Lecture 15 (Nov 16th):
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 Know about on your own (we won’t have time today):
   * Puberty
   * Mating Behaviors

Parenting Behaviors -> You can SKIP for now since you are young 😊
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 3.2 Partial List of Hormone-Releasing Glands

<table>
<thead>
<tr>
<th>Organ</th>
<th>Hormone</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothalamus</td>
<td>Various releasing hormones</td>
<td>Promote or inhibit release of various hormones by pituitary</td>
</tr>
<tr>
<td>Anterior pituitary</td>
<td>Thyroid-stimulating hormone (TSH)</td>
<td>Stimulates thyroid gland</td>
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<tr>
<td></td>
<td>Luteinizing hormone (LH)</td>
<td>Increases production of progesterone (female), testosterone (male); stimulates ovulation</td>
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<tr>
<td></td>
<td>Follicle-stimulating hormone (FSH)</td>
<td>Increases production of estrogen and maturation of ovum (female) and sperm production (male)</td>
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<tr>
<td></td>
<td>ACTH</td>
<td>Increases secretion of steroid hormones by adrenal gland</td>
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<td></td>
<td>Prolactin</td>
<td>Increases milk production</td>
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<tr>
<td></td>
<td>Growth hormone (GH), also known as somatotropin</td>
<td>Increases body growth, including the growth spurt during puberty</td>
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<tr>
<td>Posterior pituitary</td>
<td>Oxytocin</td>
<td>Controls uterine contractions, milk release, certain aspects of parental behavior, and sexual pleasure</td>
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<tr>
<td></td>
<td>Vasopressin (also known as antidiuretic hormone)</td>
<td>Constricts blood vessels and raises blood pressure, decreases urine volume</td>
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<tr>
<td>Pineal</td>
<td>Melatonin</td>
<td>Increases sleepiness, influences sleep–wake cycle, also has role in onset of puberty</td>
</tr>
<tr>
<td>Thyroid</td>
<td>Thyroxine</td>
<td>Increase metabolic rate, growth, and maturation</td>
</tr>
<tr>
<td></td>
<td>Triiodothyronine</td>
<td></td>
</tr>
<tr>
<td>Parathyroid</td>
<td>Parathyroid hormone</td>
<td>Increases blood calcium and decreases potassium</td>
</tr>
<tr>
<td>Adrenal cortex</td>
<td>Aldosterone</td>
<td>Reduces secretion of salts by the kidneys</td>
</tr>
<tr>
<td></td>
<td>Cortisol, corticosterone</td>
<td>Stimulates liver to elevate blood sugar, increase metabolism of proteins and fats</td>
</tr>
<tr>
<td>Adrenal medulla</td>
<td>Epinephrine, norepinephrine</td>
<td>Similar to effects of sympathetic nervous system</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Insulin</td>
<td>Increases entry of glucose to cells and increases storage as fats</td>
</tr>
<tr>
<td></td>
<td>Glucagon</td>
<td>Increases conversion of stored fats to blood glucose</td>
</tr>
<tr>
<td>Ovary</td>
<td>Estrogens</td>
<td>Promote female sexual characteristics</td>
</tr>
<tr>
<td></td>
<td>Progesterone</td>
<td>Maintains pregnancy</td>
</tr>
<tr>
<td>Testis</td>
<td>Androgens</td>
<td>Promote sperm production, growth of pubic hair, and male sexual characteristics</td>
</tr>
<tr>
<td>Liver</td>
<td>Somatomedins</td>
<td>Stimulate growth</td>
</tr>
<tr>
<td>Kidney</td>
<td>Renin</td>
<td>Converts a blood protein into angiotensin, which regulates blood pressure and contributes to hypervolemic thirst</td>
</tr>
<tr>
<td>Thymus</td>
<td>Thymosin (and others)</td>
<td>Support immune responses</td>
</tr>
<tr>
<td>Fat cells</td>
<td>Leptin</td>
<td>Decreases appetite, increases activity, necessary for onset of puberty</td>
</tr>
</tbody>
</table>
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.
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
  - \( \rightarrow \text{very long-lasting effects (days)} \)

**Protein/Peptide and AA Derivative Hormones**
*(Adrenaline and Noradrenaline – later in course)*
- attach to receptor on cell membrane
- activate 2\(^{nd}\) messenger system inside cell
- alters metabolism of cell
  - \( \rightarrow \text{effects last for minutes or hours} \)
Two Main Types of **Steroid Hormones**

1) **Cortisol** (later in course)

2) **Sex Hormones** (this lecture)

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)

**Cortisol** -> **TTT** -> **Estradiol**

How much of a *reaction* depends on how much substrate and how much enzyme is present, which varies from organ to organ.

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

**Aromatizing ENZYME (“Aromatase”): TTT -> Estradiol**
... much higher concentration in ovaries than testes

Also, the ADRENAL CORTEX GLAND secretes Sex Hormones to some degree.
Cortisol (produced in the Adrenal Cortex) -> TTT, and TTT -> 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)
Gender Identity (and Gender Expression)

…… is not binary (Male vs. Female)

…… and may or may not match either
   Genetic Gender or Gender Phenotype

56 Gender categories on FaceBook

http://www.slate.com/blogs/lexicon_valley/2014/02/21/gender_facebook_now_has_56_categories_to_choose_from_including_cisgender.html
San Diego Airport

“Transparent”

“Call me Caitlyn”
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!
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
Specifically, *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 mm³  HIV-
- 6 hetero FEMALE: size = 0.056 mm³  HIV-
- 19 homosexual MALE: size = 0.051 mm³  HIV+

Controversies:
- Cause vs. Effect?
- HIV effects?
Same-Sex Sexual Attraction Does Not Spread in Adolescent Social Networks

Tiffany A. Brakefield · Sara C. Mednick · Helen W. Wilson · Jan-Emmanuel De Neve · Nicholas A. Christakis · James H. Fowler
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: \( \rightarrow \text{Estradiol} \) 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-\( \rightarrow \) 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).