Male Reproductive System

- There are three main functions of the male reproductive system:
  - Produce and maintain sex cells (sperm)
  - Transport sperm and supplemental fluids to the female reproductive tract
  - Secret male sex hormones
- Sex organs can be divided into:
  - Primary sex organs (gonads) = testes (sperm, hormones)
  - Accessory (secondary) sex organs = internal and external reproductive organs

Pathway of spermatogenesis travel:
- Testes → Epididymis → Vas (ductus) deferens → Ejaculatory duct → Urethra

Structure of the Testis

- Surrounding the tunica albuginea – a tough, white, fibrous capsule that encloses each testicle
- Septa divide each testicle into about 250 lobules
- Each lobule contains 1-4 highly coiled seminiferous tubules that produce sperm
- Interstitial cells (of Leydig) lie in between seminiferous tubules and secrete male sex hormones
**Spermatogenesis** – Production of sperm

Know the order of events below and the ploidy at each step!

- Spermatogonium (2n)
- Primary spermatocyte (2n)
  - Meiosis I
  - Secondary spermatocyte (n)
    - Meiosis II
  - Spermatid (n)
  - Spermiogenesis
- Spermatozoan (n)

---

**Seminiferous Tubules and Sperm Maturation**


Supporting cells are sustentacular cells. They:
1. are important in regulating and supporting spermatogenesis
2. help maintain the blood-testis barrier (important in protecting developing sperm from immune attack)

Spermatogonium = stem cell

---

**Structure of a Sperm Cell**

- Head of sperm contains:
  1. Genetic Material
  2. Enzymes used to penetrate the egg during fertilization are contained in the acrosome

Head of sperm contains:
- Acrosome
- Nucleus
- Centrioles

Mitochondria

Only flagellum in human body

Capacitation is the complete maturation of sperm to become fully functional (able to fertilize an egg). This is normally not entirely complete until the sperm enter the female reproductive tract.
**Epididymis**
- Maintains fluid produced in the seminiferous tubules
- Recycles damaged sperm and cellular debris
- Store and protects sperm, and aids in their maturation

**Figures from:**
Martini, Anatomy & Physiology, Prentice Hall, 2001

**Ductus (Vas) Deferens**
- Muscular tube about 45 cm long; transports sperm (can store sperm for several months)
- Extends from epididymis to ejaculatory duct

**Seminal Vesicles**
- Attached to ductus deferens near base of bladder
- Secretes alkaline fluid (60% of the volume of semen)
- Secretes fructose, prostaglandins, and prostamidin
- Begins capacitation of sperm
- Contents empty into ejaculatory duct

**Prostate**
- Surrounds beginning of urethra
- Ducts of gland open into urethra
- Secrates thin, milky, slightly acidic fluid (20-30% of semen volume)
- Secretion enhances fluid mobility
- Contains seminalplasmin
- Composed of tubular glands in connective tissue
- Also contains smooth muscle

**Bulbourethral gland**
- Secrates thick, alkaline mucus helps lubricate the tip of the penis (glans) and neutralizes any urinary acids in urethra
- Fluid released in response to sexual stimulation

**Figures from:**
Martini, Anatomy & Physiology, Prentice Hall, 2001
Semen

- sperm cells
- secretions of seminal vesicles, prostate gland, and bulbourethral glands (seminal fluid)
- slightly alkaline
- prostaglandins
- nutrients
- enzymes (protease, seminalplasmin, fibrinolysin)
- 20-100 million sperm cells per milliliter
- usually about 2-5 ml of fluid per ejaculate

Scrotum

- pouch of skin and subcutaneous tissue
- dartos muscle – smooth muscle in dermis; contracts to cause wrinkling of the scrotum (traps heat)
- medial septum divides scrotum into two chambers
- each chamber lined with a serous membrane
- each chamber houses a testis and epididymis

Cremaster muscle can retract or drop testes to maintain optimum temperature for sperm development

Penis (Root, Body [shaft], Glans)

Corpora cavernosa and spongiosum (surrounds urethra) are the male erectile tissues of the penis.

Preputial glands in the prepuce (foreskin) produce a waxy material called smegma. This can be a source of bacterial growth if hygiene is poor. Circumcision is the surgical removal of the prepuce.
Erection, Orgasm, and Ejaculation

**Erection**
- parasympathetic nerve impulses cause release of nitric oxide to dilate blood vessels in penile erectile tissues
- blood accumulates in erectile tissues

**Orgasm**
- culmination of sexual stimulation
- accompanied by emission and ejaculation

**Emission and Ejaculation**
- emission is the movement of semen into urethra
- ejaculation is the movement of semen out of the urethra
- largely dependent on sympathetic nerve impulses

Bulbospongiosus m.
Ischiocavernosus m.

Hormonal Control of Male Reproduction

- hypothalamus controls maturation of sperm cells and development of male secondary sex characteristics
- negative feedback controls concentration of testosterone

Actions of Testosterone (2° Sex Char.)

- increased growth of body hair
- sometimes decreased growth of scalp hair
- enlargement of larynx and thickening of vocal cords
- thickening of skin
- increased muscular growth
- thickening and strengthening of the bones

Know these actions
Functions of the Female Reproductive System

- Produce and maintain sex cells (eggs) – a function of the ovaries, the primary sex organs
- Transport eggs to site of fertilization
- Produce female sex hormones
- Provide favorable environment for development of offspring
- Move offspring to outside (birth)

Secondary sex organs of the female
- Internal: Fallopian (uterine) tubes, uterus, vagina
- External: mons pubis, labia majora and minora, clitoris, vestibular glands

Organs of the Female Reproductive System

- Fallopian tubes
- Uterus
- Vagina
- Ovaries
- Cervix
- Vaginal glands

Ligaments of Uterus and Ovaries

- Broad ligament
- Round ligament
- Fallopian tube ligament
- Uterine artery
- Ovarian artery

Figures from Martini, Anatomy & Physiology, Prentice Hall, 2001
Overview of the Ovarian Cycle

Ovarian cycle – events occurring monthly in an ovary (oocyte growth and meiosis occur); cycle is usually about 28 days long

Two phases: 1) Follicular phase 2) Luteal phase

Ovarian Cycle – Preovulatory (Follicular) Phase

- Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001
- FSH
- Thecal and granulosa cells produce estrogens
- Meiosis I
- LH
- Meiosis II started
- Many
- One
- Few
- (Graafian)
- 1.5 cm
- Estrogen
- (FSH)
- 20

Ovarian Cycle – Postovulatory (Luteal) Phase

- Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001
- LH
- Lipids used to synthesize progestins, e.g., progesterone (prepares uterine lining for implantation)
- 12 days post ovulation
- If fertilization has not occurred
Oogenesis – generation of ova (gametes) in ovary

- Oogonium = stem cell
- Primary oocyte – diploid cell; result of mitotic division of oogonium
- Secondary oocyte – haploid cell; result of meiotic division of primary oocyte
- Polar body – shed genetic material during meiotic divisions
- Ovum – haploid gamete in metaphase II of meiosis that is released from ovary at ovulation

How does oogenesis differ from spermatogenesis? How is it the same?

Uterine (Fallopian) Tubes

- Fallopian tubes are site of fertilization of egg by sperm and transport fertilized egg to uterus for implantation
- Infundibulum contains fimbriae (inner surfaces lined with cilia that beat toward center)
- Ampulla (middle, muscular segment)
- Isthmus (segment connected to the uterine wall)

Fertilization usually occurs around here

Fallopian tube = salpinx [salping(o)-]

Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001

Uterus (hyster(o)-)

- Functions:
  - Mechanical protection (fetus)
  - Nutritional support (fetus)
  - Waste removal (fetus)
  - Ejection of fetus at birth

Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001
Two layers of endometrium:
1) Basilar zone, 2) Functional Zone

Under the influence of estrogen and progesterone, uterine glands, blood vessels, and epithelium in the functional zone of the endometrium change with the phases of the uterine (menstrual) cycle.

Acidity of vagina protects adults from bacterial infections.

Major functions:
- Passageway for elimination of menstrual fluids
- Receives penis and holds sperm prior to passage into uterus
- Inferior portion of birth canal for fetal delivery

Female external genitalia = pudendum or vulva

Includes the structures external to the vagina (within vestibule):
- mons pubis
- labia majora and minora
- clitoris (and prepuce)
- vestibular structures (enclosed within labia minora)

Opening of ducts of greater vestibular glands (Bartholin’s) = mucous secretions

Know the terms on this slide.
Female Erection, Lubrication, and Orgasm

Sexual stimulation
- Arteries in the erectile tissue dilate; vagina expands and elongates
- Parasympathetic nerve impulses from the sacral portion of the spinal cord
- Sexual stimulation intensifies
- Vestibular glands secrete mucus to lubricate
- Orgasm—rhythmic contraction of muscles of the perineum; muscular walls of uterus and uterine tubes contract

Uterine (Menstrual) Cycle

Proliferative phase – functional layer of endometrium thickens under the influence of estrogen
Secretory phase – Arteries elaborate and uterine glands enlarge, coil, and begin secreting glycogen under progesterone’s influence

Hormonal Regulation of Ovarian Activity

Estrogen is the predominant hormone prior to ovulation (follicular phase)
Progesterone is the predominant hormone after ovulation (luteal phase)

Changes in pulse rate of GnRH control secretion of LH/FSH. GnRH release is controlled by estrogen, inhibin, and progesterone.
**Effects of Estrogens (2nd sex characteristics)**

- Development of breasts and ductile system of the mammary glands
- Increased adipose tissue in breasts, thighs, and buttocks
- Increased vascularization of skin
- Maintenance of the function of accessory reproductive glands/organs
- CNS effects, e.g., sex drive, “feminization”
- Repair/growth of endometrium (following menses)

---

**Overview of Female Reproductive Cycle**

You should understand these events, and their timing, for the exam

- Ovarian cycle
- Uterine cycle

---

**Male and Female Climacteric**

**Female climacteric = menopause**
- Usually occurs in late 40s or early 50s (perimenopause)
- Reproductive cycles stop for 6 months to 1 year
- Ovaries no longer produce as much estrogen and progesterone due to depletion of ovarian follicles
- Some female secondary sex characteristics may disappear
- Sustained rise in GnRH and LH/FSH may produce hot flashes (LH) and fatigue
- Risk of atherosclerosis increases
- Hormone therapy may prevent effects on bone tissue

**Male climacteric (andropause)**
- More gradual than female climacteric
- Usually occurs after age 50
- Slowly declining levels of testosterone
- Sperm (gamete) production continues (even into 80s!)
Mammary Glands

Mammary glands as shown are for women in last trimester of pregnancy or who are nursing. The areola, a ring of pigmented skin, covers large sebaceous glands that give it a bumpy appearance. Sebum reduces chapping and cracking of the nipple.

Size of mammary glands in a nonpregnant/nonalactating woman reflects amount of adipose tissue present.

Pregnancy, Growth, and Development

Pregnancy (gestation) is the presence of a developing offspring in the uterus
- About 38-42 weeks (9 months) in length
- Divided into trimesters (about 3 months each)
- Called the ‘prenatal’ (before birth) stage of development

Embryological development – 1st 8 weeks
Fetal development – 2 weeks to term.

Growth is an increase in size. Involves increases in cell numbers and cell sizes
Development is the continuous process by which an individual changes from one life phase to another
- Prenatal (development in utero)
- Neonatal (first 28 days after birth)
- Postnatal (from birth until maturity)
- Aging and death

Major Events in Each Trimester

• First trimester (weeks 1-12)
  – Most critical period (most vulnerable to drugs, alcohol)
  – Embryological and early fetal development
  – Rudiments of all major organ systems appear
• Second trimester (weeks 13-24)
  – Development of organs and organ systems (almost complete by end of sixth month)
  – At end of trimester, fetus looks human
• Third trimester (weeks 25 to birth)
  – Rapid fetal growth
  – Deposition of adipose tissue
  – Major organ systems become functional
  – At 35 weeks (~2.5 Kg), fetus can usually survive if born early (twins typically born during this time)
## Prenatal Terminology and Times

**Embryological** (week 1 to 8)  
**Fetal** (week 9 to birth)

### Prenatal Development

- **1st trimester** (Week 1-12)  
- **2nd trimester** (Week 13-25)  
- **3rd trimester** (Week 26-38)

**Date of conception** – add 14 days to the date of the onset of the last menstrual period

**Due Date** – add 266 days to the date of conception (about 280 days from the onset of the last menstrual period)

(Rule of thumb from onset of last menstrual period: Subtract 3 months from the month of the last period, then add 4 days unless pregnancy covers an entire month of February, then add 7 days)

Know items in red

## Hormonal Changes During Pregnancy

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Source</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Chorionic Gonadotropin</td>
<td>Placenta</td>
<td>Maintains corpus luteum until week 12</td>
</tr>
<tr>
<td>Estrogen/Progestrone</td>
<td>Corpus luteum/placenta</td>
<td>Stimulates and maintains cellular lining, inhibits FSH and LH, inhibits uterine contractions, and enlarges reproductive organs</td>
</tr>
<tr>
<td>Relaxin</td>
<td>Corpus luteum/placenta</td>
<td>Possibly causes pelvic ligaments to relax, widen, and become more flexible; inhibits uterine contractions; promotes uterine blood vessel growth</td>
</tr>
<tr>
<td>Human Chorionic Somatomammotropin (also Placental Lactogen)</td>
<td>Placenta</td>
<td>Mammary gland development; glucose-sparing effect in mother; weak GH type effect</td>
</tr>
<tr>
<td>Human Chorionic Thyrotropin</td>
<td>Placenta</td>
<td>Increases size/activity of thyroid and parathyroid glands</td>
</tr>
<tr>
<td>Aldosterone</td>
<td>Adrenal cortex</td>
<td>Increases fluid retention</td>
</tr>
</tbody>
</table>

Figure from: Saladin, Anatomy & Physiology, McGraw Hill, 2007

## Hormonal Changes During Pregnancy

Relative concentrations of three hormones in maternal blood during pregnancy

Secreted mainly by placenta after about 12 weeks

Figure from: Saladin, Anatomy & Physiology, McGraw Hill, 2007
Early Embryonic Stage

Three primary germ layers form during the gastrula stage, which occurs 2 weeks (~2mm long) after fertilization.

Functions of the Placenta

<table>
<thead>
<tr>
<th>Functions of the Placenta</th>
<th>IRENE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutritional roles</td>
<td>Immune</td>
</tr>
<tr>
<td>Excretory roles</td>
<td>Respiratory</td>
</tr>
<tr>
<td>Respiratory roles</td>
<td>Endocrine</td>
</tr>
<tr>
<td>Endocrine roles</td>
<td>Nutritional</td>
</tr>
<tr>
<td>Immune roles</td>
<td>Excretory</td>
</tr>
</tbody>
</table>

Mnemonic for placental functions: IRENE

Factors Contributing to Onset of Labor

- As birth approaches, progesterone levels decrease (allowing increase in uterine contractions); estradiol continues to rise and upregulates oxytocin receptors on uterus
- Prostaglandins synthesized which may initiate labor
- Stretching uterine tissue stimulates release of oxytocin
- Oxytocin stimulates uterine contractions
- Fetal head stretches uterus, cervix, vagina, and vulva
- Positive feedback results in stronger and stronger contractions and greater release of oxytocin
Stages of Labor:
1. Dilation - Cervix dilates and effaces, and fetus begins moving toward cervical canal; “water breaks” (amniotic membrane ruptures) late in this phase.
2. Expulsion – Cervix is pushed open by approaching fetus (positive feedback cycle) and baby’s head enters vagina.
3. Placental – placenta and fetal membranes are “delivered”

Milk-Letdown Reflex:
Recall that oxytocin (OT) is a stimulus for smooth muscle contraction and is secreted by the neurohypophysis.

OT stimulates myoepithelial cells in the walls of the lactiferous ducts and sinuses.

Know this pathway.