Lecture 15 (Feb 26th):
Hormones and Sexual Behavior

Lecture Outline

1) Organs / Glands / Hormonal Communication
2) Sex Hormones: “Male” vs. “Female”
3) “Genetic Gender” (XX, XY)
4) “Gender Phenotype”: Organizing Effects of Sex Hormones in Utero and Anomalies
5) Sexual Orientation in Humans
6) Other Things to learn about on your own (we won’t have time today):
   * Puberty
   * Mating Behaviors
   * Parenting Behaviors (you won’t be tested on this though)
Exocrine Glands: Secrete stuff locally: sweat, saliva, breast milk (through ducts)
Endocrine Glands: Secrete HORMONES into the blood
  Hormones carried in blood to organs of the body
  where they influence cell activity (e.g., metabolic rate)
  Hormones have *global*, and often long-lasting, effects

In contrast to: **Neurotransmitters** that have *local, short-lived, effects*
But, some Hormones are also Neurotransmitters: Adrenaline (Epinephrine) and Noradrenaline (Norepinephrine)
…… later in course
## Endocrine (Hormone-Releasing) Glands

<table>
<thead>
<tr>
<th>Table 3.2 Partial List of Hormone-Releasing Glands</th>
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<tbody>
<tr>
<td><strong>Organ</strong></td>
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<td>Hypothalamus</td>
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<td>Anterior pituitary</td>
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<td>Adrenal medulla</td>
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<td>Kidney</td>
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<td>Thymus</td>
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<td>Fat cells</td>
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![Diagram of Endocrine System](image-url)
Control of Hormone Release: Hypothalamus & Pituitary (Master Endocrine) Gland

Hypothalamus releases hormones into the pituitary gland, and then...

Pituitary hormones are released into the bloodstream and travel to other endocrine glands, and then...

The other endocrine glands release hormones into the bloodstream, and affect cell functioning throughout the body.

Estrogen
Two Major Types of Hormones

**Steroid Hormones** (this lecture and later in course)
- diffuse across cell membrane
- attach to receptors in the cytoplasm
- receptor-hormone complex enters nucleus
- triggers gene expression
  -> very long-lasting effects (days)

**Non-Steroid Hormones**
(e.g., Adrenaline and Noradrenaline – later in course)
- attach to receptor on cell membrane
- activate 2\textsuperscript{nd} messenger system inside cell
- alters metabolism of cell
  -> effects last for minutes or hours
Two Main Types of Steroid Hormones

1) Cortisol

2) Sex Hormones

Two Main Types of Sex Hormones

1) Androgens
e.g., Testosterone (TTT) (higher levels in males)

2) Estrogens
e.g., Estradiol (higher levels in females)

Enzyme = “Aromatase”

Cortisol --> TTT --> Estradiol

How much product depends on how much substrate and how much enzyme is present, which varies from organ to organ (and gender).

Also, I think this is a ONE-way street!

…. Aromatase is much higher concentration in females (ovaries and brain) than males (testes and brain)
Sex Hormones: First, Gonads vs. Genitalia

Gonads: *endocrine glands that are part of the reproductive organs*
   1) secrete *Sex Hormones*
   2) produce/release gametes

Male Gonads: Testes (in humans, called “testicles”)
   1) secrete hormone **TTT** (and a little Estradiol)
   2) produce sperm (male gamete)

Female Gonads: Ovaries
   1) secretes hormone **Estradiol** (and a little **TTT**)
   2) produce ovum (egg) (female gamete) (All eggs present at birth)

Also, the ADRENAL CORTEX GLAND secretes Sex Hormones to some degree.
   Cortisol (produced in the Adrenal Cortex) \(\rightarrow\) **TTT**, and **TTT** \(\rightarrow\) **Estradiol**
   relevant to Gender Phenotype Anomalies (later today)

Genitalia: *non-endocrine parts of the reproductive organs*
   (have external and internal structures)
Gender

- Genetic Gender
- Gender Phenotype
- Gender Identity (and Expression)

Vs. Sexual Orientation
Genetic Gender (XX vs. XY), i.e., “Genotype”

Genetic Gender dictates GONADS
    .... not GENITALIA (you’ll see why soon)

The Y chromosome contains the gene to form the TESTES (male gonads)

At 7 weeks prenatal (in humans),
    If have Y chromosome -> TESTES formed
    If no Y chromosome -> “default”: OVARIES (female gonads)
    Or is the X chromosome actively forming the ovaries?
     This is controversial

So…. gonads are based on GENETICS (XX vs. XY)!!
This is FIXED!!
Gender Phenotype

Organizing Effects of **Sex Hormones** *in utero*…

…. determine the outcome of:

1) Genitalia

2) Sexually Dimorphic Nuclei (SDN) in the *Hypothalamus* of the **BRAIN**

   e.g., interstitial nucleus of anterior hypothalamus-3 (INAH-3)

   2 to 3 times larger in males than females (in humans and other animals)

   Relevant to topic of homosexuality… later today

*Early* in fetal development, (1) and (2)

   are the same for males and females,

   i.e., appear “female-like”
**Gender Phenotype**

1) **Genitalia**

   *TTT in utero* “Masculinizes” the Genitalia

   In utero: Male Gonads (Testes) secrete TTT -> Male Genitalia develop
   In utero: Female Gonads (Ovaries) secrete Estradiol

   *Without TTT*, Female Genitalia develop (this is the default!)

   *This is not controversial*

2) **Sexually Dimorphic Nuclei (SDN) in the Hypothalamus of BRAIN**

   *TTT in utero* “Masculinizes” the SDN

   In utero: TTT enters Neurons -> Large (Male) SDN
   In utero: Without TTT -> Small (Female) SDN (the default!)

   Note: Book tells a different (and very interesting) story for RATS.
   So, ignore that, because that story is not true for humans.
When Sex Hormones go Awry in Utero -> Gender Phenotype “Anomalies” (i.e., Phenotype != Genotype)

1) Female Masculinization (“Intersexes” or “PseudoHermaphrodites”)
   GENETIC FEMALE, XX
   But exposure of the fetus to TTT in utero:
   A) The Adrenal Cortex gland (mother or fetus):
      excess of steroids -> excess of TTT
   B) anti-miscarriage drug -> mimics TTT
   
   Genitalia are intermediate (but have female gonads)
   These people are infertile and usually made into phenotypic females

2) Testicular Feminization (Androgen insensitivity syndrome, AIS, gene mutation)
   GENETIC MALE (XY)
   But insensitive to TTT in utero (and always), because lacking (or
dysfunctional) TTT receptors, so TTT cannot activate genes inside cells.
   Genitalia (and general appearance) are female
   (but have male gonads, testes, that are small and do not descend)
Sexual Orientation in Humans

Does homosexuality arise from abnormal levels of Sex Hormones? (in utero? In adulthood?)

First, animal studies:

1) FEMALE rats injected with TTT during the “sensitive period” of fetal development (few days before birth) mount other females as adults

2) MALE Rats, pigs, zebra finches, in whom TTT receptors are blocked during sensitive period of fetal development, show a sexual interest in other males as adults

Note that the genitalia of (1) and (2) are anatomically irregular!

Human studies of Homosexual Men and Women:

Same Genitalia as Heterosexuals!

Same levels of Sex Hormones as Heterosexuals!

So, human Homosexuality cannot simply be due to Sex Hormone Levels!

Lisa Diamond: “Born this Way”:
https://www.youtube.com/watch?v=RjX-KBPmgg4
Does homosexuality arise from Nature (Genes) or Nurture?

**HEREDITY (TWIN) STUDIES IN MEN:**

**MEN:** Frequency of homosexuality ~ 10%

**Brothers of a homosexual MAN:**
- Monozygotic twin (52% homosexual)
- vs. Dizygotic twin (22% homosexual)
- vs. Adopted brother (11% homosexual)

Is homosexuality all genetic? Same results in WOMEN
Brains of Homosexual vs. Heterosexual Males

Sexually Dimorphic Nuclei (SDN) in the Hypothalamus

*Interstitial Nucleus of Anterior Hypothalamus-3 (INAH-3)*

Heterosexual MALE > Heterosexual FEMALE (by ~2x).

**Levay study (1993):** measured the size of nucleus in:
- 16 hetero MALE: size = 0.12 mm\(^3\)  
- 16 hetero FEMALE: size = 0.056 mm\(^3\)  
- 19 homosexual MALE: size = 0.051 mm\(^3\)  
- HIV-
- HIV+

**Newer data (Byne et al. 2001)**

Controversies:
- Cause vs. Effect?
- HIV effects?
Puberty

Onset of sexual maturity (12-14 years of age)

*TTT* & *Estradiol* start being produced AGAIN by the Testes and Ovaries, respectively (under control of the HYPOTHALAMUS, *Luteinizing Hormone Releasing Hormone*)

What is the SIGNAL? AGE? WEIGHT?

**Ovaries** (*Estradiol*) -> Menstrual cycle

1x/month, release an egg

**Testes** (*TTT*) -> continual sperm production

Secondary Gender Characteristics:

*Estradiol*: broader hips, breast development
*TTT*: beard, broader shoulders, myofibrillar proteins (muscles)
*TTT*: in BOTH Males and Females -> pubic and underarm hair
Effects of Sex Hormones on Sexual/Mating Behaviors: Females

Female Mammals:

Menstrual Cycle (reproductive cycle):
Involves the hypothalamus, pituitary and gonads.
In the middle of cycle: \[ \text{Estradiol} \text{ increases} \]
    Produces the release of an egg (from ovaries).
In Humans: “ovulation”, In Non-humans: “estrus”
Some female mammals (e.g., dogs) only accept and make advances when in estrus.

Primates: Human and Non-Human

Sexual behavior is less governed by sex hormones.
Still, human females initiate sexual activity more often at ovulation (see Figure in book)….

…. maybe because estradiol (which peaks right before ovulation) increases area of skin that excites the pudendal nerve.
(pudendal nerve-> pleasure signal to brain)
Effects of Sex Hormones on Sexual/Mating Behaviors: Males

**Males:** Some male animals only mate when TTT high (e.g., birds)

**Human Males**

**Testosterone** is key
- After castration, lose sexual drive
- Low Testosterone can result in *impotence*
- Sexual “prime” and TTT levels are maximal: 15 - 25 years

Does TTT cycle in males?
- **Annually?** Yes, for some males, e.g., birds.
- **Daily?** Yes, all male mammals, including humans, cycle TTT as part of the circadian rhythm (peak TTT is in the early morning around the time they wake up).
TTT and Estradiol vs. Age
(you won’t be tested on this slide, but in case you are interested)