The Basics of Reproductive Anatomy & Physiology

1. Basic male & female anatomy
2. Production of reproductive hormones
3. Production of sperm or eggs
4. Common reproductive disorders

Reading Assignments:
1. The Reproductive System
2. Male Andropause, parts 1
3. Male Andropause, part 2
4. Cervical Cancer Vaccine
5. Genital Mutilation
6. Hormone Replacement Therapy (WHI study)
The Basics of Reproductive Anatomy & Physiology

Testes = paired gonads that produce sperm and testosterone
  - Seminiferous tubules = coiled tubes within testes where sperm produced.

3 cell types in seminiferous tubules:
  1. Sertoli cells – respond to FSH by helping in sperm production.
  2. Leydig cells - respond to LH by producing
  3. Spermatogonia = go through meiosis to become sperm.

Epididymis = where sperm stored & mature before ejaculation.

Scrotum = contain testes outside of abdomen ~3°C lower than body temp of 98.6.
  - Helps sperm formation.

Cremaster muscle = muscle that lifts/lowers testes for temperature regulation.

**QUESTION:** Why is lifting & lowering the testes important in male reproductive function?

Correct temp. needed for sperm production.

Inguinal ring = opening in abdominal cavity where testes descend into scrotal sac of male fetus by 7 months gestation.

Cryptorchidism = when one or both testes are retained within the abdomen. Abnormal! Must be removed or risk testicular cancer.
3 Sperm Transport Tubes:
1. **Vas deferens** = transport sperm from epididymis to seminal vesicles.

   **QUESTION:** What is a vasectomy? = surgical cutting of **Vas deferens**

2. **Ejaculatory duct** = found in prostate gland.

3. **Urethra** = passageway for urine or semen, but not at same time!

3 Male Secretory Glands:
1. **Seminal vesicles** = Largest glands contributing to semen.
   - produce:
     - **alkaline mucus** (counteract vaginal acidity)
     - **prostaglandin** (cause uterine contractions)
     - **fructose** (energy source)

2. **Prostate** – produce alkaline mucus.

3. **Bulbourethral gland** - produces lubricant during sexual arousal.
The Prostate Gland

**Benign prostate hyperplasia (BPH)**
- Prostate grows with age.
- Non-cancerous growth of prostate.
- Can block urine or semen transport.

**Prostate cancer**
- Malignant
- Detect with **PSA** = prostate-specific antigen. High levels in blood indicate possible prostate cancer.
The Penis

**Corpus cavernosa** = upper left and right chamber
- have arterial blood supply to fill with blood.
- arteries open up (vasodilate) based on nitric oxide (NO) & cGMP.

**Corpus spongiosum** = lower chamber surrounding urethra

**Foreskin (prepuce)** = loose flap of skin covering the head (glans) penis.

**Circumcision** = surgical removal of the foreskin.

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How an erection works:

1. **Stimulation** Causes nitric oxide (NO) release in arteries of corpus cavernosa.

2. NO causes production of a chemical messenger called cGMP.

3. **cGMP** causes arteries to relax & they open wide (vasodilate) allowing blood into spongy chambers.

4. Fluid pressure of blood causes erection.

5. When stimulation done, or after ejaculation, cGMP is broken down by enzyme (phosphodiesterase). Erection ends.

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*Erection lasting more than 3 hrs = priapism*
Erectile Dysfunction (ED) = inability to achieve or maintain an erection.

Many possible causes:

Treatments:
1. Counseling if psychological
2. Pharmacological (drugs)
   A) testosterone supplements if low T.
   B) ED drugs (ex. Viagra, Cialis, Levitra)
   These drugs work by ___________________________
3. Surgical options:
   A) Semi-rigid malleable rod implanted into penis. Can manually straighten rod for erection.
   B) Inflatable implant = implant fluid reservoir into abdomen, pump into scrotum, and tubes into penis. Squeeze the pump to push fluid into tubes for erection. Hit a release valve to return fluid to reservoir to end erection.

How ED Drugs work (Viagra, Cialis, Levitra):

Question: What is phosphodiesterase?

Phosphodiesterase inhibitor = a chemical that inhibits phosphodiesterase.

So ..., what would giving a phosphodiesterase inhibitor do to cGMP levels in the corpus cavernosa?

\[ \uparrow \text{cGMP} \]

What would that do to arteries in the penis? open wide

What would that do w/respect to an erection? get one

Viagra, Cialis, & Levitra are phosphodiesterase inhibitors.
Steroidogenesis in males & females:

**Steroidogenesis** = production of sex steroids in males & females.

The **BRAIN controls steroidogenesis!**

- **Hypothalamus** = brain structure that controls it.

- Hypothalamus secretes **GnRH** = gonadotropin-releasing hormone.

- GnRH tells anterior pituitary (in brain) to secrete **LH & FSH** (see next slide!)
  - **LH** tells testes to make testosterone & ovaries to make estrogen.
  - **FSH** tells testes to mature sperm & ovaries to mature eggs.

- **Luteinizing hormone**
- **Follicle stimulating hormone**
**Steroidogenesis in males & females:**

**LH (luteinizing hormone)**
> stimulates testes (leydig cells) to make **testosterone**.
> stim. ovaries to make **estrogen & progesterone**

When levels of testosterone, estrogen, or progesterone are high it inhibits pituitary release of LH & FSH as part of negative feedback to control hormone levels.

- Reduced LH will **stop** testosterone or estrogen production.
- Reduced FSH will **stop** sperm or egg formation.

**FSH (follicle-stimulating hormone)** > stim. sperm or egg development
Steroidogenesis in males & females:

High blood levels of testosterone, estrogen, and progesterone inhibit pituitary LH & FSH.

Gametogenesis in males:

Gametogenesis = production of eggs or sperm.

> Spermatogenesis = production of sperm in seminiferous tubules of testes. Is driven by testosterone (controlled by brain).
**Spermatogenesis** = production of sperm in seminiferous tubules of testes.

- **Spermatogonia (2n)** = primitive sperm cells that become primary spermatocytes.
- **Primary spermatocyte (2n)** = cells that undergo meiosis 1
- **Secondary spermatocytes (1n)** = cells that undergo meiosis 2
- **Spermatids (1n)** = immature sperm cells.
- **Spermatozoa (1n)** = mature sperm cells.
Male Fertility – need ~ 20 million sperm / ml of semen. Of these sperm, 40% must have normal movement (good swimmers!) and 60% must have normal shape (morphology)

**CAUSES OF MALE INFERTILITY:**

- Poor sperm count, or abnormal movement or morphology.
- Testes too warm (try boxers not briefs!).
- Testicular injury or cancer.
- Health issues (heart, diabetes, etc...)
- Obesity
- Prostate problems (BPH or cancer)
- Long term use of anabolic steroids
- Deletions from the Y chromosome (deletions from the AZF region)

See reading assign.: “Why the Y?” Pg 61
Review

• Male reproductive anatomy & physiology
• - reproductive structures
• How an erection works
• BPH, prostate cancer, ED, ED drugs
• Spermatogenesis
• Male fertility and infertility

The Basics of Female Reproductive A & P

Ovaries = paired gonads making eggs, estrogen, & progesterone.

Vagina = copulatory & birth canal.

External genitalia:
> Vulva = labia major & minor
> Clitoris = erectile tissue with sensory nerves (similar to head of penis)

Uterus = muscular sac capable of supporting developing fetus.
> Fallopian tubes = paired tubes that can transport fertilized egg from ovaries to uterus.
> Cervix = entryway into uterus from vagina.
> Endometrium = secretory layer of uterus.
> Myometrium = muscular layer of uterus, responds to oxytocin & prostaglandin.
Female reproductive anatomy Fig. 27.7
**External Genitalia**

- **Clitoris** = equivalent of glans penis. Same sensory nerves & erectile tissue
- **Labia minor** = smaller inner labia
- **Labia major** = larger outer labia
- **Vestibule** = tissue surrounding urethral & vaginal openings. Prone to tearing during childbirth!

**Question:**

What is an episiotomy?
**Clitorectomy** (see reading assignment online)

= surgical removal of clitoris (C in photo)

**Infibulation** = removal of labia minor and suturing (stitching) of labia major partially closed (narrow opening left for menstrual flow). A & B in photo. Can often include clitorectomy.

See reading assign.: “Genital Mutilation”
Circumcision (in males)?

https://medlineplus.gov/ency/article/002998.htm

Uterus and Uterine tubes

https://commons.wikimedia.org/wiki/File:Illu_cervix.jpg
Human uterus: normal Vs menstrual

I wanted to share this image with you. In my hand are life sized replicas of a non-menstruating uterus and a menstruating uterus.

Endometriosis = when endometrial tissue of uterus wanders out of uterus to different locations. Still responds to progesterone by proliferating, and then shedding when progesterone declines each menstrual cycle. *Painful!
The Fallopian Tubes

**Ectopic Pregnancy** = pregnancy “out of place” (basically anywhere except within the uterus). Frequency of 2% among females.  

**Danger of an Out-of-place pregnancy** = only uterus & its strong ligaments can support weight of growing fetus. Only endometrium capable of forming a fully functional placenta. All other tissues not compatible for pregnancy.

An ectopic pregnancy is NEVER viable for the embryo AND is life-threatening for the mother.
The Cervix
= entryway to uterus.

> normally ~ 2.5 cm in diameter.
> Can dilate during childbirth over 10 cm!

Let’s look at an analogy, shall we??

Question: What is a PAP smear?
Sampling of cervical cells for abnormal growth.

HPV – human papilloma virus. Present in 50% of sexually active adult population. Can cause polyps and warts at site of contact. Can lead to increased risk for cancer.

Cervical cancer stages

Vaginal warts

Cervical warts

Throat cancer?

Penile warts
HPV Vaccine - 2006

Gardasil marketed by Merck & Cervarix by GlaxoSmithKline
- Both are set of 3 vaccinations.

Only Gardasil is:
- Effective against 4 strains HPV – 2 which cause cancer & 2 which cause warts
- Tested & recommended for 9-26 yr old girls AND boys
  (younger is better - before sexual exposure!)
- Can get up to 21-26 yrs but protection goes down w/sexual exposure.

See reading assign.: Cervical cancer vaccine

Source: www.cdc.gov/hpv/vaccine

Cervical Cancer Vaccine

The Ovaries have follicles that contain a developing egg. Once a month one follicle & egg mature. A secondary oocyte is ovulated. The remaining follicle becomes the corpus luteum & produces progesterone.

“Mittelshmerz” = pain associated with ovulation.
**Polycystic Ovarian Syndrome** = follicles in ovary fill with fluid (cysts). Painful condition that decreases fertility.

Treatment:

hormonal
birth control

**Ovarian cancer**

↑ risk factors include:
> Genetics (close female relative had it)
> mutation in BRCA gene!!!!
> More menstrual cycles in life
  (never on birth control, never pregnant)
> hormonal problems
> Polycystic ovarian syndrome

↓ risk factors include:
> not have genetics
> no mutation in BRCA gene
> fewer menstrual cycles
  (have taken BC, or pregnant)

Question: Why do you think having been on birth control lowers risk of ovarian cancer??
Ovarian and Breast Cancer and the BRCA Gene:

**BRCA Gene** = tumor suppressor gene that normally suppresses tumor growth (a good thing!)

**Mutation in BRCA Gene** – means the gene does not suppress tumors. Mutation in this gene associated with increased risk for ovarian & breast cancer.

**Can get blood test for it.**

<table>
<thead>
<tr>
<th>Mutation in</th>
<th>BRCA 1</th>
<th>BRCA 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast cancer</td>
<td>↑ risk by 65 – 85%</td>
<td>↑ risk by 39%</td>
</tr>
<tr>
<td>Ovarian cancer</td>
<td>↑ risk by 45%</td>
<td>↑ risk by 11%</td>
</tr>
</tbody>
</table>

**CA-125 test** = cancer antigen 125

Increased levels of this in blood associated with ↑ risk of ovarian cancer (separate from BRCA gene)

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Gametogenesis in females:

**Oogenesis** = production of eggs in ovaries. Is driven by estrogen (controlled by brain).
Oogenesis:
- Oogonium (2n)
  - Primary oocyte (2n)
    - Secondary oocyte (1n) = egg that gets ovulated from the “graafian follicle”
      - graafian follicle becomes corpus luteum (CL) “which produces progesterone ~14 days

Progesterone = hormone released from CL that maintains uterus in pregnancy-friendly state. Prevents egg development and ovulation.

Puberty
- After puberty:
  - Secondary oocyte (1n) = egg that gets ovulated from the “graafian follicle”

IF no fertilization:
- Corpus luteum breaks down and stops progesterone secretion @day 28.
- Without progesterone, uterine lining breaks down.
- Menstrual flow – egg and lining shed

Home pregnancy tests detect hCG = human chorionic gonadotropin.

hCG produced by embryo within 1 – 2 weeks of fertilization.

IF fertilization:
- Embryo makes hCG within 1 week (the hormone pregnancy tests detect)
- hCG “rescues” corpus luteum – it keeps making progesterone ~ 1month (until placenta forms and takes over progesterone production).
**Ovarian cycle**

Days:
1- 13 = Follicle phase
- Egg development
Day 14 = ovulation
  LH high
Days 15-28 =
- CL makes progesterone

**Menstrual cycle**

Days:
1- 5 = menstruation
- progesterone low
5 – 14 = Estrogen ↑
15 – 28 =
- endometrium thickens
- progesterone ↑
Menopause = end of woman’s reproductive cycle. Ovaries suddenly stop producing eggs, estrogen, & progesterone (age 50 or so).

Symptoms:
> moodiness
> hot flashes
> vaginal dryness
> osteoporosis (thinning of bones)
> ↑ libido (due to testosterone from adrenal glands)
> ↑ facial hair growth in some women (hirsutism)

Andropause = gradual decline in man’s reproductive function. Testosterone and sperm production slowly decline from age 40 & on.

CAUSES OF FEMALE INFERTILITY:

- Menopause
- Radiation exposure
- WHR above 0.80
- Ovarian cancer
- Polycystic ovarian syndrome
- Birth control
- Endometriosis
- STD's

Review

- Female reproductive anatomy & physiology
  - Reproductive structures
- Ectopic pregnancy, endometriosis, polycystic ovarian syndrome, episiotomy.
- HPV, warts, cervical cancer, HPV vaccine, breast & ovarian cancer, mutations in the BRCA gene, CA125 test.
- Genital mutilation
- Oogeneis
- Menstrual cycle (follicle & uterine cycles)
- Role of hCG in rescuing corpus luteum in pregnancy
- Menopause & Andropause
- Fertility and infertility in women