24 The Reproductive System

Taft College Human Physiology
Introduction

• All of the systems we have studied so far have played a role in maintaining homeostasis of the body. The normal functioning of the reproductive system is not necessary for individual survival. But it is necessary for the survival of the species.
  – At least for the time being, (e.g. human cloning, external wombs).

• Only through the reproductive process can the complex genetic blueprints survive beyond the individual lives of the members of a species.
  – Now we can even change the blueprints without sex using genetic engineering! Changes maybe made in early stage embryos that will affect every cell in the organism.

• The reproductive system strongly influences our psychological behavior and social structures.
  – Our feelings of maleness and femaleness and organization into family units are examples.
  – These behaviors are conducive for perpetuating our species.

• The population explosion of humans is putting pressure on the earth’s dwindling resources and pollution is causing global damage.
  – So, there is concern to provide the means to reproduce at sustainable rates.
For each of us life began with the fusion of 2 remarkable cells:

- **Sperm** for a male = spermatozoa
- **Egg** from a female = ova
- **Spermatozoa and ova** are known collectively as **gametes = sex cells**
- **Union of the ova and sperm** is called **fertilization** = time of conception.
- **The fertilized egg** is known as a **zygote**.
Introduction

- The zygote contains genetic material from each of the parents in a unique combination giving rise to a unique individual with various characteristics (traits), some from the mother, others from the father, some as the result of both together (recessive traits).
Introduction

• The organs that produce the sex cells (gametes) are known collectively as the **gonads**.

• The gonads are the essential organs of reproduction:
  – **Testes** = male = spermatozoa
  – **Ovaries** = female = ova
The Components of the Male Reproductive System

1. **Essential organs = testes**
   - Products:
     - Sex cells = spermatozoa
     - Hormones

2. **Genital Ducts = tubing.**
   Function to conduct or store sperm.

3. **Accessory Glands.** Produce fluids, suspension, activation, nourishment of sperm.

4. **Penis =** copulatory organ for introduction of sperm into vagina of female = insemination.
Formation of Sperm

- Formation of sperm (average of several million/day) occurs from adolescence (13-15 years) to old age. >90 years old. Viable? Defective?
- Sperm are formed within the testes in seminiferous tubules = seed bearing.
- Production of spermatozoa within seminiferous tubule takes about 74 days.
- Not all tubules show same stage of development at same time. (makes sense – or could only produce new crop every 74 days).
- Sexually active male with self or partner would run out temporarily.
- Ejaculation 3-4 times a week is about the limit before ‘running low’ on sperm.
• **Spermatogenesis** = sperm production

• **Gametogenesis** = gamete production.

• Spermatogenesis takes place in a number of steps within **seminiferous tubules.**

• **Meiosis** is type of **cell division** that occurs **only in sex cells.**

Humans = 44 somatic + 2 sex chromosomes = 46
Spermatogenesis

Sperm begin as spermatogonium (stem cell) - one daughter cell stays behind undifferentiated as a reserve for more sperm) with full complement of chromosomes = 2n or diploid i.e. 44 somatic (= autosomal) chromosomes + 2 sex chromosomes X + Y = 46 total

1- Spermatogonium (stem cell) (2n)
  Mitotic Division
  25 days
  GnRH FSH w/ testosterone

1- Primary Spermatocyte (2n)
  DNA replication, tetrad formation, and crossing-over
  16 days

2- Secondary Spermatocyte (n)
  16 days
  Each chromosome has two chromatids

3- Spermatids (n)
  16 days
  Cytoplasmic bridge

4- Sperm (n)
  2 with 22 autosomes + X sex chromosome
  2 with 22 autosomes + Y sex chromosome

Stem cell stays behind

Meiosis I = Reduction division
= Haploid or n = ½ total # chromosomes
22 chromosomes + X, ½ are this type
or 22 chromosomes + Y, ½ are this type
Autosomes maybe all maternal, paternal, or combination (due to crossing over). Independent assortment too.

Meiosis II = Equatorial division
= no DNA replication, division of 2 sister chromatids of same chromosome.
Sperm = haploid (n)
## Sperm Differences

<table>
<thead>
<tr>
<th>Male Producing Sperm</th>
<th>Female Producing Sperm</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{1}{2}$ sperm produced = 22 autosomal chromosomes + Y chromosome</td>
<td>$\frac{1}{2}$ sperm produced = 22 autosomal chromosomes + X chromosome</td>
</tr>
<tr>
<td>Male producing sperm = androsperm</td>
<td>Female producing sperm = gynosperm</td>
</tr>
</tbody>
</table>

Note: Ova can only have:

- 22 autosomal chromosomes + X chromosome

<table>
<thead>
<tr>
<th>Chromosomes</th>
<th>Male XY</th>
<th>Female XX</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 chromosomes + X (from ova)</td>
<td>22 chromosomes + X (from ova)</td>
<td></td>
</tr>
<tr>
<td>22 chromosomes + Y (from sperm)</td>
<td>22 chromosomes + X (from sperm)</td>
<td></td>
</tr>
<tr>
<td>44 chromosomes + X + Y = 46 chromosomes</td>
<td>44 chromosomes + X + X = 46 chromosomes</td>
<td></td>
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</table>

- Y chromosome smaller
- X chromosome larger (2.8% more DNA per sperm cell)

Other differences:

<table>
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<tr>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small, rounded head</td>
<td>Large, oval shaped head</td>
</tr>
<tr>
<td>Greater in number at time of ejaculation</td>
<td>Fewer in number</td>
</tr>
<tr>
<td>Does poorly in acidic environment (vagina)</td>
<td>Does better in acidic environment</td>
</tr>
<tr>
<td>Does best in alkaline environment</td>
<td>Does well in alkaline environment</td>
</tr>
<tr>
<td>Swims faster</td>
<td>Swims slower</td>
</tr>
<tr>
<td>Survives about 1 day in female</td>
<td>Survives about 2-3 days in female</td>
</tr>
<tr>
<td>Does best in high sperm count</td>
<td>Does best in low sperm counts</td>
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</tbody>
</table>

These criteria have been challenged.
YOU CAN CHOOSE YOUR BABY’S SEX OR THE DO IT YOURSELF LOW TECH METHOD
(Harmless and 80% boys, 75% girls success rates)

Male Producing Sperm (Andro sperm)

Y chromosomes
small, round-headed
greater in number
does poorly in acidic environment (vagina)
does best in alkaline environment
swims faster
survives about 1 day in female
does best in high sperm count

Female Producing Sperm (Gynosperm)

X chromosomes
large, oval shaped
fewer in number
does better than andro sperm in acidic environment
does well in alkaline environment
swims slower
survives about 2-3 days in female
does best in low sperm count

Procedure For Male Offspring

1. Intercourse should be timed as close to the moment of ovulation as possible.
   Female secretions are most alkaline at this time.
2. Intercourse should be immediately preceded on each occasion, by a baking soda
douche consisting of two tablespoons baking soda to a quart of water. The solution
should be permitted to stand fifteen minutes before use. This allows soda to
dissolve completely.
3. Female orgasm is not necessary but is desirable, if a woman normally has
   orgasm, her mate should time his to coincide with hers or let her experience
   orgasm first.
4. Vaginal penetration from the rear is the recommended position. This helps to
deposit sperm at the entrance of the womb. The secretions within the cervix and
womb will be highly alkaline, more so even than in the vagina, in spite of the
alkaline douche, and an alkaline environment is most favorable to andro sperm.
5. Deep penetration at the moment of male orgasm will help ensure deposition of
   sperm close to the cervix.
6. Prior abstinence is necessary. Intercourse should be avoided completely from the
   beginning of the monthly cycle to the day of ovulation. This helps ensure a
   maximum sperm count, favoring andro sperm.

Procedure For Female Offspring

1. Intercourse should cease two or three days before ovulation to insure acidic
   environment. Timing is the most important factor.
2. Intercourse should be immediately preceded on each occasion by an acidic
douche consisting of two tablespoons of white vinegar to a quart of water. The
timing might be enough to ensure female offspring, but the douche increases
success since the acidic environment immobilizes andro sperm.
3. If the wife normally has orgasm, she should try to avoid it. Orgasm increases the
   flow of alkaline secretions, and these could neutralize or weaken the acidic
   environment that enhances the chances of the gynosperm.
4. The face-to-face or “missionary” position should be assumed during
   intercourse. it is less likely that the sperm will be deposited directly at the cervix
   where they might escape the acidic environment of the vagina
5. Shallow penetration by the male at the time of male orgasm is recommended.
   Again, this helps make sure that the sperm are exposed to the acid in the vagina
   and must swim through it to get to the cervix.
6. No abstinence is necessary until after the final intercourse two or three days
   prior to ovulation. Frequent intercourse decreases sperm count favoring
   gynosperm.

Newer Methods of Gender Preselection (at a price)

1. The Microsoft method. Developed by The Genetics & IVF Institute. Cytometric separation of X and Y bearing sperm. The sperm are separated on the basis of the 2.8% difference DNA content using a fluorescence activated cell sorter. DNA fluorescent tagged probes are used to identify X and Y chromosomes. Current methods allow for a 60-70% chance of gender selection. This method is currently considered investigational for procedure to predetermine sex at this time. $2,500.

2. Embryo Selection. A form of in vitro fertilization (IVF). Ova and sperm are collected and put together outside the body in a “test tube”. Once the test tube embryo is in a very early multi-cell state it is possible to tease out a cell and determine the presence of X or Y chromosome. This method employs PGD (preimplantation genetic diagnosis). PGD technology offers a 99.99% success rate for obtaining the desired sex in a baby. Most early embryos can lose a cell with no harm. Embryos of a male or female can be ID with certainty by checking for an X or Y chromosome. IVF can be accomplished with embryos of a selected sex. Success rate is nearly 100% if pregnancy is achieved. $25,000.
Gender Selection News

New research shows that X and Y sperm have the same shape and size

Gender Selection

• The Shettles method is not reliable.
• Preconception: MicroSort (MS) is a technique for separating X and Y sperm, with a success rate of 91% for a girl, and 76% for a boy. This is the only method proved to effectively sort X and Y sperm, and is available only in the US. Preconception.
• Preimplantation: Preimplantation Genetic Diagnosis (PGD) is the only method which can guarantee the gender of your choice with virtually 100% accuracy, because embryos are tested for gender before being implanted in the mother's womb.
• Both MS and PGD require Assisted Reproduction Technologies (ART). Getting pregnant by IUI (artificial insemination) or IVF (in vitro fertilization) is no easy task and is expensive.

Erection of the Penis

• Erection of the penis is an adaptation to ensure deposition of sperm in female reproductive tract.

Stimuli for erection:
• **Neural stimulus**
• Mental, special senses detect erotic stimuli (vision, hearing, smell)
• **Mechanical stimulus of pressure receptors.**
• Tactile stimulation of genital area, especially the glans.
Erection of the Penis

Mechanical stimulus of pressure receptors:
• Tactile stimulation of genital area, especially the glans.
• Stimulus leads to parasympathetic impulses (response) sent through sacral segments (2-4) that innervate arteries of the penis.
• This parasympathetic reflex triggers release of NO (nitric oxide) which relaxes vascular smooth muscle, causing arterioles to dilate.
• **Note – this is where Viagra (sildenafil) and similar drugs are effective.**

Viagra is an enzyme inhibitor of PDE5 (phosphodiesterase type 5). PDE5 turns off the trigger for erection by opposing the action of the released nitric oxide (NO).

- So as the man ages and less NO is released, Viagra allows less NO to trigger the erection mechanism.
- Viagra has no effect until sexual stimulation is present: it just lowers the trigger mechanism.
Erection of the Penis

- The vascular space of the erectile tissue fills with blood and penis becomes erect (turgid).
- Expansion compresses the drainage veins so the erection is maintained.
- This is a rare example of parasympathetic control of arterioles.
- Another parasympathetic response is stimulation of the bulbourethral glands (Cowper’s gland) with ducts to the urethra that inject mucus to lubricate the glans and an alkaline substance to protect sperm.
Ejaculation & Formation of Semen

- **Ejaculation** is the propulsion of semen from the male genital ducts.

- **Ejaculation** is under *sympathetic control* (L1-L2 level).

- After continued stimulation a massive discharge of nerve impulses leads to:
  1. Contraction of smooth muscle in the genital ducts which delivers semen into the urethra.
  2. The bladder sphincter closes (prevents urine flow and semen into bladder).
  3. Ejaculatory muscles undergo rapid contraction propelling sperm up to 200 inches/sec.
Ejaculation & Formation of Semen

• In ejaculation, sperm is forced from the epididymis, where it is stored, into the genital ducts, to the urethra, and to the outside.

• Along the way secretions enter from the seminal vesicles and prostate gland.

• This entire event is called climax or orgasm which results in intense pleasure, general muscle contraction, rapid heartbeat, elevated blood pressure.

• Orgasm is quickly followed by muscular and psychological relaxation and vasoconstriction of penile arterioles cause return to flaccid state. The refractory period (no orgasm) may last minutes to hours and increases with age.
Ejaculation & Formation of Semen

- **Semen (ejaculate)** = mixture of sperm and seminal fluid.
- **Seminal fluid** is the liquid portion of the semen from the seminiferous tubules, seminal vesicles, prostate and bulbourethral glands.
Constituents of Semen (Semen Analysis)

1. **Volume**: 2.5 - 5 ml per emission
2. **Motility**: at least 60% should show good forward motility within 3 hours
3. **Sperm count** = 50-150 million/ml. If below 20 million, then infertility problems. Although only one sperm fertilizes the egg, many sperm are needed to release hyaluronidase and proteinases (from acrosome) to digest materials surrounding the oocyte (secondary).
   - Sperm count may go down as a person ages, due to less testosterone.
   - Tight fitting clothes and too many hot baths, or emissions too often may lower count as well.
4. **Liquefaction** – delayed liquefaction greater than 2 hours indicates inflammation of accessory glands.
5. **Morphology** – no more than 30-35% should have abnormal shapes
6. **pH** = 7.2 – 7.7
7. **Fructose**: absence indicates obstruction or congenital defect.
   - *absence of sperm and zero motility are the only definitive signs of sterility*
Of Total Semen Volume:

60% = from **Seminal Vesicles**.
- Sticky, viscous, consistency with yellow color.
- Contains:
  - **Fructose** provides for ATP for motility.
  - **Prostaglandins** causes of motility increase in sperm and reverse peristalsis in uterus and uterine tubes.
  - **Clotting proteins** (different from plasma)
  - **Alkaline pH** protects from acids in vagina (pH = 3.5 – 4).

25% = from **Prostate Gland**.
- Milky white, slightly acidic (pH 6.5) fluid.
- Contains:
  - **Citrate (ionized citric acid)** - used to make ATP
  - **Prostatic-specific antigen (PSA)** and other proteolytic enzymes that that liquefy coagulated semen.
  - PSA can be monitored annually to check for prostate cancer in men over 50. It increases when a cancer grows. A DRE should be performed at the same time.

13% = from Other - **Seminiferous Tubules and Bulbourethral Gland**. For suspension of sperm and to lubricate penile urethra and glans penis.

2% = **Sperm**. So, a **vasectomy** (vas deferens are cut to prevent sperm in ejaculate) shows little difference in amount of ejaculate.
Role of Male in Reproduction

- Insemination of female
- Sperm is deposited in the vagina of the female.
- Sperm must make its way from the vagina via the cervix and uterus to uterine (fallopian) tubes where fertilization occurs.