Online Physiology 2130 - Reproduction

Introduction

Dear Student,
Thank you for opening this resource for Physiology 2130, and welcome. This resource has been created by the Education Team at WebStraw. The Education Team consists of students that have previously taken and/or students that are currently taking Physiology 2130.

Purpose

This resource focuses on key concepts that are important for students to understand to succeed within this course. This resource was created by students for other students. Our goal is to help students (1) further develop their understanding of course content and (2) achieve greater academic success. (3) Our resource is also open access meaning there are no financial or legal barriers to students who wish to access and use our resource.

Instructions

These study resources consists of several parts. The first part includes a condensed review of the major takeaways from each physiology module. This is followed by a series of questions and fill in the blank worksheets that should be completed after you have gone through the module and course material, in order to verify your understanding.

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We wish you the best of luck on your exams!
The WebStraw Team

Note to Instructors: If this resource has been created for your course and you would like to collaborate with us, please email us at team@webstraw.ca

Module 14 – Reproduction

Fetal Development Overview

- Each cell in the body contains 23 pairs of chromosomes
  - Includes sex chromosomes (X and Y)
  - All eggs contain an X chromosome
  - Sperm can carry either an X or Y chromosome
- Sex of baby determined during fertilization when sperm penetrates egg (XY = male, XX = female)

Fetal Development Timeline

First 6 Weeks

Male and female embryos contain common gonads (structures that will form either testes or ovaries)

Two sets of primitive reproductive tracts:
1. Mesonephric or **Wolffian Duct**
2. Paramesonephric or **Mullerian Duct**

7 Weeks

Presence of Y chromosome causes indifferent gonads to develop into the testes

Male fetus: testicular cells begin to produce **Mullerian inhibiting hormone (MIH)** → causes Mullerian duct to regress

9 Weeks

XX chromosomes activated and ovaries develop
Male fetus: testicular cells begin to develop testosterone
- Stimulates Wolffian duct to develop into epididymis, vas deferens, seminal vesicles, urethra
- Causes development of male external genitalia

Additional Notes

- Once the testes/ovaries have developed, reproductive tracts and external genitalia follow
- Female reproductive tract and external genitalia require **no hormonal control**
  - Lack of MIH allows Mullerian duct to develop into fallopian tubes, uterus, cervix, and part of the vagina
  - Lack of testosterone causes the Wolffian duct to regress and female external genitalia to develop

Functions Continued

Bulbourethral/Cowper's gland – secretes a fluid that helps to neutralize pH and lubricate the urethra and vagina → creating optimal environment for the sperm

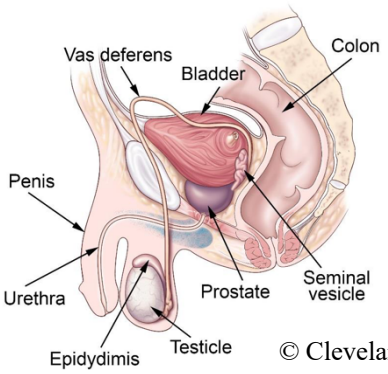
Urethra – transports sperm during ejaculation and drains the bladder during urination

Reproductive System

Function (both male/female): to pass on the genes of individuals and maintain the species

Male Reproductive System

Function: to produce testosterone (sex steroid), sperm (via spermatogenesis), and deliver it to the female vagina



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Functions of Male Reproductive Organs

Seminiferous tubules – site of spermatogenesis

Sertoli cells – regulate spermatogenesis and maintain the developing sperm cells (called **spermatogonia)**
- Produce inhibin (hormone)
- Secrete fluid that pushes immature sperm into epididymis
- Form the blood-testis barrier (BTB)

Leydig cells – located in the interstitial space between the seminiferous tubules and produce testosterone

Epididymis – final maturation area and storage site form sperm

Vas (or ductus) deferens – carries the sperm from the epididymis into the ejaculatory duct (which drains into the urethra)

Seminal vesicles – contribute a large amount of fluid to the semen during ejaculation (fluid rich in fructose and enzymes, helps to maintain and nourish the sperm)

Prostate gland – secretes enzymes and fluids that help to neutralize the acid environment of the urethra and vagina

Spermatogenesis

Begins as the male enters ***puberty*** and starts producing testosterone

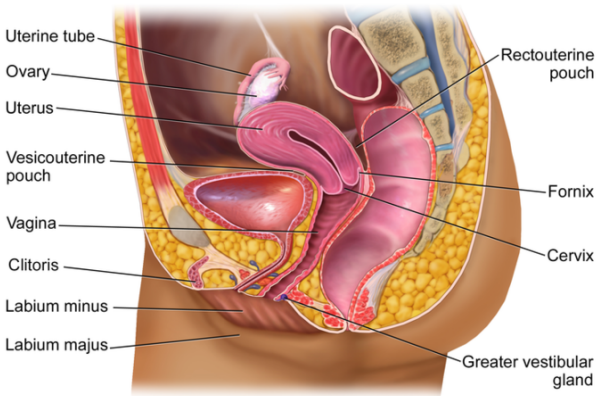
- Spermatogonia (or germ cells) contain 46 chromosomes, located at outer edge of seminiferous tubules
- Divide by mitosis into 2 cells → one continues as ***spermatogonia*** and the other develops into ***primary spermatocyte***
  - Each still contains 46 chromosomes
- ***Primary spermatocyte*** divides by meiosis into ***secondary spermatocytes*** (1st meiotic division) and then into four ***spermatid*** (2nd meiotic division)
- Throughout this process, dividing cells are surrounded and nourished by ***Sertoli cells*** and work their way to the center of the tubule
- Spermatids develop into ***sperm cells***
  - Released by Sertoli cells into the lumen of the seminiferous tubules
- Whole process takes ***64 days*** to complete and results in 4 sperm cells that contain 23 chromosomes each (half of original)

Control/Regulation of Male Reproductive System

Testicular Function

- Controlled by follicle stimulating hormone (FSH) and luteinizing hormone (LH, sometimes called interstitial cell stimulating hormone or ICSH)
  - Released by anterior pituitary gland in response to gonadotropin releasing hormone (GnRH) from the hypothalamus
- ***FSH*** acts on ***Sertoli cells*** to promote ***spermatogenesis*** while also producing ***inhibin*** (hormone)
  - Inhibin feeds back into the anterior pituitary to decrease the release of LH and FSH
- ***LH*** stimulates the ***Leydig cells*** to produce ***testosterone***
  - Testosterone feeds back to both the hypothalamus and the anterior pituitary to decrease the production and secretion of LH and FSH

Female Reproductive System



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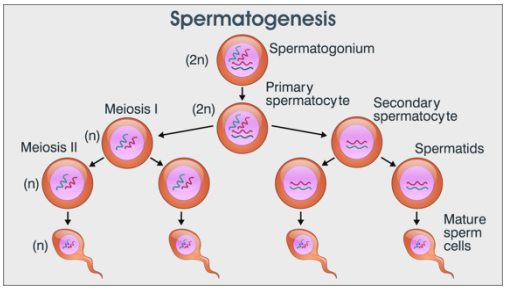
Sperm Maturation

- Sperm not fully mature and able to swim
- Contains head with an ***acrosome***, ***nucleus***, ***midpiece*** with mitochondria, and ***flagellum*** (long tail that will propel the sperm once it fully matures)
- Complete maturation of the sperm takes another 12 days. Occurs as the sperm are moved to the epididymis by the fluid secreted by ***Sertoli cells***



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Testosterone Production

- Rise in testosterone levels during fetal development
  - Necessary for development of male reproductive tract and external genitalia
- Another brief increase after birth (low until puberty)
  - Function of this unknown
- Puberty occurs between ages 9-14
  - Levels of GnRH begin to increase
  - Leads to increase in LH and FSH
  - Also causes testosterone levels to rise
- Sexual maturity and peak testosterone levels are reached around age of 16-18

Testosterone Functions

1. Development of male reproductive tract and external genitalia in the embryo
2. Growth and development of all male reproductive organs at puberty
3. Development of the male secondary sex characteristics at puberty (muscle, hair growth on face and around genitalia, deep voice)
4. Sex drive at puberty
5. Spermatogenesis
6. Bone and skeletal muscle growth
7. Increased aggressiveness

Female Reproductive System

- External genitalia (aka vulva) includes the clitoris, labia majus, labia minus
- Internal genitalia includes the cervix, fimbria, ovaries, vagina, uterus and fallopian tubes

Function of Female Reproductive Structures

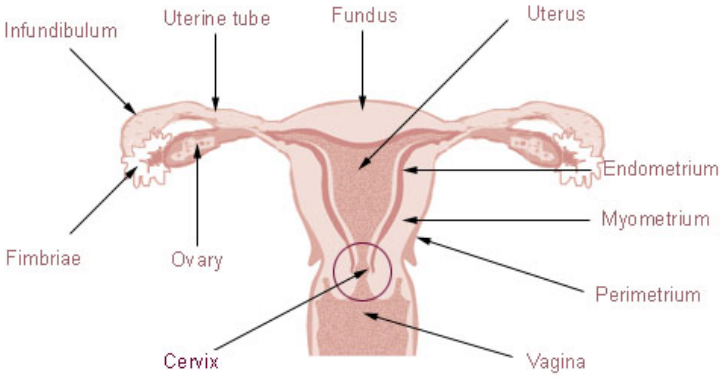
- **Vagina** – receives penis & sperm during intercourse. Allows for discharge of fluid during menstruation and childbirth
- **Cervix** – secretes mucus
  - Thin mucus – facilitates sperm entry
  - Thick mucus – prevents sperm entry
- **Uterus** – site of fertilized egg implantation
  - Developing embryo is nourished and maintained here
  - Uterine lining undergoes changes during menstrual cycle
- **Fallopian tubes** – site of egg fertilization
  - Contain cilia that pass egg from fimbria to uterus
- **Fimbriae** – capture egg after it is expelled from ovaries & funnel it into infundibulum
- **Ovaries** – produce eggs (through oogenesis) & hormones estrogen and progesterone

Ovulation

- As follicle grows, it causes granulosa cells to grow and produce more estrogen as well
- During ovulation, increased estrogen causes FSH & LH levels to increase (positive feedback)
- ***'LH surge'*** causes granulosa cells to secrete large amounts of fluid into antrum causing antrum to swell, rupture and expel egg → ***LH surge*** causes ***ovulation***
- Egg is gathered by fimbriae into fallopian tube
- Mature follicle then degenerates into **corpus luteum**
- If pregnancy does not occur, corpus luteum will degenerate into **corpus albicans**

Hormones of the Ovaries

- **Estrogen** – a group of hormones that includes estradiol, estrone and estriol
  - **Estradiol** – main estrogen secreted by the ovaries (much more potent than the others)
  - As follicle grows, it causes granulosa cells to grow and produce more estrogen as well
  - During ovulation, increased estrogen causes FSH & LH levels to increase (positive feedback)
- **Progesterone** – secreted in large amounts by ***corpus luteum*** after ovulation to prepare uterus lining for implantation
- LH is essential for production of both hormones and both estradiol and progesterone are involved in uterine lining growth



Oogenesis

- **Oogenesis** – production of an ovum (egg)
- Development of egg takes place in the follicle
- Begins with the production of millions of oogonia in the developing female embryo
  - Oogonia develop into a ***primary follicle*** containing the primary oocyte
    - Follicle consists of a single outer layer of granulosa cells
    - **Granulosa cells** – secrete fluid into interior of follicle, forming the **antrum**
- At puberty, ovaries are activated by LH & FSH
  - Primary follicles develop another ring of cells outside the granulosa cells, called **theca cells**
  - Primary follicles slowly enlarge & develop into **mature follicles**
  - The oocyte will separate from the granulosa cells and float around freely in the antrum immediately before ovulation
- Note: oogenesis produces ***one*** viable oocyte whereas spermatogenesis produces ***millions*** of sperm

Menstrual Cycle

- **Proliferative phase (day 7-14):**
  - Follicle increases production of estrogen, causing LH to surge
  - Follicle ruptures and expels egg
  - Estrogen & progesterone stimulate growth of uterine lining
- **Secretory/luteal phase (day 14-28):**
  - Follicle develops into corpus luteum and increases production of progesterone (which prepares uterus for implantation)
  - Without implantation, corpus luteum degenerates into corpus albicans and progesterone levels drop
- **Menses (day 0-7):**
  - Low levels of LH, FSH, estrogen and progesterone
  - Lining of uterus cannot be maintained and is lost

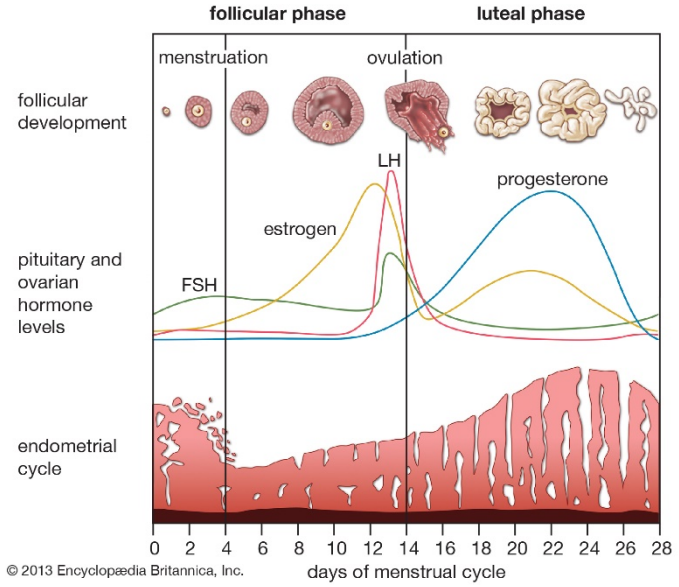
Review Questions

1. Without Sertoli cells, what would happen?
   a. Spermatogenesis would be inhibited
   b. Granulosa cells would not develop
   c. Oocyte maturation would not occur
   d. Testosterone would not be produced

2. Which of the following anatomical structures is INCORRECTLY matched to its function?
   a. Fallopian tubes; site of egg fertilization
   b. Ovaries; site of oogenesis
   c. Leydig cells; produce testosterone
   d. Prostate gland; secretes a neutralizing fluid
   e. Sertoli cells; site of spermatogenesis

3. Which of the following concerning luteinizing hormone (LH) in males is correct?
   a. LH secretion is stimulated by the presence of inhibin
   b. LH secretion is stimulated by the presence of testosterone
   c. LH secretion is stimulated by the presence of GnRH
   d. LH causes Sertoli cells to release testosterone
   e. LH *directly* promotes spermatogenesis

Menstrual Cycle



4. Which of the following is correct regarding the corpus luteum?
   a. It forms prior to the LH surge
   b. It develops and maintains the uterus lining following ovulation by producing high levels of progesterone
   c. It inhibits the production of estrogen and progesterone
   d. It forms only if the follicle becomes fertilized
   e. It develops and maintains the uterus lining prior to ovulation by producing high levels of estrogen

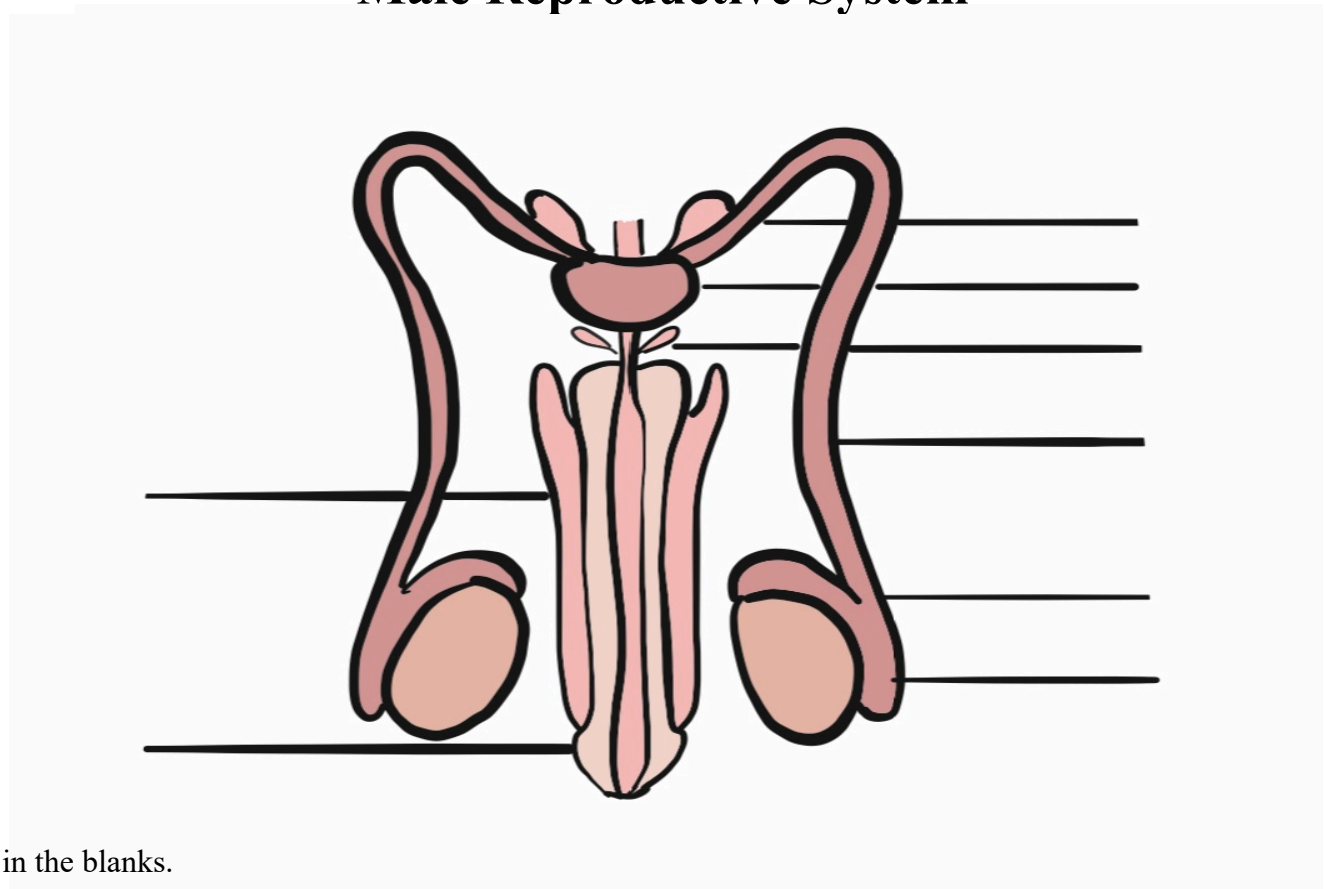
5. Which of the following is directly triggered by the LH surge
   a. Ovulation
   b. Menstruation
   c. Menopause
   d. An increase in FSH
   e. Degeneration of the follicle

6. Which of the following is correct regarding the cervix?
   a. It is the site of fertilized egg implantation
   b. It is considered to be external genitalia
   c. It secretes thin mucus to facilitate sperm entry
   d. It is the site where a developing embryo is nourished and maintained

7. Which of the following is not considered to be external female genitalia?
   a. Clitoris
   b. Labia majus
   c. Labia minus
   d. Vagina

Answer Key:
1. A 2. E 3. C 4. B 5. A 6. C 7. D

Male Reproductive System



Fill in the blanks.

1. The _____ is the final _____ area and _____ site for sperm.
2. The _____ carries the sperm from the _____ to the _____. The ejaculatory duct drains into the _____.
3. _____ partake in a large amount of fluid to the _____ during ejaculation.
4. The _____ secretes _____ and _____ that neutralizes the _____ environment of the _____ and _____.
5. The _____ secretes a _____ that helps to neutralize the _____ and _____ the urethra and vagina.

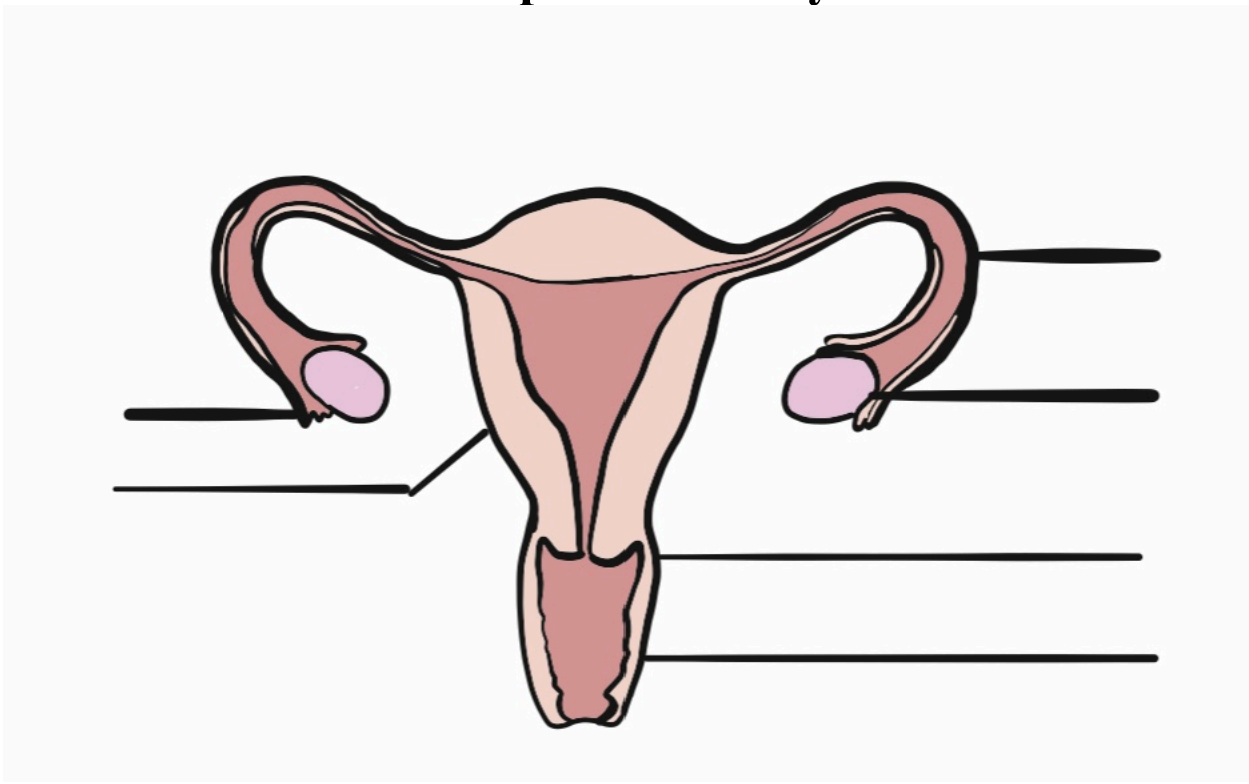
1. Which of the following is NOT a function of testosterone?
   1. Decreased aggressiveness
   2. Growth of all male reproductive organs
   3. Decreased skeletal muscle growth
   4. Development of external genitalia in the embryo

a) 1, 2, and 3 only
b) 1 and 3 only
c) 2 and 4 only
d) 4 only
e) None of the above

FUN FACT

A healthy male can produce 500 million sperm cells on a daily basis. Having less than 15 million sperm cells per mL of semen is considered low sperm count. Low sperm counts leads to difficulty when trying to conceive.

Female Reproductive System



Fill in the blanks.

1. The _____ will travel through the cervix.
2. The vagina is the _____ that _____ the penis during intercourse and where sperm is _____.
3. After going through the cervix, the _____ will travel through the cervix into the _____. The _____ is a _____ organ.
4. The sperm will now continue to the _____.
5. The end of the _____ is the _____. The egg is produced in the _____ and after being released, it _____ through the _____ to the fallopian tubes to meet the _____.

2. At menopause, the menstrual cycle becomes irregular and stops. Which of the following would you EXPECT?
   1. More estrogen is produced.
   2. Less estrogen is produced.
   3. Primary follicles have increased in the ovaries.
   4. Primary follicles have decreased in the ovaries.

a) 1, 2, and 3 only
b) 1 and 3 only
c) 2 and 4 only
d) 4 only
e) All of the above

FUN FACT

A woman can produce more than one dominant follicle and can experience many ovulatory events leading to the pregnancy of more than one baby (ex. Twins).

Answers:
1.B 2.C