Chapter 5

Sex Hormones, Sexual Differentiation, and the Menstrual Cycle
Sex Hormones

• Hormones are powerful chemical substances manufactured by the endocrine glands and secreted directly into the bloodstream.

• Most important sex hormones:
  – Testosterone
  – Estrogen
  – Progesterone
Hypothalamus-Pituitary-Gonad Feedback Loop (F)

- Hypothalamus
- Pituitary gland
- FSH and LH
- Uterus
- Estrogen and progesterone negative feedback
- Ovary
- Estrogen
- Progesterone
- Endometrium
Sex Hormones in the Male

- Testosterone - masculinizing sex hormone.
- Follicle-stimulating hormone (FSH) - controls sperm production.
- Luteinizing hormone (LH) - controls testosterone production.
- Gonadotropin-releasing hormone (GnRH) - regulates the pituitary’s secretion of gonad-stimulating hormones.
Hormonal Control of Testosterone

Hypothalamus

GnRH

Pituitary

FSH

LH

Spermatogenesis

Inhibin

Testes

Testosterone secretion
Sex Hormones in the Female

- Estrogen - brings about many of the changes of puberty.
- Progesterone
- Prolactin - stimulate secretion of milk by the mammary glands.
- Oxytocin - stimulates contractions of the uterus during childbirth.
Prenatal Sexual Differentiation

- **Sex chromosomes** - transmit information to various organs on how to differentiate in the course of development.

  - **XX** = female
  - **XY** = male
Prenatal Development of Gonads

- In the 7th week after conception, sex chromosomes direct gonads to begin differentiation.
- Male - undifferentiated gonad develops into a testis at about 7 weeks.
- Female - ovaries develop at around 10-11 wks.
- If SRY (sex-determining region, Y chromosome) is present, then testes differentiate and male development occurs.
Prenatal Hormones and the Genitals

- In the female, Mullerian ducts turn into fallopian tubes, the uterus, and the upper part of the vagina.
- In the male, Wolffian ducts, supported by testosterone, turn into the epididymis, vas deferens, and ejaculatory duct.
Development of M/F External Genitals

UNDIFFERENTIATED

- Glans area
- Epithelial tag
- Urethral fold
- Urethral groove
- Lateral buttress
- Anal pit
- Anal tubercle
- Genital tubercle
- Tail (cut away)
Development of M/F External Genitals

MALE
- Glans
- Epithelial tag
- Coronal sulcus
- Site of future origin of prepuce
- Urethral fold
- Urogenital groove
- Lateral buttress (corpus or shaft)
- Labioscrotal swelling
- Urethral folds partly fused (perineal raphe)
- Anal tubercle
- Anus

PARTIALLY DEVELOPED

FEMALE
Development of M/F External Genitals

FULLY DEVELOPED

- Urethral meatus
- Glans penis
- Prepuce
- Shaft or body of penis (corpus)
- Penoscrotal raphe
- Scrotum
- Body of clitoris
- Prepuce
- Glans clitoridis
- Urethral meatus
- Inner labia
- Outer labia
- Vagina
- Perineal rephe
- Perianal tissues including external sphincter
Descent of the Testes and Ovaries

- Ovaries and testes change shape and position as developmental changes take place.
- Testes travel from near the top of the abdominal cavity down into the scrotum via the *inguinal canal*.
  - Cryptorchidism (undescended testes) occurs in 2% of all males.
Brain Differentiation

• During the prenatal period, sex hormones act on the brain:
  – If testosterone is present during fetal development, estrogen receptors in the hypothalamus become insensitive to estrogen.
  – If estrogen is present, they become highly sensitive to levels of estrogen in the bloodstream.
Homologous and Analogous Organs

• **Homologous** organs - organs in the male and female that develop from the same embryonic tissue.

• **Analogous** organs - organs in the male and female that have similar functions.
<table>
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<th>Embryonic Source</th>
<th>Homologous Organs</th>
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<td>In the Adult Male</td>
<td>In the Adult Female</td>
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<td>Gonad (medulla plus cortex)</td>
<td>Testes (from medulla)</td>
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<td>Genital tubercle</td>
<td>Glans penis</td>
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<td>Genital swelling</td>
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<td>Müllerian duct</td>
<td>Degenerates, leaving only remnants</td>
<td>Degenerates, leaving only remnants</td>
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<td>Wolffian duct</td>
<td>Epididymis, vas deferens, seminal vesicles</td>
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<td>Urethral primordia</td>
<td>Prostate, Cowper’s glands</td>
<td>Skene’s glands, Bartholin glands</td>
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Variables of Gender

- Chromosomal gender
- Gonadal gender
- Prenatal hormonal gender
- Prenatal and neonatal brain differentiation

- Internal organs
- External genital appearance
- Pubertal hormonal gender
- Assigned gender
- Gender identity
Atypical Prenatal Gender Differentiation

• **Intersex** (pseudohermaphrodite) - biologically a person’s gender is ambiguous.

• **Congenital Adrenal Hyperplasia** (CAH) - also called adrenogenital syndrome; normally-developed ovaries begin to function abnormally later in the course of prenatal development.
Puberty vs. Adolescence

- **Puberty** is the time during which there is sudden enlargement and maturation of the gonads, other genitalia, and secondary sex characteristics, leading to reproductive capacity.

- **Adolescence** represents a psychological transition from the behavior and attitudes of a child to the behavior, attitudes, and responsibilities of an adult.
Pubertal Changes in the Female

• Puberty includes:
  – breast development
  – growth of pubic hair
  – increased body growth

• **Menarche** - first menstruation at about 12 to 13 years of age.
Pubertal Changes in the Male

• Growth of testes and scrotal sac
• Growth of pubic hair
• Penis enlarges
• Growth of facial and axillary hair
• Erections increase
• Voice drops or changes
• Increased body growth
Biology and the Menstrual Cycle

• Menstrual cycle is regulated by fluctuating levels of sex hormones.
• These hormones produce certain changes in the ovaries and uterus.
• Humans are nearly unique among species in having a menstrual cycle.
• Other species of mammals have estrous cycles.
The Phases of the Menstrual Cycle

• The menstrual cycle has 4 phases:
  – 1. Follicular phase - proliferative or preovulatory phase.
  – 2. Ovulation
  – 3. Luteal phase - secretory or postovulatory phase.
  – 4. Menstruation
The Biological Events of Menstrual Cycle

(a) Levels of hormones produced by the pituitary
The Biological Events of Menstrual Cycle

(b) Levels of hormones produced by the ovaries

Plasma concentrations of ovarian hormones, arbitrary units

- Estrogen
- Progesterone

Ovarian hormones
The Biological Events of Menstrual Cycle

(c) Changes in ovarian follicles and uterine endometrium

Days 1 5 10 15 20 25 28

Uterine phases
- Menstrual flow
- Proliferative phase
- Secretory phase

Ovarian phases
- Follicular
- Ovulation
- Luteal

Ovarian follicles
Endometrium
What Happens in the Ovaries During the Menstrual Cycle

• Follicular phase - high levels of FSH secreted.
  – Function is to stimulate follicles in the ovaries.
  – One follicle begins to ripen and brings an egg to maturity.
  – Follicle secretes estrogen.

• Ovulation - follicle ruptures open and releases the ripened egg.
What Happens in the Ovaries During the Menstrual Cycle

- **Luteal phase** - after releasing an egg, the follicle turns into the *corpus luteum* and manufactures progesterone.
- **Menstruation** - shedding of the inner lining of the uterus.
A Basal Body Temperature Graph
What Happens in the Uterus During the Menstrual Cycle

• Follicular phase - high levels of estrogen stimulate the endometrium.

• Luteal phase - progesterone secreted by the corpus luteum stimulates the glands of the endometrium to start secreting nourishing substances.
What Happens in the Uterus During the Menstrual Cycle

• Corpus luteum continues to produce estrogen and progesterone for about 10 to 12 days.

• If pregnancy has not occurred, hormone output declines.

• Menstrual fluid is combination of blood from the endometrium, degenerated cells, and mucus from the cervix and vagina.

• The ovaries call the shots in regulating the cycle.
Length and Timing of the Menstrual Cycle

• Normal menstrual cycle = 20 to 36 - 40 days; average is about 28 days. In an average cycle:
  – Menstruation begins on day 1 and continues until about day 4 or 5.
  – Follicular phase - about days 5-13.
  – Ovulation occurs on day 14.
  – Luteal phase - day 15 to the end of the cycle, day 28.
Ovulation

- *Mittelschmerz* (*middle pain*)—some women report that they can feel themselves ovulate in the form of cramping in lower abdomen.

- *Anovulatory cycle*—menstruation may take place without ovulation.
Other Cyclic Changes

- Two other physiological processes fluctuate with the menstrual cycle:
  - The cervical mucus cycle
  - The basal body temperature cycle
Hormone Levels Over Menstrual Cycle

Group 1: Nonpill women
- Estrogen
- Progesterone

Group 2: Combination pill

Group 3: Sequential pill
Menstrual Problems

- **Dysmenorrhea** - painful menstruation
  - Possible cause - **prostaglandins**
- **Endometriosis** - the endometrium grows in a place other than the uterus.
- **Amenorrhea** - absence of menstruation
  - Primary amenorrhea - when girl has not menstruated by about age 18
  - Secondary amenorrhea - absence of menstruation if she has had at least one period
Fluctuations in Mood

- Premenstrual syndrome (PMS) - a combination of severe physical and psychological symptoms, such as depression and irritability, occurring just before menstruation.
  - American Psychiatric Association has formalized PMS with the diagnosis premenstrual dysphoric disorder (PMDD).
Fluctuations in Performance

• Research on intellectual or athletic performance generally shows no fluctuations over the cycle.
• Research on academic performance, problem solving, memory, or creative thinking shows no fluctuations over the cycle.
Fluctuations in Sex Drive

• Studies have indicated contradictory results.
  – Some found a peak frequency of intercourse around ovulation.
  – Others found peaks just before and just after menstruation.
  – One indicated that sexual activity initiated by the woman peaked during the three days before and three days after ovulation.
What Causes Mood Fluctuations Across the Menstrual Cycle?

• Biological explanation - changes in hormone levels during the cycle.
• Cultural explanation - there are widespread cultural expectations and taboos surrounding menstruation.
Cycles in Men

• Hormone levels do fluctuate - over the day, possibly the month, and other the year.

• One study found no differences between men and women in day-to-day mood changes.