genital ducts to the exterior
Male Duct System & Accessory Glands
Testis and Associated Structures

- Head of epididymis
- Ductus deferens
- Efferent ductule
- Rete testis
- Body of epididymis
- Tail of epididymis
- Blood vessels and nerves
- Spermatocord
- Seminiferous tubule
- Septum
- Lobule
- Tunica vaginalis
- Tunica albuginea
Spermatogenesis and Histology of Testis

(a) Interstitial cells
Blood vessel
Germ cells
Sustentacular cell
Tails of spermatozoa

(b) Blood vessel
Seminiferous tubule
Spermatids
Sustentacular cell nuclei
Tubule lumen
Germ cells
Connective tissue wall of tubule
Interstitial cells

50 µm
• Describe the involvement of the nervous system with respect to erection, emission, and ejaculation
Male Sexual Response

- Brought to general public by groundbreaking publication of research papers by William Masters and Virginia Johnson (1966)

- Sexual Response divided into four recognizable phases (note: see next slide)
  - **Excitement**
  - **Orgasm (ejaculation) – emission stage**
  - **Orgasm (ejaculation) – expulsion stage**
  - **Resolution**

- led to therapy for sexual dysfunction

- sexual intercourse is also known as *coitus*, *coition*, or *copulation*
Male Sexual Response
Innervation of the Penis

- The glans has an abundance of tactile, pressure, and temperature receptors

  - **dorsal nerve of penis** and **internal pudendal nerves** lead to integrating center in sacral spinal cord

  - both autonomic and somatic motor fibers carry impulses from integrating center to penis

- **sympathetics** induce an *erection in response to input from the special senses* and to sexual thoughts

- **parasympathetics** induce an *erection in response to direct stimulation of the penis*
Orgasm and Ejaculation

• **orgasm** or **climax** – a short but intense reaction associated that is *usually marked by the discharge of semen*
  
  – lasts 3 to 15 seconds
  – heart rate, blood pressure, and breathing greatly elevate

• **ejaculation occurs in two stages:**
  
  – **Emission**
    • sympathetic nervous system stimulates peristalsis which propels sperm through ducts as glandular secretions are added
  
  – **Expulsion**
    • semen in urethra activates somatic and sympathetic reflexes that stimulate muscular contractions that lead to expulsion
    
    • sympathetic reflex constricts internal urethral sphincter so urine cannot enter the urethra and semen can not enter the bladder

• ejaculation and orgasm are not the same // orgasm can occur without ejaculation
Parasympathetic signals produce an erection along with direct stimulation of penis or perineal organs.
Spinal cord (sacral)

Visual, mental, and other stimuli

Stimulation of genital region, especially glans

Internal pudendal nerve

Pelvic nerve

Efferent parasympathetic signals

Excitation

Deep artery of penis dilates; erectile tissues engorge with blood; penis becomes erect

Trabecular muscle of erectile tissues relaxes; allows engorgement of erectile tissues; penis becomes erect

Bulbourethral gland secretes bulbourethral fluid
Note: semen moves into urethra / this initiates an afferent nerve signal / see next slide
Semen in urethra

Orgasm — expulsion stage

- Prostate releases additional secretion
- Seminal vesicles release additional secretion
- Internal urethral sphincter contracts; urine is retained in bladder
- Bulbocavernosus muscle contracts, and rhythmically compresses bulb and root of penis; semen is expelled (ejaculation occurs)
Resolution

- Internal pudendal artery constricts; reduces blood flow into penis
- Trabecular muscles contract; squeeze blood from erectile tissues
- Penis becomes flaccid (detumescent)
Sexual Response

**Excitement**
- Deep artery of penis dilates; erectile tissues engorge with blood; penis becomes erect
- Trabecular muscle of erectile tissues relaxes; allows engagement of erectile tissues; penis becomes erect
- Bulbourethral gland secretes bulbourethral fluid

**Orgasm — emission stage**
- Ductus deferens exerts peristalsis; sperm are moved into ampulla; ampulla contracts; sperm are moved into urethra
- Prostate secretes components of the seminal fluid
- Seminal vesicles secrete components of the seminal fluid

**Semen in urethra**

**Orgasm — expulsion stage**
- Prostate releases additional secretion
- Seminal vesicles release additional secretion
- Internal urethral sphincter contracts; urine is retained in bladder
- Rhythmic contraction of the bulb of the penis; semen is expelled (ejaculation occurs)

**Resolution**
- Internal pudendal artery constricts; reduces blood flow into penis
- Trabecular muscles contract; squeeze blood from erectile tissues
- Penis becomes flaccid (detumescence)
• About puberty and secondary sex characteristics
• Gonadotropin releasing hormone initiates puberty in both male and female

• GRH produced in hypothalamus by nuclei

• Delayed development of nuclei corresponds with the start of puberty

• Puberty associated with development of secondary sexual characteristics and sexual behavior
• List the primary and secondary sex organs of the female reproductive system and give the generalized function of each
• **Primary sex organ = ovaries // produce female gamete (egg)**

• **Secondary sex organs = fallopian tubes, uterus, vagina**
Mons pubis

Labia majora (spread)

Labia minora (spread exposing vestibule)

Hymen

Prepuce of clitoris

Clitoris

External urethral orifice

Vaginal orifice (dilated)

Anus

(c) Inferior view
ANTERIOR

- Rectus abdominis muscle
- Urinary bladder
- Uterus
- Round ligament
- Ovarian ligament
- Mesovarium
- Cecum
- Broad ligament
- Vermiform appendix
- Cardinal ligament
- Uterosacral ligament
- Common iliac artery

POSTERIOR

Superior view of transverse section

- Uterine (fallopian) tube
- Ovary
- Rectouterine pouch
-Suspensory ligament
- Ureter
- Ileum
- Sigmoid colon
• Discuss the structure of the uterus including the layers and divisions
The Uterus

• uterus – thick muscular chamber that opens into the roof of the vagina
  – usually tilts forward over the urinary bladder
  – harbors fetus, provides a source of nutrition, and expels the fetus at the end of its development
  – pear-shaped organ

• fundus – broad superior curvature
• body (corpus) – middle portion
• cervix – cylindrical inferior end
The Uterus

– lumen is roughly triangular
  • upper two corners are the openings to the uterine tube
  • lower apex is internal os
  • not a hollow cavity, but a potential space in the non-pregnant uterus

– cervical canal connects the lumen to vagina
  • internal os – superior opening of the canal into the body of the uterus
  • external os – inferior opening of the canal into the vagina

– cervical glands – secretes mucus that prevents the spread of microorganisms from the vagina to the uterus
Uterine Wall Layers
(serosa / myometrium / endometrium)

- external serosa layer = outer layer

- myometrium = middle muscular layer // constitutes most of the uterine wall
  - composed mainly of smooth muscle
    - sweep downward from fundus and spiral around the body
  - less muscular and more fibrous near cervix
    - produces labor contractions, expels fetus
Uterine Wall

- endometrium = inner mucosa
  - simple columnar epithelium, compound tubular glands, and a stroma populated with leukocytes, macrophages, and other cells.
  - stratum functionalis – superficial half, shed each menstrual period
  - stratum basalis - deep layer, stays behind and regenerates a new stratum functionalis with each menstrual cycle
- during pregnancy, the endometrium is the site of attachment of the embryo and forms the maternal part of the placenta from which the fetus is nourished
Histology of Endometrium

- Surface epithelium
- Endometrial gland
- Lamina propria
• Give the endocrine functions of the placenta
• Blastocyst attaches to endometrium to initiate the formation of the placenta

• Placenta is the organ used to exchange nutrients and metabolic waste between mother and conceptus

• After placenta developed it secretes several hormones that maintain pregnancy and alter female physiology
  – Estrogen
  – Progesterone
  – Human chorionic gonadotropin (hCG)
  – Relaxin
• Identify the structures that together constitute the female external genitals
Female Perineum Showing Vulva

- Mons pubis
- Labia majora (spread)
- Labia minora (spread exposing vestibule)
- Hymen
- Prepuce of clitoris
- Clitoris
- External urethral orifice
- Vaginal orifice (dilated)
- Anus

(c) Inferior view
• Identify the phases of the endometrial or menstrual cycle
Menstrual Cycle

- The menstrual cycle is also referred to as the sexual cycle. It is approximately 28 days long and occurs when there is no pregnancy.

- It is associated with changes in the tissues of the uterus.

- There are four phases: menstrual, proliferative, secretory, and premenstrual.

- The first phase starts on day one of the cycle.

- The menstrual cycle coincides with ovarian events associated with the development of the female gamete (egg).
Menstrual Cycle // Menstrual Phase

- Associated with day one of new cycle
- Beginning of blood, serous fluid and endometrial tissue discharged
- Anticoagulants prevents blood clotting
Menstrual Cycle  //  Proliferative Phase

- day 6-14 rebuild endometrial tissue (mitosis)
- estrogen responsible for endometrium’s hyperplasia
- estrogen also up-regulates endometrium with progesterone receptors
- further thickening of endometrium due to secretion and fluid accumulation - not mitosis
- due to progesterone stimulation of glands
Menstrual Cycle // Premenstrual

(b) Menstrual cycle

Ovarian hormone secretion

Estradiol

Progesterone

Thickness of endometrium

Menstrual fluid

Days

1 3 5 7 9 11 13 15 17 19 21 23 25 27 1

Menstrual phase Proliferative phase Secretory phase Premenstrual phase
Ovarian Cycle
Follicular & Luteal Phases

(a) Ovarian cycle

Gonadotropin secretion

LH

FSH

Developing follicles
Primary
Secondary
Tertiary
Ovulation
Corpus luteum
Involution
Corpus albicans

New primordial follicles

Days
1 3 5 7 9 11 13 15 17 19 21 23 25 27 1

Follicular phase

Luteal phase
• Explain the hormonal control of the cyclical changes that occur in the ovaries
Pituitary-Ovarian Axis

1. Maturing follicle secretes estradiol
2. Estradiol stimulates hypothalamus and anterior pituitary
3. Hypothalamus secretes GnRH
4. GnRH and estradiol stimulate pituitary to secrete LH and FSH
5. Oocyte completes meiosis I; follicle rapidly enlarges and then ovulates

Note:
After corpus luteum forms it produces Inhibin // it suppresses FSH secretion
1. High levels of estrogens from almost mature follicle stimulate release of more GnRH and LH

2. GnRH promotes release of FSH and more LH

3. LH surge brings about ovulation

- Ovary
- Almost mature (graafian) follicle
- Corpus hemorrhagicum (ruptured follicle)
Ovarian Cycle

Follicular & Luteal Phases

(a) Ovarian cycle

Gonadotropin secretion

LH

FSH

Developing follicles

Primary

Secondary

Tertiary

Ovulation

Corpus luteum

Involution

Corpus albicans

New primordial follicles

Ovarian events

Follicular phase

Days 1 3 5 7 9 11 13

Luteal phase

Days 15 17 19 21 23 25 27 1
• Female fertility
Female Fertility

E.R. TE VELDE ET AL., 1998
Fig. 2. Men’s and women’s age-specific fertility rates, 1993–97
(TFR = total fertility rate)
• Secondary sex characteristics of male and female expressed at puberty
Secondary sex characteristics

- features that further distinguish the sexes and play a role in mate attraction

- develop at puberty to attract a mate

- both sexes develop pubic and axillary hair

- scent glands (apocrine glands)

- male characteristics = facial hair, coarse and visible hair on the torso and limbs, relatively muscular physique, deeper voice

- female characteristics = redistribution of body fat, breast enlargement, and relatively hairless appearance of the skin