Course Content

• Section 1:
  • The biology of the body typically labeled female
    • Embryological Sex Differentiation
    • Anatomy and Physiology (mostly reproductive)
    • Reproductive Endocrinology – hormones and how they work together

• Assumes no biology background
Course Content

• Section 2:
  • Experiences of female-identified and female-bodied individuals across the lifespan
    • From puberty to menopause
    • Biological changes and their interactions with behavior
Limitations of the Course

• This course generally deals with anatomical structures and hormones that are commonly biologically-assigned as female and with the experiences of individuals with such structures who identify as women/female.

• We recognize that not all individuals who identify as women/female actually have all, or, possibly, any, of the structures and/or hormones we will address.
Understandings

• **Gender is not binary.** Not all people neatly fall into the culturally-mandated female and male identity categories. Some people are gender fluid and identify with different gender categories at different times or in different situations. Others have identities which are totally unrelated to the traditional male/female binary.

• **Sex is not binary.** Not all people fall into completely female or completely male biological categories that we casually assume are universal. Many people have anatomical structures and hormones that fall somewhere between the poles of the male-female continuum. While variation in biological differentiation may affect the ability to reproduce, it does not reflect poor health or mandate any gender or sex identity.
Limitations of the Course

- We will attempt to address the complications that arise from the use of the term women/females and the culturally-based, gender- and sex-binary categorization that demands that all individuals fit into one (and only one) of two arbitrary boxes whenever we can.

- But limitations of time and often of data, make it impossible to address all the possible variation that is seen in the entire population of individuals who identify as (or who others identify as) women.
Embryological Sex Differentiation
Sex is not determined by any single biological factor.

Biological sex differentiation occurs in stages as different parts of the embryo develop.

Each stage is independent of the other stages.
Bipotentiality of Sex Differentiation

- Undifferentiated structures necessary to develop in either the biologically female or the biologically male direction are typically available at all stages of development.

- The biological environment at the moment that a stage of differentiation is taking place determines the path taken at that stage.

- The same path does not have to be taken at each stage.
Stage 1 - Chromosomal Sex

- Typically humans have 46 chromosome (23 pairs)
- 44 chromosomes are autosomes (not directly related to sex)
- 2 chromosomes are sex chromosomes
  - typical human male sex chromosome complement = XY
  - typical human female sex chromosome complement = XX
Stage 1 – Chromosomal Sex

- Bipotentiality:
  - A functional ovum (egg) typically has one X chromosome.
  - Sperm typically have either an X or a Y sex chromosome.
  - Chromosomal sex is determined by which sperm fertilizes the egg.
  - Y bearing sperm move faster.
  - X bearing sperm live longer.
X and Y Chromosomes
Stage 1 - Chromosomal Sex

- Many sex-chromosome complements other than XX or XY naturally occur.
- 1 in 400 individuals identified as male at birth have a sex-chromosome make-up other than XY.
- 1 of 700 individuals identified as female at birth have a sex-chromosome complement other than XX.
Stage 1 - Chromosomal Sex

- Some individuals have only one sex chromosome, but that sex chromosome must be an X (XO sex chromosome complement).
  - The YO combination cannot survive.
- The X chromosome has more than 1000 genes while the Y has only about 70 genes.
X and Y Chromosomes
Turner Syndrome

- Individual with only 1 sex chromosome (XO).
- Occurs in 1 of every 3500 female births
- Due to fertilization of the ovum by a sperm that has no sex chromosome
- Typically identified as female at birth and typically raised as a girl
Turner Syndrome

- Does not develop functional ovaries - infertile.
- At puberty, she does not spontaneously develop female secondary sex characteristics. (Missing major source of estrogen.)
- Typically receives estrogen treatment to stimulate female-typical development.
Some individuals have more than 2 sex chromosomes.

The added sex chromosomes can be carried by the ovum or the sperm.

The greater the number of sex chromosomes:
- The less likely is the combination is to occur.
- The more likely that the individual also will have atypical number or types of autosomes (non-sex chromosomes).
Stage 2 - Gonadal Sex

- Gonads are glands that produce the reproductive or germ cells, i.e., they produce the ova or the sperm.
- Typical male - 2 testes
- Typical female - 2 ovaries
- Gonads begin to sex differentiate about 6 weeks after conception
Stage 2 - Gonadal Sex

- Raw material - the undifferentiated gonads
- Undifferentiated gonads have 2 parts - the cortex (outer rind) and the medulla (inner core)
- All developing individuals have undifferentiated gonads that contain both a cortex and a medulla so they are bipotential (can develop either ovaries or testes)
Undifferentiated Gonad

Cortex

Medulla
Embryo at 3 Weeks

- Head End
- Undifferentiated Gonad
- Tail End
- Yolk Sac
- Primordial Germ Cells
Primordial Germ Cells

- Form in the yolk sac.
- **Must** migrate to the undifferentiated gonads before sex differentiation of the ovaries can start. Testes can develop without the migration.
- The PGCs are the earliest form of all the ova a female will ever possess.
Development of Male Gonads - Testes

Requires:

1. the presence of a functional Y chromosome
   - A functional Y chromosome has a complete and functional SRY gene.
   - A functional SRY gene stimulates an autosome (a non-sex chromosome) to produce H-Y antigen.

2. H-Y antigen
   - H-Y antigen stimulates the medulla of the undifferentiated gonads to develop into testes. (The cortex fades away.)
Differentiated Male Gonad
Testis

Cortex
(residual/shrinking)

Medulla
(has developed into a testis)
Development of Female Gonads - Ovaries

- Requires:
  1. the migration of the PGCs to the undifferentiated gonads

- When PGCs arrive at cortex of undifferentiated gonad, each is surrounded by a ball of cortical cells forming an ovarian follicle.
PGC – Ovarian Follicle

Primordial Germ Cell (PGC)

Cortical cells surrounding PGC to form Ovarian Follicle
Development of Female Gonads - Ovaries

- Requires:
  - 2. the absence of a functional Y chromosome (no SRY-gene or no H-Y antigen).
  - 3. the presence of at least 2 functional X chromosomes (don’t specifically know how to define these)
Development of Female Gonads - Ovaries

- Under these conditions, the cortex of the undifferentiated gonads develops into ovaries and the medulla fades away.
Differentiated Female Gonad

Ovary

Medulla
(residual/shrinking)

Cortex
(has developed into an ovary)
Development of Gonads

- The presence of any functional Y chromosome and H-Y antigen results in development of testes regardless of how many Xs are present.

- With only 1 X chromosome (and no functional Y), the gonads remain in the undifferentiated state - gonadal streaks. (Turner Syndrome)

- If sex chromosomes are XY, but the SRY gene is absent or nonfunctional, the gonads remain undifferentiated – gonad streaks. (Swyer Syndrome)
Swyer Syndrome

- Chromosomes – 46, XY
- Y chromosome lacks functional or complete SRY gene
- Gonads – not sex differentiated – gonadal streaks
- Typically identified as female at birth and raised as a girl.
Swyer Syndrome

- Lack of gonads means no germ cells produced - infertile.
- No source of typical ovarian hormones so she does not spontaneously develop female secondary sex characteristics at puberty.
- Typically receives hormone treatment to stimulate female-typical development.
Stage 3 - Internal Genitalia

- Internal reproductive plumbing
- Male: seminal vesicles, epididymus, ejaculatory ducts and tubes
- Female: uterus, oviducts (Fallopian tubes) and vagina
Stage 3 - Internal Genitalia

- **Raw materials** = Wolffian ducts and Müllerian ducts
  - Both types of ducts are found in all developing individuals regardless of paths taken in Stages 1 and 2
Undifferentiated Internal Genitalia

- **Gonad** (not part of internal genitalia)
- **Müllerian Duct**
- **Wolffian Duct**
- **Bladder** (not part of internal genitalia)
Development of Male Internal Genitalia

- Requires the production of and ability to respond to:
  - 1. Androgens
  - 2. Müllerian Inhibiting Factor
  - 3. Inductor Substance
Development of Male Internal Genitalia

- All 3 substances are typically produced by the newly-formed testes.
- Stimulate the development of the Wolffian ducts into male internal genitalia and the regression of the Müllerian ducts.
Differentiated Male Internal Genitalia

Epididymis
Vas Deferens
Seminal Vesicle

Testis
(gonad - not internal genitalia)

Male internal genitalia developing from the Wolffian duct.

Müllerian duct receding
Development of Female Internal Genitalia

- Requires the **ABSENCE** of (or inability to respond to):
  - 1. Androgens
  - 2. Müllerian Inhibiting Factor
  - 3. Inductor Substance

- In the absence of these 3 substances, the Müllerian ducts develop into female internal genitalia and the Wolffian ducts regress.
Differentiated Female Internal Genitalia

Ovary
(gonad - not internal genitalia)

Wolffian duct receding

Uterus

Oviduct
Female internal genitalia forming from Müllerian duct.

Vagina
Turner Syndrome and Swyer Syndrome

- In both cases, there are no testes to produce androgen, Müllerian inhibiting factor and inductor substance.
- Result – typical female internal genitalia.
Stage 4 - External genitalia

- Undifferentiated raw materials
  - genital tubercle
  - labio-scrotal swelling
  - uro-genital fold

- Found in all developing individuals regardless of sex chromosomes, gonads, or internal genitalia.
Undifferentiated External Genitalia

- Genital Tubercle
- Urogenital Fold
- Labio-Scrotal Swelling
- Anus
Male External Genitalia

To develop in the male-typical direction, the fetus must:

1. Have a source of androgens (typically the testes)
2. Have receptors that recognize the presence of androgen
Male External Genitalia

- If androgens and functional receptors for androgen are present:
  - genital tubercle $\rightarrow$ penis
  - labio-scrotal swelling $\rightarrow$ scrotal sac or scrotum
  - uro-genital fold $\rightarrow$ urethra
Differentiated Male External Genitalia

- Urethra (from Urogenital Fold)
- Penis (from Genital Tubercle)
- Scrotal Sac (from Labio-Scrotal Swelling)
- Anus (not part of external genitalia)
If androgens are not produced or the fetus cannot react to androgens, the undifferentiated structures develop into female-typical external genitalia.

- genital tubercle $\rightarrow$ clitoris
- labio-scrotal swelling $\rightarrow$ labia majora
- uro-genital fold $\rightarrow$ labia minora
Differentiated Female External Genitalia

- Clitoris (from genital tubercle)
- Labia Minora (from uro-genital fold)
- Labia Majora (from labio-scrotal swelling)
- Vaginal Opening
- Anus (not part of the external genitalia)
Turner and Swyer Syndrome

- No testes
- No source of androgen
- Typical female external genitalia
Androgen Insensitivity Syndrome (AIS)

- Lacks receptors that respond to androgens
  - Can be partial or complete. List below addresses complete AIS
- XY sex chromosome complement
- Normal testes
- Internal genitalia ambiguous
- External genitalia female
- Typically raised as female and have female gender identity
Congenital Adrenal Hyperplasia (CAH)

- Produce excess androgen due to a malfunction of the adrenal gland
- Effects vary with when the increased androgen starts and how high the levels are
- May result in ambiguous internal genitalia and male-typical external genitalia in an XX individual with ovaries.