Bio40C Schedule

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Chapter 28
the Reproductive Systems

Males & Females
Family planning

The male reproductive system

- Designed for the continuous production of a large number of sperm
- Produces testosterone, the male sex hormone

Male reproductive system

- Gonads—testes
  - produce sperm and secrete testosterone
- Ducts—epididymis, vas deferens, urethra
  - Transport and store sperm, assist in their maturation
- Accessory sex glands—semenal vesicles, prostate, Cowper’s gland
  - Secrete fluids in semen
- Penis and scrotum

Male anatomy: Scrotum

- Cutaneous outpouching of the abdomen that supports the testes
- Internally a vertical septum divides it into two sacs, each containing a single testis

Scrotum

- Normal sperm production requires a temperature 2-3° below core body temp.
- The temperature of the testes is regulated by
  - location of the scrotum
  - contraction of the cremaster muscle
    - elevates the testes and brings them closer to the pelvic cavity or relaxes to move them away
Embryology: Testes

- In the embryo, the testes develop near the kidneys, in posterior abdominal wall.
- Testes descend into the scrotum through the inguinal canals during the 7th month of fetal development.
- Failure of the testes to descend is called cryptorchidism, involving one or both testes.
- Occurs in 3% of full-term infants and 30% of premature infants.

Male anatomy: Testes

- Sperm are produced in seminiferous tubules.
- Contain 2 types of cells:
  - Spermatogenic cells
  - Sertoli cells – support spermatogenesis
  - Nutrient developing sperm
  - Secrete the hormone inhibin
  - Leydig (interstitial) cells – secrete testosterone
  - Found in spaces between seminiferous tubules

Spermatogenesis

- Takes place inside the tightly coiled seminiferous tubules.
- As the cells undergo meiosis and mature into sperm, they move toward the lumen of the tubule.

Meiosis: review

- Meiosis occurs in two cell divisions:
  - Not one as in mitosis.
  - But DNA is replicated only once.
- The result:
  - One diploid stem cell forms 4 haploid cells.

Meiosis plays a key role in spermiogenesis

- In males, meiosis typically produces 4 sperm.

Spermatogenesis

- Diploid spermatogonia (stem cells) on the outside of the tubule:
  - Divide by mitosis to reserve future stem cells and to develop primary spermatocytes (2n) for sperm production.
- Primary spermatocytes undergo meiosis and mature into haploid sperm.
- The sperm are released into the seminiferous tubules.
**Sperm cells**
- Highly specialized for their role in fertilization
- **Head**: contains the nucleus
- **Acrosome**: contains enzymes to digest a passage to the egg
- **Mitochondria**: function?
- **Tail**: for movement

**Hormonal control of spermatogenesis**
- At puberty, gonadotropin releasing hormone (GnRH) stimulates anterior pituitary to secrete follicle-stimulating hormone (FSH) and luteinizing hormone (LH).
- LH stimulates production of testosterone.
- FSH and testosterone stimulate spermatogenesis.
- Sertoli cells secrete androgen-binding protein, which binds to testosterone and keeps its concentration high in seminiferous tubules.

**Inhibin**
- Produced by Sertoli cells.
- Inhibits FSH release and helps to regulate the rate of spermatogenesis.

**Testosterone**
- Binds to androgen receptors (AR) in target cells; regulates gene expression
- Develops male sex characteristics
- Enlarges the sex organs and develops male secondary sex characteristics
- Develops sexual function
- Sex drive (libido), sperm maturation
- Stimulates anabolism
  - bone growth, protein synthesis and sperm maturation

**Spermatogenesis**
- After a sperm cell is made in the testis, it is delivered to a long, coiled tube called the **epididymis**
- the sperm cell matures and develops motility
- Stored here for a month, after which they are either expelled or degenerated and reabsorbed
- From the epididymis, the sperm is delivered to the **vas deferens**
- When sperm is ejaculated, it travels from the vas deferens to the **urethra**
  - serves as a passageway for semen and urine
Semen

- Sperm leave the penis in a fluid called semen
- mixture of sperm and seminal fluid
- Various glands (seminal vesicle, prostate gland and Cowper’s gland) add fluids
  - provides the fluid in which sperm are transported
  - provides nutrients
  - neutralizes the acidity of the male urethra and female vagina

Accessory Sex Glands

- The seminal vesicles
  - Secrete an alkaline, viscous fluid that contains fructose (used for ATP production by sperm).
- The prostate gland
  - secretes a slightly acidic fluid that contributes for sperm motility
- The bulbourethral (Cowper’s) glands
  - secrete mucus for lubrication and an alkaline substance that neutralizes acid

Sperm delivery system

- The penis contains 3 cylinders of spongy tissue
- It is designed to inflate
  - Nerve impulses cause the blood vessels leading into this tissue to expand
  - Blood collects in the spongy tissue and causes the penis to become erect and rigid
  - Continued stimulation is required for ejaculation

The female reproductive system

- Designed to
  - Produce 1 egg each month
  - Prepare the uterus for implantation of the fertilized egg

Meiosis in females

- Meiosis produces one large egg, plus small polar bodies.
Anatomy of the female reproductive system

- The eggs, or ova, mature in the ovaries
- The fallopian tubes transport egg to the uterus
- The uterus is lined with epithelial tissue called the endometrium
  - the surface of the endometrium is shed during menstruation
  - the uterus narrows to a muscular "neck" called the cervix
- The vagina leads from the uterus to the external genitalia

Histology of the ovary

- Covered by the germinal epithelium
- Ovarian follicles, in various stages of development, lie in the cortex
- A mature follicle expels a secondary oocyte by a process called ovulation.
  - A corpus luteum – the remnants of an ovulated follicle – produces progesterone, estrogens, relaxin, and inhibin until it degenerates

The Female Reproductive Cycle

- The female reproductive cycle is actually two cycles in one:
  - The ovarian cycle
    - controls the growth and release of an egg
    - Coordinated by FSH and LH
  - The menstrual cycle
    - prepares the uterus to receive a fertilized egg – implantation of an embryo.
    - Coordinated by estrogen and progesterone

The ovarian cycle:
One egg matures each month

- Eggs develop from cells called oogonia
  - diploid (2n) stem cells
- At birth, the ovary contains ~2 million oocytes
- During each reproductive cycle, (usually) one of the oocytes matures
  - Only ~400 oocytes mature and are ovulated

Oogenesis, the development of eggs within the ovaries
Oogenesis, the development of eggs within the ovaries

In a secondary oocyte, meiosis II is completed only if fertilization occurs.

Ovulation – only 1 egg matures each month

- Ovulation: the mature follicle discharges the oocyte
- The oocyte is swept up into the Fallopian tube
- the normal site of fertilization
- transport ova from the ovaries to the uterus

Fallopian (uterine) tubes

- Ciliated cells and peristaltic contractions help move the ova toward the uterus

The egg’s journey

- After ovulation, the egg is carried down the Fallopian tube by peristalsis
- If the egg is fertilized, it finishes meiosis II, the oocyte splits into the mature egg and a 2nd polar body
- The nuclei of sperm and egg units and zygote begins mitosis, becoming a blastocyst
- The blastocyst implants in the wall of the uterus, where it continues developing
The female reproductive cycle

- Includes the ovarian and uterine cycles, the hormonal changes that regulate them, and cyclical changes in the breasts and the cervix.
- The ovarian cycle
  - maturation of an ovum
- The uterine (menstrual) cycle
  - changes in the endometrium to prepare for the implantation of fertilized ovum.

Hormonal Regulation of the Female Reproductive Cycle

- GnRH stimulates the release of FSH and LH by the anterior pituitary gland
- FSH stimulates
  - the initial development of ovarian follicles
  - secretion of estrogens by the ovaries.
- LH stimulates
  - further development of ovarian follicles, ovulation
  - the secretion of estrogens and progesterone by corpus luteum

Hormonal regulation of female reproductive cycle

Estrogens have several important functions

- Develop and maintain female reproductive structures, secondary sex characteristics, and the breasts
- Increase protein synthesis
- Preserve bone density
- Regulate synthesis of cholesterol by liver

Progesterone, relaxin, inhibin

- Progesterone works with estrogens
  - prepares the endometrium for implantation
  - and the mammary glands for milk synthesis
- Relaxin
  - relaxes the uterus at time of implantation
  - At end of pregnancy, relaxin relaxes the pubic symphysis and helps dilate the uterine cervix to facilitate delivery.
- Inhibin
  - inhibits secretion of FSH and, to a lesser extent, LH.

Four Phases of the Female Reproductive Cycle
1. Menstrual Phase

- The menstrual cycle (menstruation) lasts for approximately the first 5 days of the cycle.
- Events in the ovary
  - small secondary follicles in each ovary begin to develop.
- Events in the uterus
  - the stratum functionalis layer of the endometrium is shed, discharging blood, tissue fluid, mucus, and epithelial cells.

2. Preovulatory Phase

- The time between menstruation and ovulation.
- Events in the ovary
  - primary follicles develop into secondary follicles and (usually) one matures
  - The dominant follicle increases its estrogen production under the influence of an increasing level of LH
- Events in the uterus
  - Endometrial proliferation and repair

3. Ovulation

- The mature follicle ruptures and releases a secondary oocyte into the pelvic cavity.
  - usually occurs on day 14 in a 28-day cycle.
  - The high levels of estrogen during the last part of the preovulatory phase exert a positive feedback on both LH and GnRH to cause ovulation
  - GnRH promotes LH release
  - The LH surge triggers ovulation

4. Postovulatory Phase

- This phase lasts from days 15-28 in a 28-day cycle
- Events in the ovary
  - After ovulation, the mature follicle collapses (and blood within it forms a clot) to become the corpus hemorrhagicum
  - In time, the follicular cells enlarge, change character, and form the corpus luteum, or yellow body, under the influence of LH.
  - Stimulated by LH, the corpus luteum secretes large amounts of estrogens and progesterone.

4. The postovulatory phase

- Events in the uterus
  - If fertilization and implantation do not occur, the corpus luteum degenerates and becomes the corpus albicans, or white body.
  - The decreased secretion of progesterone and estrogens then initiates menstruation

Anterior pituitary and ovarian hormones

- Estrogens are the primary ovarian hormones before ovulation
- At midcycle, a surge of LH triggers ovulation
- After ovulation, both progesterone and estrogens are secreted by the corpus luteum
Anterior pituitary and ovarian hormones

- Which hormones are responsible for the proliferative phase of endometrial growth? **estrogens**
- For ovulation? **LH**
- For growth of the corpus luteum? **LH**
- For the surge of LH at midcycle? **estrogens**

Summary

- Hormones from the anterior pituitary regulate ovarian function
- Hormones from the ovaries regulate the changes in the endometrial lining of the uterus

And if the egg is fertilized?

- The corpus luteum is maintained by human chorionic gonadotropin (hCG) from the developing placenta until the placenta takes over its hormone-producing function.
- The corpus luteum secretes estrogens and progesterone to support pregnancy and breast development for lactation.
- Then the placenta begins secreting estrogens and progesterone
  - the role of the corpus luteum becomes minor.

Female athlete triad

- Women athletes who train intensively may develop three conditions
  - Disordered eating/harmful weight-loss practices
  - Amenorrhea (absence of menstruation)
  - Premature osteoporosis
- Amenorrhea results from reduced secretion of GnRH
- What effect would this have on
  - Ovulation?
  - Estrogen levels?
  - Monthly menstrual bleeding?
  - Bone mineral levels?
Hormonal regulation of female reproductive cycle

Family planning

Preventing pregnancy

Birth control

- Contraception methods differ in their effectiveness
- Most effective
  - Sterilization (vasectomy, tubal ligation)
  - IUD
  - Implant
- Least effective
  - Withdrawal
  - Spermicides

- See Birth control effectiveness chart on Planned Parenthood website
  

What is an IUD?

- The letters IUD stand for "intrauterine device"
- IUDs are small, "T-shaped" devices inserted into a woman's uterus to prevent pregnancy
- Effective for about 10 years
- How Does an IUD Work?
  - IUDs prevent fertilization by blocking sperm from entering the Fallopian tubes

Sterilization—vasectomy and tubal ligation

- A matchstick-sized rod that is inserted in the upper arm
- Releases the hormone progestin and prevents ovulation
- It protects against pregnancy for up to 3 years.
Other methods that use hormones to prevent ovulation

- **Hormone methods**
  - Birth control Shot, Pill, Ring, Patch
  - Breast feeding
  - The birth control shot contains progestin
  - The pill, ring and patch contain both estrogen and progestin.
  - The hormone methods work by preventing ovulation

- **Breast feeding**
  - While a woman is continuously breastfeeding, her body does not make hormones that are necessary for ovulation
  - Less than 1 out of 100 women who practice continuous breastfeeding perfectly will become pregnant
  - Using breastfeeding as birth control can be effective for six months

How do these hormones prevent ovulation?

- Female sex hormones coordinate the reproductive cycle
  - FSH and LH → Ovulation
  - Estrogen and progesterone → prepare the uterine lining for implantation
  - Birth control pills contain estrogen and progestin
  - Turn off production of FSH and LH
  - Prevent ovulation

Breastfeeding

- Condoms
  - Condoms are thin latex or plastic sheaths that are worn on the penis during intercourse.
  - Condoms prevent pregnancy by collecting semen when a man ejaculates. This keeps sperm from entering the vagina and "meeting" the egg.
  - They also reduce the risk of sexually transmitted infections.

Barrier methods: Condoms

- Diaphragms
  - A shallow latex cup inserted into the vagina. When in place, it covers the cervix (the opening to the uterus)
  - Diaphragms prevent pregnancy by keeping sperm from entering the uterus
  - In order to be as effective as possible, the diaphragm is used with spermicide cream or jelly.

Barrier methods: Diaphragms

Recap: How different birth control methods work

- Prevent ovulation
  - Hormone methods – Implant, birth control pill, shot, ring, and patch; breast feeding
  - Prevent fertilization
  - IUD
  - Block or kill sperm
    - IUD, condom, diaphragm, spermicidal jellies
  - Sterilization
  - Which of these prevent STIs?
  - Which are the woman’s responsibility?
An oral contraceptive pill for males? Why not?

Would a testosterone pill be effective? What is the problem?

How does the pregnancy test work?

- It measures hCG levels
- The embryo secretes human chorionic gonadotropin (hCG)
- Because hCG is produced by the chorion of the embryo and not the mother, hCG levels are measured in all pregnancy tests
- Excess hCG is excreted in the mother’s urine

Abortions

- Spontaneous
  - Naturally occurring; a miscarriage
- Induced
  - Intentionally performed

Plan B (morning after pill)

- What is Plan B?
  - Plan B is emergency contraception
  - Should be taken within 72 hr after intercourse
  - Plan B contains only progestin, a synthetic hormone used in birth control pills
  - It is currently available only by prescription

How does Plan B work?

- Plan B acts primarily by stopping the release of an egg from the ovary (ovulation).
  - It may prevent the union of sperm and egg (fertilization).
  - If fertilization does occur, Plan B may prevent a fertilized egg from implanting in the uterus.
  - If a fertilized egg is implanted, Plan B will not work.

Mifepristone: miniprex or RU486

- It blocks the action of progesterone by binding to and blocking progesterone receptors
- Progesterone prepares the uterine lining for implantation and then maintains the lining
- If the action of progesterone is blocked during pregnancy, menstruation occurs and the embryo sloughs off with the uterine lining
- Use a second drug, Misoprostol to stimulate uterine contractions
given after RU486 to aid in expelling the endometrium