Ch 20: Reproduction

Keypoints:
- Human Chromosomes
- Gametogenesis
- Fertilization
- Early development
- Parturition
SLOs

- Contrast mitosis/meiosis, haploid/diploid, autosomes/sex chromosomes.
- Outline the hormonal control pathway that governs reproductive function.
- Explain spermatogenesis and the timeline on which it occurs. Identify anatomical structures and the roles of hormones involved.
- Outline oogenesis and explain the timeline on which it occurs.
- Diagram the menstrual cycle and its complex hormonal control patterns.
- Diagram the erection reflex.
- Describe methods of contraception currently available.
- Diagram the process of fertilization and embryo implantation in the endometrium.
- Describe the role of hCG during pregnancy.
- Describe the processes of labor and parturition.
Sex Determination and the Human Chromosomes

- How many autosomes / sex chromosomes?
- X-linked disorders: mechanism? examples?
Sex Determination cont.

Fig 20-3

SRY gene

TDF ______
Review of Gametogenesis

Starts *in utero* – resumes at puberty

General principle same for males and females

**Male**: continuous sperm manufacture.
Meiosis produces ________________________

**Female**: born with all possible oocytes.
Meiosis produces ______________________
Male vs. Female Gametogenesis

- **Female**: Oögonium → Oögonia → Primary oocyte → Sister chromatids → First polar body (may not occur) → Disintegrates → Egg released from ovary at ovulation.
  - One primary oocyte yields 1 egg.

- **Male**: Germ cells: Spermatogonium → Spermatogonia → Sister chromatids → Primary spermatocyte → Secondary spermatocytes → Spermatids → Sperm.
  - One primary spermatocyte yields 4 sperm.

**Stage of Cell Division**

1. **MITOSIS**
   - Germ cell proliferation
   - 46 chromosomes per cell (only two shown here)
   - 46 (diploid)

2. **MEIOSIS**
   - DNA replicates but no cell division.
   - 46 chromosomes, duplicated
   - First meiotic division
     - Primary gamete divides into two secondary gametes.
     - 23 chromosomes, duplicated
   - Second meiotic division
     - Secondary gamete divides.
     - 23 chromosomes (haploid)
Nondisjunction

Meiosis 1

Meiosis 2

X Y
X Y
X Y
X Y

Nondisjunction

Meiosis 1

Meiosis 2

X Y
X Y
X Y
X Y

Nondisjunction

Y + X = XY [Normal Male]

XY + X = XXY [Klinefelter’s Male]

YY + X = XYY [XYY Male]
Clinical Application: Abnormal Karyotypes

**XO:** Turner Syndrome

**XXX:** Triple-X Syndrome

**XXY:** Klinefelter Syndrome

**XYY:** Jacob Syndrome

**Trisomy 21:** Down Syndrome
Turner Syndrome

Monosomy X (45,X)
Characteristically broad, "webbed" neck. Stature reduced, edema in ankles and wrists.

Relatively normal lives – but no functional ovaries.
1 in 2,500 female births worldwide. Much more common among miscarriages and stillbirths.
Klinefelter Syndrome

**XXY karyotype.** Maternal or paternal non-dysjunction ⇒ ovum: XX; sperm: XY

Symptoms may be mild. May be tall and have small testes. Infertility due to absent sperm. 1 in 500-1,000 males affected.
Nondisjunction of Autosomal Chromosomes

**TRISOMY 21**: Most frequent viable autosomal aneuploidy.
Disorders of Embryonic Sexual Development: (Pseudo)hermaphrodites

**True hermaphrodite:** rare / testicular and ovarian tissues present

**Pseudohermaphrodite**

external genitalia of one sex and internal sex organs of the other sex. No ambiguity in the sex of the external genitalia $\Rightarrow$ no question about gender at birth
One form of **male pseudohermaphroditism** due to 5 $\alpha$-reductase deficiency and ↓ DHT production.

**Fig 20.7**

**Most common female Pseudohermaphroditism:** Congenital adrenal hyperplasia
20.2 Endocrine Regulation of Reproduction

Secretion of GnRH is pulsatile so FSH and LH are also pulsatile (more apparent in females than males)

Frequency of pulsations affects the target gland’s response

Compare to Fig. 20.9
Growth as a function of sex and age

Fig 20.10

The graph shows the height gain (cm per year) as a function of age (years) for males and females. The graph indicates that males experience a more rapid growth spurt compared to females, with a peak around 14 years of age. Females show a more gradual increase in growth rate, peaking around 12 years of age.
20.3 Male Reproductive System

Male Gametogenesis =

Know terminology, when and where it happens.

Compare to Fig 20.15
Spermatogenesis in ________________ tubules of testes

Pulsatile GnRH needed

**Sertoli cells** *(other name?)*:
- androgen binding protein
- blood testis barrier, *etc.*

**Leydig (?) cells** *(other name?)*:
- production of ____________
- some conversion to ________
<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>FUNCTION</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sperm</td>
<td>Gametes</td>
<td>Seminiferous tubules</td>
</tr>
<tr>
<td>Mucus</td>
<td>Lubricant</td>
<td>Bulbourethral glands</td>
</tr>
<tr>
<td>Water</td>
<td>Provides liquid medium</td>
<td>All accessory glands</td>
</tr>
<tr>
<td>Buffers</td>
<td>Neutralize acidic environment of vagina</td>
<td>Prostate, bulbourethral glands</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Nourish sperm</td>
<td>Seminal vesicles</td>
</tr>
<tr>
<td>Fructose, Citric acid, Vitamin C, Carnitine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enzymes</td>
<td>Clot semen in vagina, then liquefy the clot</td>
<td>Seminal vesicles and prostate</td>
</tr>
<tr>
<td>Zinc</td>
<td>Unknown, possible association with fertility</td>
<td>Unknown</td>
</tr>
<tr>
<td>Prostaglandins</td>
<td>Smooth muscle contraction; may aid sperm transport</td>
<td>Seminal vesicles</td>
</tr>
</tbody>
</table>
Testosterone in the Brain

Testosterone conversion to its derivatives in brain cells

Male and female brains are different – due to the effects of testosterone and estradiol

Fig 20.13
Androgens Influence Secondary Sexual Characteristics

1° sex characteristics: Internal organs and external genitalia that distinguish males from females

2° sex characteristics: Other traits distinguishing males from females
- Body shape
- Beard and body hair
- Muscular development
- Lowering of voice
- Libido

Anabolic steroids are used illegally by athletes
Male Contraception

Vasectomy

New male contraceptives

1) hormonal contraceptive = “male pill”

2) Gossypol – interferes with sperm production

Fig 20-22

Anything missing here?
20.4 Female Reproduction

Anatomy review: Internal ovaries and uterus

Compare to Fig 20.23/26
Oogenesis: Egg Cell Formation

Oogonia mitosis ceases before birth

- At birth: only primary oocytes, suspended in prophase of meiosis I (= prophase I)

- At puberty: _____ initiates ovarian cycle

*Fig 20.30*
Ovarian Cycle

Phases of the Ovarian Cycle

<table>
<thead>
<tr>
<th>Phases of the Ovarian Cycle</th>
<th>Follicular Phase</th>
<th>Ovulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonadotrophic hormone levels</td>
<td>FSH</td>
<td>LH</td>
</tr>
</tbody>
</table>

Ovarian cycle

- Primary follicle
- Theca
- Antrum
- Ovulation
- Corpus luteum formation
- Mature corpus luteum
- Corpus albicans

Fig. 26-13

Follicular phase

**estrogen**

Luteal phase

**progesterone**
20.5 Menstrual Cycle lasts ~ 1 month
range 24-35 days

**Ovarian cycle** (changes in follicles)
function: monthly production of gametes

**Uterine cycle** (changes in endometrial lining) function: receive developing embryo

Fig 20.23
Uterine Cycle: regulated by hormones of ovarian cycle

Begins due to follicular phase of ovaries during luteal phase of ovaries

Compare to Fig 20.33
Procreation

Species specific behaviors ensure reproductive success

Terrestrial vertebrates require adapted genitalia

Male sex act: Erection
- Parasympathetic activation
- Sympathetic inhibition
- Arterial smooth muscle relaxes

Male sex act: Ejaculation
- Sympathetic activation of duct system smooth muscle

Erectile dysfunction (ED) in both genders
Birth Control = Contraception

Voluntary regulation of # of children produced & when

List methods of contraception from most effective to least effective

<table>
<thead>
<tr>
<th>Method</th>
<th>Pregnancy Rate With Typical Use*</th>
</tr>
</thead>
<tbody>
<tr>
<td>No contraception</td>
<td>85%</td>
</tr>
<tr>
<td>Spermicides</td>
<td>29%</td>
</tr>
<tr>
<td>Abstinence during times of predicted fertility</td>
<td>25%</td>
</tr>
<tr>
<td>Diaphragm, cervical cap, or sponge</td>
<td>16–32%†</td>
</tr>
<tr>
<td>Oral contraceptive pills</td>
<td>8%</td>
</tr>
<tr>
<td>Intrauterine devices (IUDs)</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Contraceptive hormone injection</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Male condom</td>
<td>15%</td>
</tr>
<tr>
<td>Female condom</td>
<td>21%</td>
</tr>
<tr>
<td>Sterilization</td>
<td>&lt; 1%</td>
</tr>
</tbody>
</table>

†Lower rates are in women who have never delivered a child.
Fertilization

Where?
~ 100 sperm needed

When?
Egg: 12-24 h post ovulation
Sperm: viable for up to 72 h
Then: 3-4 day journey to uterus

Fig 20.37
Fertilization cont.

Sperm must penetrate several layers

Acrosomal reaction allows sperm penetration

1st sperm reaching egg binds to sperm-binding receptors on oocyte membrane & enters

Cortical reaction prevents polyspermy

Resulting structure = ?
Developing Embryo Implants into Secretory Endometrium

Dividing embryo moves from fallopian tube to uterine cavity over period of 4 – 5 days

Implantation ~ 7 days after fertilization

Compare to Fig 20.41
hCG Production During Pregnancy

hCG secreted by developing blastocyst

Related to?

⇒ Prevents __________ from degenerating and stimulates it to produce ______________

⇒ Prevents __________

Week 7: placenta taking over _______ production

hCG also important in pregnancy testing
Prenatal Genetic Testing

Amniocentesis: Fetus is 14-16 weeks old

- Biochemical analysis of fluid searches for disease markers
- Cell culture can take several weeks ⇒ Karyotyping and DNA testing

Compare to Fig 20.47
Chorionic Villi Sampling

Can be done at 8 weeks (recommendation: 10 weeks)

No cell culture necessary

Higher risk of miscarriage and misdiagnosis
Labor and Delivery

**Functions of uterus:**
1. Protection of embryo/fetus
2. Nutritional support
3. Ejection of fetus at birth

Parturition = Birthing process

At 38 - 40 weeks of gestation

Initiation poorly understood – sequence of events well understood

The positive feedback loop of parturition - how is + feedback loop stopped?
Fetus drops lower in uterus

Cervical stretch

Oxytocin from posterior pituitary

Uterine contractions

Prostaglandins from uterine wall

The END