Hormones and Sex
Hormones and Sexual Development

Humans are dimorphic – that is, most come in two standard models: male and female.

Sexual differentiation in mammals begins at fertilization with the production of two different kinds of zygotes: one with an XY (male) pair of sex chromosomes and one with an XX (female) pair.

Sex chromosomes contain the genetic programs that direct sexual development. Hormones have both organizational (body development) and activational effects (triggering reproduction-related behaviors in mature adults).
Steroid Hormones

The hormones that influence sexual development and behavior are steroid hormones.

There are three kinds of sex hormones: androgens (testosterone), estrogens (estradiol) and progestogens. In general, androgens are considered “male” sex hormones, whereas estrogens and progestogens are “female” hormones; however, all types are present in each sex at different levels.

Steroid hormones are synthesized from cholesterol, and exert their effects by:
A. binding to metabotropic receptors;
B. entering the cell and binding/activating receptors in the cytosol;
C. entering the nucleus and activating receptors that bind to chromosomes, where they activate/inactivate genes.
The endocrine system consists of a variety of organs (shown below) whose primary function is to release hormones directly into the circulatory system.

The primary organs that release sex hormones are the gonads: the male testes; and the female ovaries. [In adults, testes also produce the sperm and the ovaries make the eggs that join to form the zygote.] The adrenal glands also release small amounts of sex hormones.

The testes release more (not only) androgens; the ovaries more estrogens.

All endocrine organs are directly regulated by signals from the nervous system (hypothalamus and pituitary).
Neurons in the periventricular nucleus (PN) of the hypothalamus via the anterior pituitary regulate the release of sex hormones from the gonads.

Cells scattered throughout the PN secrete gonadotropin releasing hormones (GnRH) into the portal system. [Releasing = hypothalamus; tropic = hormones whose primary function is to influence the release of hormones from other glands]

The gonadotropins released from the anterior pituitary are called follicle-stimulating hormone (FSH) and luteinizing hormone (LH).
Control of Sex Hormone Release 2

Sex hormone release is regulated by two different kinds of signals:
• from the central nervous system;
• from circulating hormones

The hypothalamus receives input from the reticular formation and limbic system. Experience can alter hormone release.

The hypothalamus receives non-neural inputs from the vascular system (sex hormones pass the blood-brain barrier). Two detectors:
• arcuate nucleus, negative feedback = stabilize levels, male
• anteroventral PN, positive feedback = surge, female

Detectors use the hormone kisspeptin (KISS) to activate the GnRH neurons.
In early stages of development, each fetus, regardless of its genetic sex, has the same pair of gonadal structures, called primordial gonads. Each gonad has an outer covering (cortex) and inner core (medulla).

- cortex: potential to be an ovary
- medulla: potential to be a testis

In the seventh week after conception, the Sry gene on the Y chromosome triggers the synthesis of Sry protein, and this protein causes the medulla to grow into a testis. If no Sry protein is present, the cortex develops into an ovary.
Both sexes begin with two sets of reproductive ducts.

- **Wolffian system**: male; seminal vesicles, vas deferens
- **Müllerian system**: female; uterus, vagina, fallopian tubes

Differentiation of the ducts begins in the third prenatal month.

- Testes produce testosterone and Müllerian-inhibiting substance. As a result, the Wolffian system develops, the testes descend, and the Müllerian system degenerates.
- If there are no testes, then there are no testicular hormones. Now, the Müllerian system develops and the Wolffian system degenerates.
External reproductive structures (genitalia) develop from *one* bipotential precursor.

The bipotential precursor consists of four parts: the glans; the urethral folds; the lateral bodies; and the labioscrotal swellings.

Differentiation occurs in the second month of fetal development.

- Testosterone produces male structures.
- Without testosterone, female structures develop.
Puberty: Secondary Sex Characteristics

During childhood, levels of circulating sex hormones are low, reproductive organs are immature, and males and females differ little in general appearance.

Puberty – the transitional period between childhood and adulthood – is associated with an increase in the release of hormones (growth and sex tropic) by the anterior pituitary.

During puberty, fertility is achieved, and secondary sex characteristics develop. More androgens: the male pattern; more estrogens: the female pattern.
Genotype and Phenotype Variations

Genotype

• XX and XY
• XXX, XYY, XO, and XXY, the latter two usually cause infertility.

Phenotype:

• XX and XY produce female and male sex characteristics
• XX females with adrenogenital syndrome (AS; over-release of androgens by the adrenals)
• XY males with androgen insensitivity syndrome (CAIS) or no androgen receptors (AR)
• Anabolic steroids
Effects on Brain Structure/Function

The brains of men and women are similar in overall structure/function. However, there are regional anatomical and physiological differences, likely caused by both genetic and hormonal influences.

Anatomical differences include the volumes of individual nuclei and tracts, numbers and types of cells and types of synapses. In particular, differences are found in the hypothalamus and amygdala.

The major physiological difference involves the regulation of gonadal hormone levels. The hypothalamus in women produces a 28-day cyclical pattern (the menstrual cycle); in men, the levels are constant. Exposure to perinatal androgens leads to the male pattern.
Hormonal Mechanisms of Sexual Behavior

Male Behavior
• Loss of testes leads to reduced sexual interest and behavior
• Level of male sexuality is NOT correlated with testosterone levels in healthy men (there is more than enough)

Female Behavior
• In most mammals, surges of sex hormones (particularly estrogen and progesterone) initiate estrus, a period of fertility and receptivity.
• In women, sexual motivation and behavior are not tied strictly to the menstrual cycle but do peak about ovulation.
• Sex drive may be under androgenic control (low but enough).
Brain Mechanisms of Sexual Behavior

Human sexual behavior is complex and varied. Sexual practices vary from culture to culture, and person to person within a culture. Moreover, behavioral preferences of individuals are often changed by experience.

Four areas are known to be involved: cortex (“love”); ventral striatum (“libido”); hypothalamus (“labor”); and amygdala (“likes”).

Oxytocin is produced by the paraventricular nucleus of the hypothalamus and released centrally and peripherally (by the posterior pituitary). It plays a role in all aspects of sexual behavior (“pair-bonding”, “cuddle”, “love” hormone).
Gender: the concept of self as male or female, or a blend of both or neither. Identities may coincide with or differ from a person’s anatomical sex.

Orientation: an enduring pattern of romantic or sexual attraction to persons of the opposite sex/gender (heterosexuality), the same sex/gender (homosexuality), or to both sexes/multiple genders (bisexuality). Asexuality, lack of sexual attraction

Influencing factors
• genetics (identical:fraternal twins): transgender 10:1; homosexual 3:1
• hormones: in males (females), low (high) levels of organizational testosterone increases the likelihood of homosexuality (4:1)
• social (observation and imitation): e.g., family, friends, mass media