The Reproductive System

Why Reproduce?

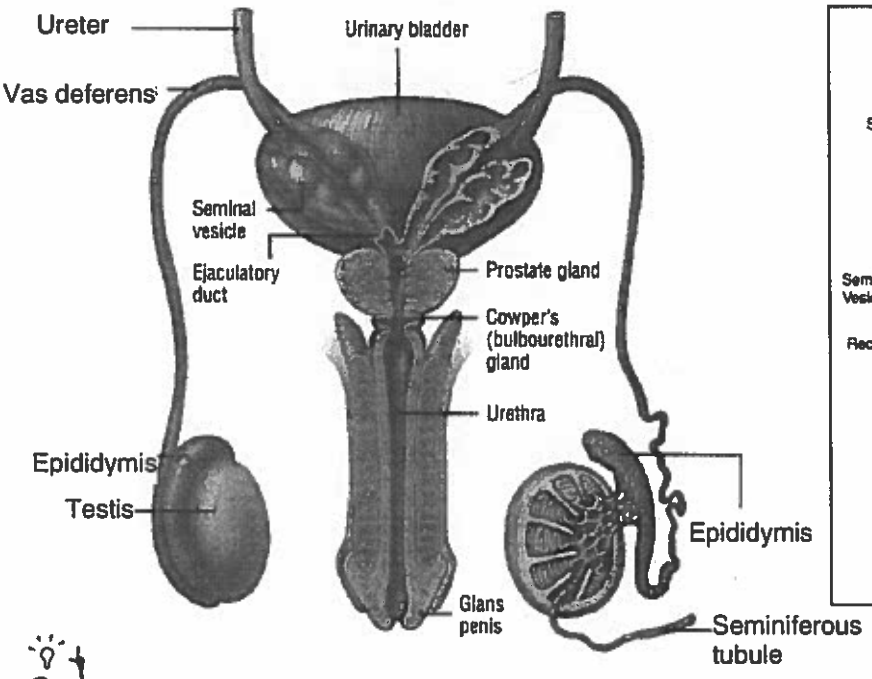
- Reproduction of individuals within a species ensures that the species will **SURVIVE**!

How Does Human Reproduction Work?

- Male and female **gametes** (sex cells) combine providing an individual with a **distinct genetic make-up.**
  - ⇨ This type of **variance** within a population increases the chances of some individuals surviving if selective pressures within their environment change.
- The primary goal of reproduction is to merge the **sperm** and **egg** or **ovum** (process called **fertilization**) to produce a **zygote**.

The Male Reproductive System

A. Structures and Functions



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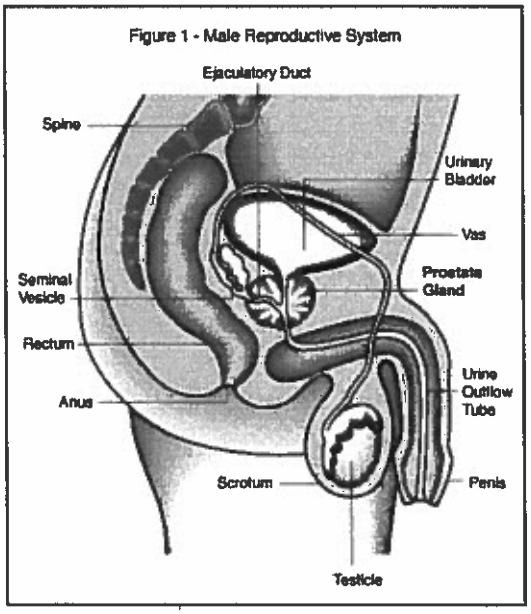


Did you know? *Men produce 1 BILLION sex cells (sperm) every day from about age 13 to age 90!*

Testes (*testis* singular)

- Male gonads that **produce sperm** and **male sex hormones (testosterone)**!
- **Castration** is the removal of the testes.

Scrotum

- Sac or pouch of skin that contains the testes.
- **Hang low** because temperature of scrotum needs to be 1 – 2 °C **lower** than normal body temperature in order for sperm to develop properly.
- **Inguinal Hernia** – tear in the membrane of the body cavity which can let intestines slip into the scrotum!

Epididymis

- Located outside of the testes
- Immature sperm travel from each testis to this coiled tube, where they mature in about 20 days.
- Stores sperm cells.

Vas deferens

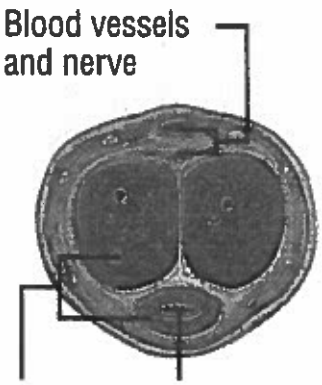
- Connects epididymis to urethra
- Regulated by the **ejaculatory duct** which allows **semen** to enter the urethra if the urinary sphincter is closed.
- **Vasectomy** – cutting of vas deferens

Seminal Vesicles, Prostrate Gland and Cowper's (Bulbourethral) Gland

- Produce a number of secretions which surround, nourish and protect sperm
- **SEMEN** = sperm + secretions

Erectile Tissues

- Controlled by a **parasympathetic nerve** (part of the **autonomic nerves** so <u>not</u> under conscious control)
- Located on the top side of the penis.
- Fills the penis with blood during sexual excitement:
    - **Arterioles** that carry blood to the penis **dilate** allowing increased blood flow to penis.
    - **Venules** that carry blood away from the penis **constrict**, resulting in increased blood pressure
    - Penis becomes hard and erect and is ready for **ejaculation**.



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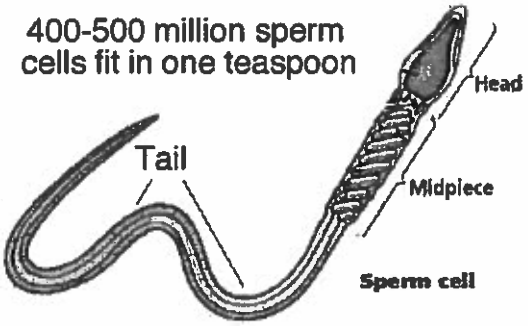
Did you know? *Impotency can be caused by a number of factors including damage to nerves, hormone imbalance, stress or other psychological contributors.*

B. Sperm Anatomy



- The sperm cell is a specialized cell designed for **motion**
- tiny – microscopic (0.05 mm)
- Three main parts:

I. Head

- → contains **haploid nucleus** (n, 23 chromosomes) – this is half of the number of chromosomes in a regular human cell (46, diploid or 2n)
- → tipped with special body called an **acrosome** which contains enzymes that help the sperm penetrate the egg (when released they dissolve the outer coating of the egg).

II. Midpiece

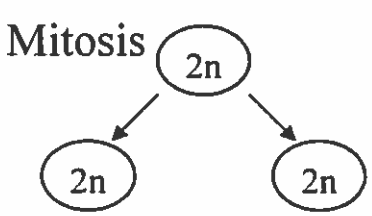
- → Large numbers of **mitochondria** that produce ATP (cellular respiration) for movement of the tail

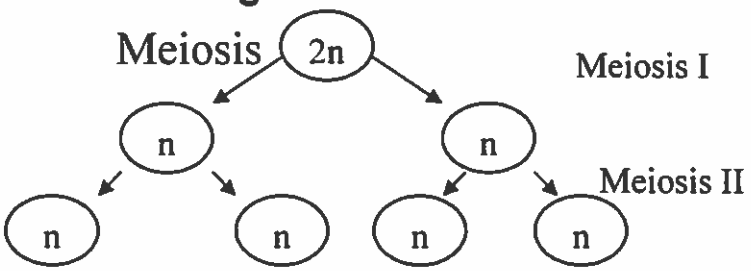
III. Tail

- → **Flagellum** – little tail that **whips** the sperm along – motility!

C. Mitosis & Meiosis – An Introduction

- Our **genetic information** (**genes/DNA**) is contained within the **nucleus** of cells on **chromosomes**.
- Each **human cell** (except sex cells) has **46** chromosomes (**2n, diploid**).
- The **sex cells** or **gametes** (**sperm** and **ovum**) have **23** chromosomes (**n, haploid**)
  - → when the 23 chromosomes from the ovum combine with the 23 chromosomes from the sperm a **fertilized cell** with **46** chromosomes results!
- **Mitosis** is cell division that creates **two daughter cells** that are identical to the parent cell ⇨ cloning of parent cell!
- **Meiosis** is cell division that creates **4** daughter cells that have **half** the chromosomes of the parent cell → creates **gametes**!

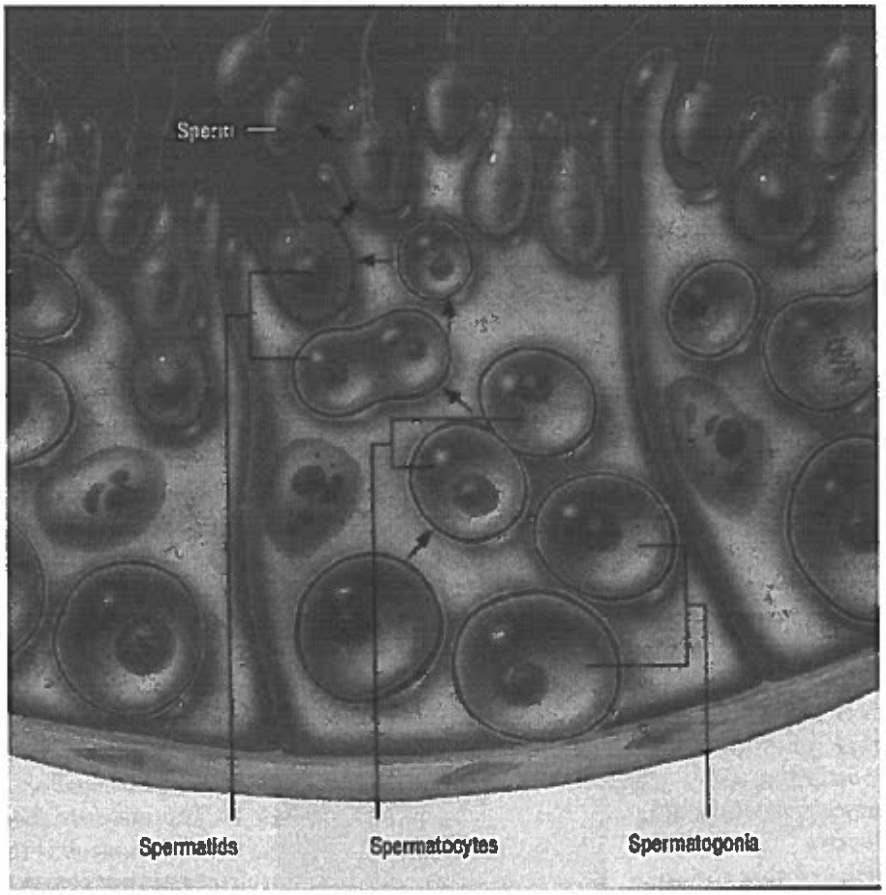




D. Spermatogenesis

- The production of mature sperm cells
- Testes contain many twisting tubules called **seminiferous tubules** which produce sperm!
- Seminiferous tubules are lined with sperm producing cells called **spermatogonia** – regular body cells (2n, 46 chromosomes, diploid) that have been designated as potential sperm cells.
- Through process of **meiosis** divide to form **spermatocytes** which have **23** chromosomes (haploid, n) each.
- **Sertoli cells** in the testes nourish developing spermatocytes for 9-10 weeks
- Become **spermatids** which mature in the **epididymis** – grow flagella and mature into **sperm cells** within 4 days.

See Figure 17.4 Nelson Biology Page 409
Draw process of Spermatogenesis in your notes!



E. Seminal Fluid (SEMEN)

- Semen is the fluid which is added to the sperm which provides the sperm with a swimming medium.
- Semen improves sperm motility while it nourishes and protects!
- Sperm last 24-72 hours in semen
- The average male ejaculation contains about **500 million sperm** cells and **3** to **4 mLs of fluid.**
- **Three accessory glands** along the vas deferens and urethra **secrete fluid** to increase the chances that the sperm complete their function:

1. Seminal vesicle

- Adds **fructose** for energy
- Adds **prostaglandins**→ hormones (chemical signal) that triggers contractions of the female reproductive tract which helps sperm to travel

2. Prostrate Gland

- Adds **alkaline buffer** to protect sperm from acidic vagina and any acidity left by urine in the male urethra.

3. Cowper's (Bulbourethral) Gland

- **Mucus rich** fluids to protect sperm and assist in sperm movement
- Small quantities of fluid are released just prior to release of sperm

F. Hormonal Control

- Two male hormones are produced by the **interstitial cells** of the **testes:**

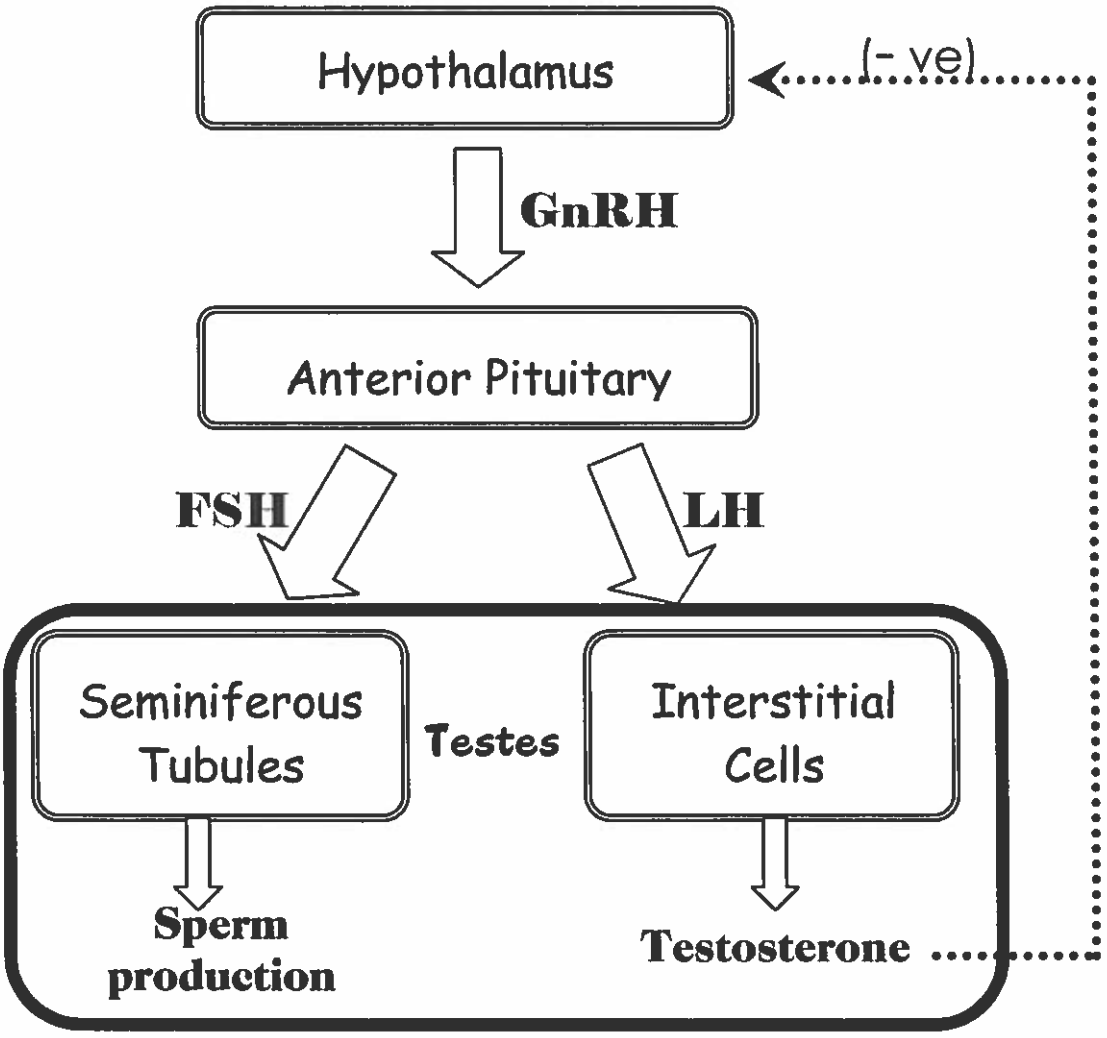
Testosterone and Androsterone

TESTOSTERONE

- Most potent of two hormones
- Stimulates **spermatogenesis**
- Influences development of **secondary sex characteristics**
  - Growth of facial, axillary and pubic hair
  - Receding Hair Line
  - Growth of larynx → lowering of the voice,
  - Strengthening of muscles,
  - Secretion of body oils→ acne and body odor
  - Thickening of the skin
  - Increased red blood cell count
  - Growth of long bones
  - Increased basal metabolic rate
- related to **sex drive** → **eunuchs!**

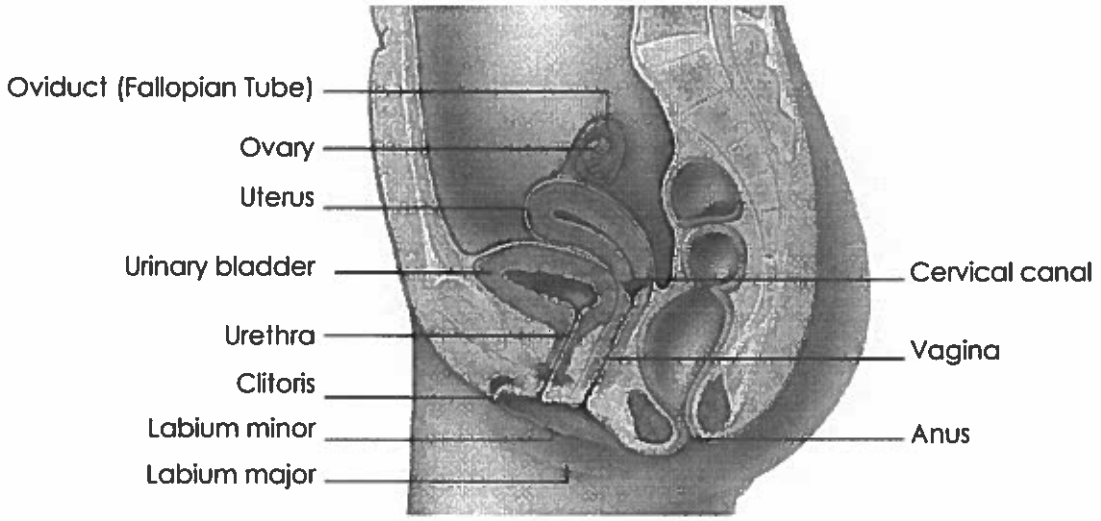
Regulation of testosterone:

- Feedback is controlled by the **hypothalamus-pituitary complex**
- Hypothalamus produces **gonadotropin-releasing hormone** (GnRH) which causes the **anterior pituitary** to release
  1. **Follicle-stimulating hormone (FSH)**
     - **FSH** stimulates **spermatogenesis** in the seminiferous tubules
  2. **Luteinizing hormone (LH).**
     - **LH** promotes production of **testosterone** by the interstitial cells
- **NEGATIVE FEEDBACK:**
  - ⇔ High levels of testosterone are detected by the hypothalamus which will release less GnRH → decreased production of LH by anterior pituitary.
  - ⇔ **Sertoli** cells in testes may produce a peptide hormone (inhibin) which feeds back to turn off GnRH and FSH.



The Female Reproductive System

A. Structures and Functions



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Vagina

- **Muscular tube** averaging 7 – 10 cm in length.
- Functions:
  1) receives the **penis** (and **sperm**) during sexual intercourse
  2) serves as the **birth canal** during childbirth
  3) provides a passage for **menstrual flow** during menstruation
- Importance of pH:

  strong acidity = bad environment for bacteria
  → helps prevent infections!
- Three layers:
  - innermost layer is lined with **mucous membrane**,
  - middle layer is **fibrous elastic tissue**,
  - outermost layer is a **muscular wall**
- Has **erectile tissue** which fills with blood during sexual excitement.
- Unlike the penis of the male, urine is released through the much smaller **urethral orifice** (opening) that is anterior to the vagina.

Uterus

- Hollow, pear-shaped muscular organ about the size of a fist.
- **Primary function** is to provide a **favorable environment** in its internal walls for the **fertilized ovum** (egg) to **attach**.

- Three layers:
  - **Perimetrium** – outermost layer, fibrous, elastic layer, connected to ligaments
  - **Myometrium** – composed of strong smooth **muscle** – which is the strongest muscle in the human body!
  - **Endometrium** – important mucous membrane lining the inside of the uterus
    - Where fertilized egg attaches!
      - **IMPLANTATION** – the attachment of fertilized ovum to endometrium!
    - **Glandular tissue** that provides nourishment for the developing embryo
    - If pregnancy (implantation) does not occur, the endometrium sheds – **MENSTRUATION.**
- **Ectopic pregnancy** – embryo attaches to **oviduct** instead of uterus – "tubal pregnancy" → very dangerous to both embryo and mother!

Cervix

- **Narrow muscular opening** at the bottom of the uterus.
- Separates vagina from uterus
- Holds baby in the uterus during pregnancy – this is the opening the doctors are measuring during labor to see how far the woman has "**dilated**"
- Secretes a **mucous** which can **encourage** or **prevent** sperm from entering the uterus.
- Susceptible to cancer ➔ **Cervical Cancer**
  - ***Pap test*** during yearly physical – scraping of cervix cells.

Ovaries (sing. ovary)

- **Gonads** of the female (counterpart of the male testes).

  ➔ produce the female sex hormones and ova (eggs)!
- Paired structures (2) – 3.5 cm long, 2 cm wide and 1 cm thick!
- Grey-pink and almond-shaped
- Located about 10 cm above the uterus – one on each side.

Did you know? Ovary development is largely complete by the time the female fetus is in the 3rd month in the womb and few major changes take place until puberty! At birth, the ovaries contain, between them, about 400,000 follicles, each containing an immature egg. At most only 500 or so of these eggs will ever be released, and probably no more than half a dozen – if that – will develop into new human beings.

Oviducts (aka Fallopian Tubes)

- 10 cm long tube that **carries ovum** (egg) from the **ovary** to the **uterus**
- two oviducts – one for each ovary
- finger like structures called **fimbrae** at opening of oviducts pick up the ovum that is released from the ovary
- **cilia** and **peristalsis** aid movement of ovum down the oviduct
- place where **fertilization** (union of sperm and egg) occurs (upper 1/3 of oviduct)
- takes fertilized ovum **3-5 days** to complete the **10- 12 cm** journey from the oviduct to the uterus
- unfertilized ovum's lifespan is about 2 days
- **tubal ligation** – "tubes tied" – cut and tie off oviducts!

External Female Genital Structure

Labia Majora

- protective fatty outer fold of skin containing pubic hair and sweat glands

Labia Minora

- inner fold of skin containing erectile tissue that is sensitive during sexual excitement

Clitoris

- 2-3 cm long structure of erectile tissue; located anterior to the urethra

Together labia and clitoris are referred to as the **vulva.**

Vestibular Glands

- glands of female reproductive system which produce secretions for lubrication during sexual intercourse
- located in the area between the labia minora

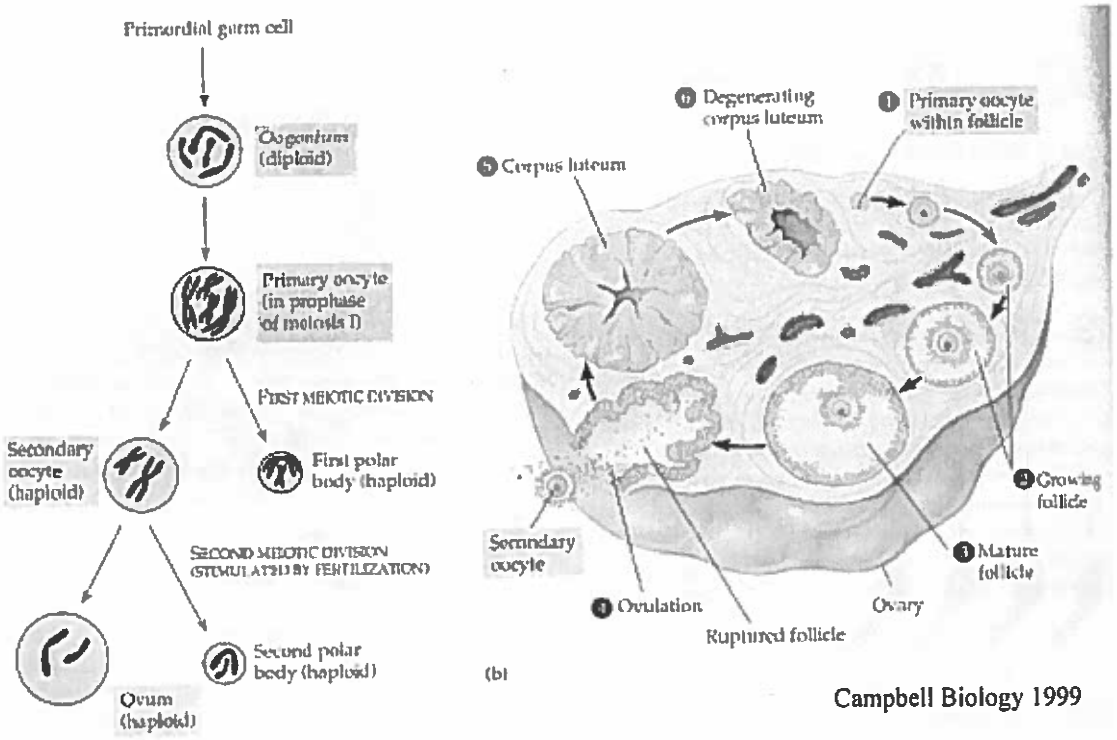
B. Oogenesis and Ovulation

- **Follicles** are structures in the ovary that contain the **egg** and secrete **estrogen.**
- Follicles composed of two types of cells:
  1. **Primary oocyte**
     - Oocyte containing 46 chromosomes
     - Undergoes meiosis to become a mature oocyte (ovum)
  2. **Granulosa oocyte**
     - Provide nutrients for the oocyte

- Unlike the testes which replenish sex cells, the female ovary undergoes **continual decline** after the **onset of puberty**.
  - Ovaries contain about **400 000** follicles at puberty.
  - Approx. **1000** follicles develop during each female reproductive cycle.
  - Usually only **1 (one)** follicle becomes dominant and **reaches maturity**.
- Between the ages of **12** and **50** in a women's life about 400-500 eggs will mature.
- By the time a woman reaches **menopause** few follicles remain.
  - Menopause marks the **end** of a woman's reproductive life and signals a drop in the production of female hormones.

Follicle Development

- Controlled by a hormone produced in the pituitary gland.
  - **Follicle-Stimulating Hormone (FSH)**
- Nutrient follicle cells surrounding the primary oocyte begin to divide.
- **Primary oocyte** (**2n** or **46** chromosomes) undergoes **meiosis I**.
- The majority of cytoplasm and nutrients move to one of the poles and form a **secondary oocyte** (**n** or **23** chromosomes).
- The remaining cell (called the **polar body**) receives little cytoplasm and dies.
- The secondary cells surrounding the secondary oocyte develop forming a fluid-filled cavity.
- **OVULATION** – involves the **release** of the **egg** from the follicle held within the ovary.
  - **Dominant follicle** pushes outward, ballooning the outer wall of the ovary.
  - Outer surface of ovary wall **bursts** and the secondary oocyte is released.
- **CORPUS LUTEUM** – follicle without the egg
  - Surrounding follicle cells remain within the ovary and are transformed into the corpus luteum
  - Secretes hormones essential for pregnancy
    - If pregnancy does not occur, the corpus luteum degenerates after about 10 days.
- **Secondary oocyte** (n, 23 chromosomes) enters the oviduct and undergoes **Meiosis II**
  - Again the division of the cytoplasm and nutrients is unequal.
  - Cell that retains most of the cytoplasm is the **mature oocyte** or the **ovum**; Polar body deteriorates.



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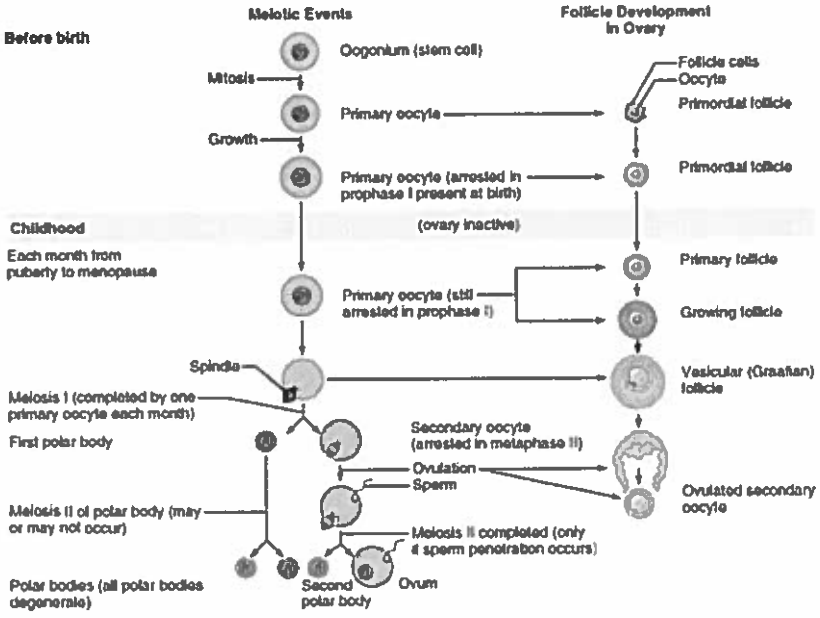
Oogenesis



14.3

C. The Menstrual Cycle

⇨ The female menstrual cycle takes approximately 28 days and goes through 4 stages:

1. Flow Phase

- Shedding of the **endometrium**.
- Only phase which is externally noticeable ➔ thus marks beginning of the cycle.
- Duration approx. **5 days**. (day 0 to 5)

2. Follicular Phase

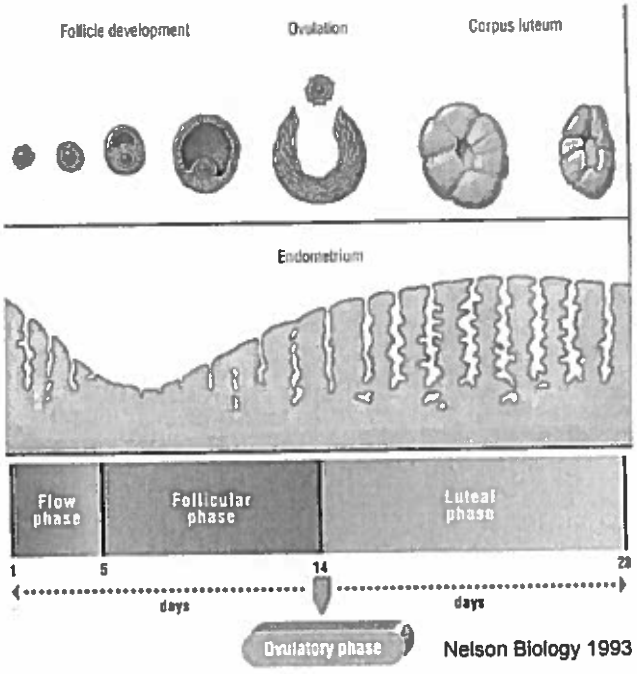
- Development of follicles in the ovary
- Promotes **estrogen secretion** ➔ development of secondary sex characteristics (breasts, body hair) and thickening of endometrium.
- Duration **8 days** (up to day 13).

3. Ovulation

- Egg bursts from the ovary and the follicle cells surrounding the egg form the **corpus luteum**
- Occurs on **day 14**.

4. Luteal Phase

- Corpus luteum secretes **estrogen** and **progesterone**.
- Progesterone stimulates the endometrium and prepares the uterus for an embryo.
- Progesterone also shuts off further ovulation and prevents uterine contractions ➔ birth control pills contain [high] of progesterone.
- If the ovum is unfertilized estrogen and progesterone decrease and the endometrium is shed marking the beginning of a new phase.
- Duration **14 days** (day 15-28).



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D. Hormonal Control

- The hormones of the ovary (**estrogen** and **progesterone**) are **regulated** by the **hypothalamus-pituitary** complex.
- The pituitary releases two hormones collectively called **gonadotropins**.

1. Follicle-stimulating Hormone (FSH)

- → Stimulates the development of follicle cells in the ovary
- → Follicle cells secrete **estrogen**

2. Luteinizing hormone (LH)

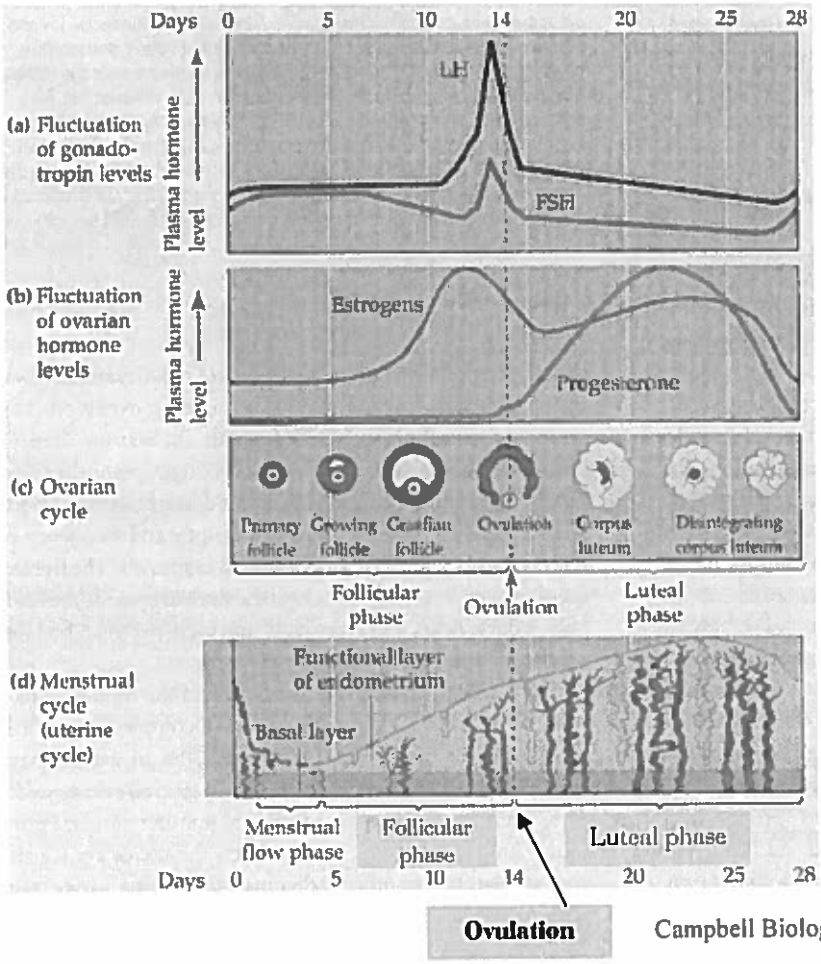
- → Stimulates **ovulation**, and the formation and maintenance of the **corpus luteum**
- → Corpus luteum secretes **estrogen** and **progesterone**

- The onset of **female puberty** is signaled by the release of **GnRH** (**gonadotropin-releasing hormone**) from the hypothalamus.

- GnRH activates the **pituitary gland** which is the storage site for **FSH** and **LH**.
- **Progesterone**
  - Female sex hormone
  - Inhibits ovulation
  - Inhibits uterine contractions
  - Stimulates the endometrium
- **Estrogen**
  - Female sex hormone
  - Produced by follicle cells
  - Inhibits growth of facial hair
  - Initiates secondary female characteristics
  - Initiates thickening of endometrium

Secondary Sex Characteristics

- growth of axillary and pubic hair
- maintains low blood cholesterol levels
- growth of the breasts
- increased deposits of subcutaneous fat (especially in hips and breasts) – female fat distribution
- widening of the pelvis
- increased basal metabolic rate
- facilitates calcium uptake
- increased water content of skin
- growth of long bones
- increased secretion of body oils (acne)



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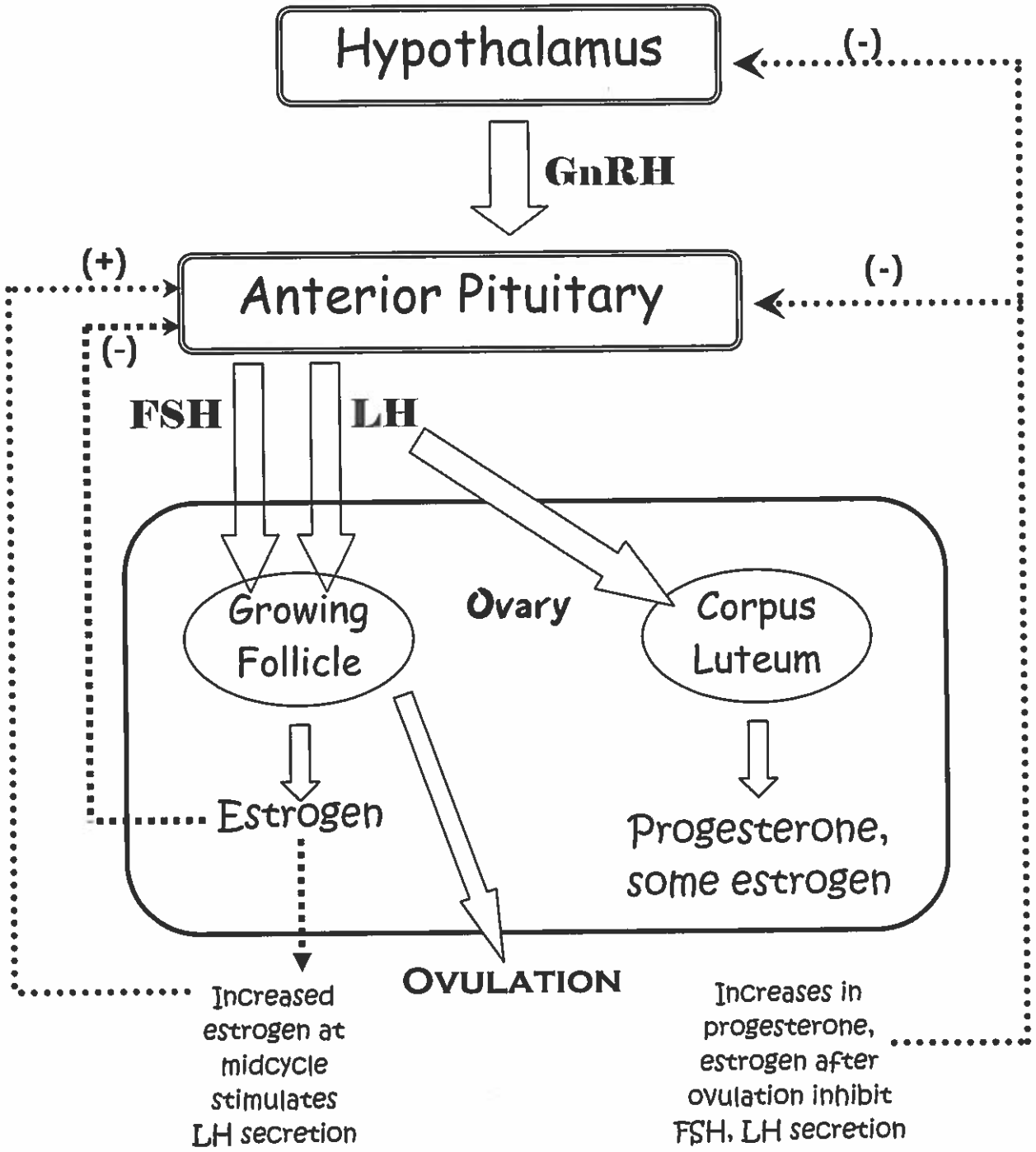
HORMONAL REGULATION OF FEMALE R.S.



Internet Resource! For an animation of the physiological and biological changes in the menstrual cycle as well as a detailed look at the 4 stages of the menstrual cycle check out: www.howstuffworks.com/menstruation.htm

Ch 15.

Fertilization and Pregnancy

- Between 150 million and 300 million sperm travel into the cervix during intercourse BUT only a few hundred actually reach the oviducts! WHY??

Did you know? *The oocyte is capable of being fertilized for up to 24 hours after ovulation, and some sperm remain viable in the female reproductive tract for up to 72 hours, although most have degenerated after 24 hours. Therefore, for fertilization to occur successfully, sexual intercourse must occur approximately between 3 days before and 1 day following ovulation.*

- Only one sperm will fertilize or penetrate the ovum in the upper portion of the oviduct.
  - Enzymes in the acrosome of the sperm help break down the egg's outer layer.
  - Once one sperm enters the ovum, a protein layer forms which acts as a barrier against all other sperm.
- The fertilized egg is now called a **Zygote** and begins cell divisions.
- The zygote cleaves (divides) to produce **two identical cells** by **Mitosis**.
- Mitotic division continues → by third day cluster of cells called a **morula**.
- By **day 6**, the single fertilized egg has been transformed into a **cell mass** with a hollow core and is called a **Blastocyst**.
- The blastocyst attaches itself to the uterus wall lining (**endometrium**)
  - referred to as **implantation**
  - **pregnancy** has occurred.
- For the blastocyst to develop into an embryo the **endometrium** must be maintained; however, this presents a **problem** for the hormonal system!
  - **Estrogen** and **Progesterone** do help **maintain** the **endometrium** <u>BUT</u> they also have a **negative feedback effect** on the **hypothalamus** and **pituitary** to turn **off LH** secretion.
  - Without LH the corpus luteum breaks down and estrogen and progesterone levels decrease → endometrium breaks down and sheds → termination of pregnancy.

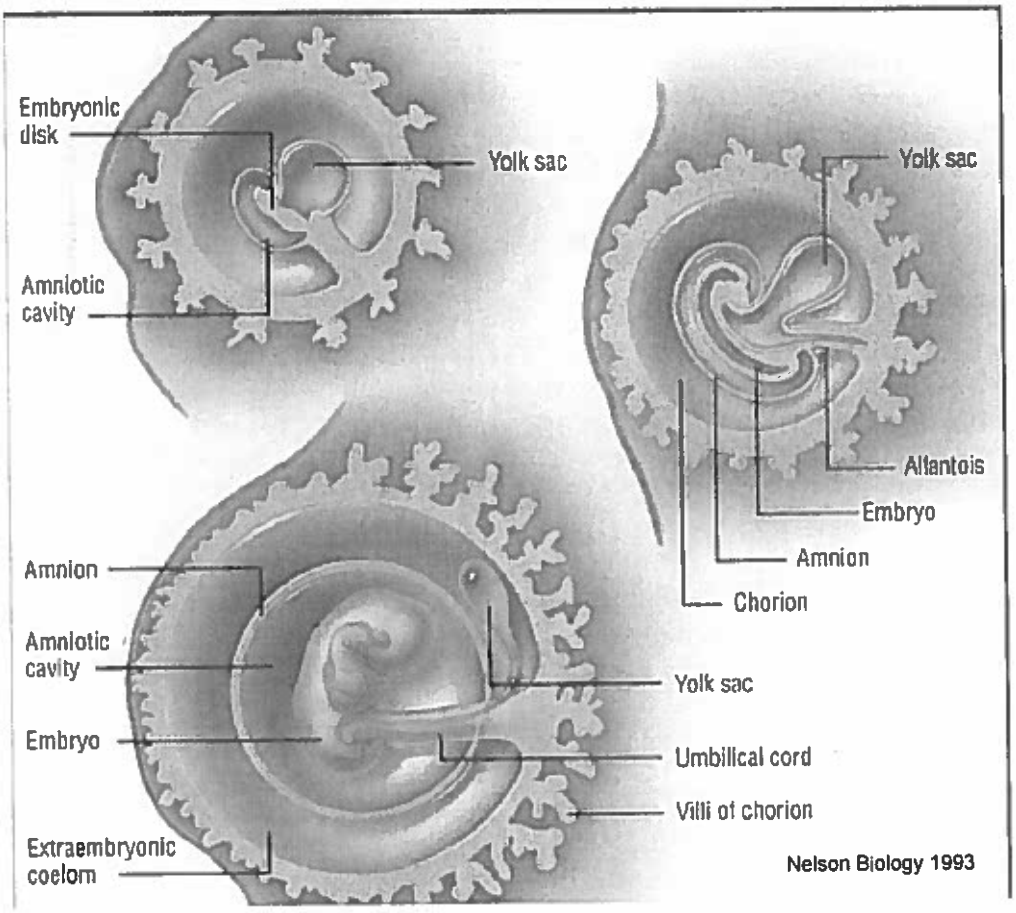
- **HOW ARE ESTROGEN AND PROGESTERONE LEVELS MAINTAINED?**
  - The outer layer of the developing blastocyst starts producing a hormone called **HCG** (**Human Chorionic Gonadotropic Hormone**) that maintains the corpus luteum for the first three months of pregnancy (1st trimester).
  - **Pregnancy tests** identify HCG levels in the urine of women.

Once a woman is pregnant she cannot become pregnant again during that particular pregnancy. What role does progesterone play in this?

Prenatal Development

- What is the difference between an **embryo** and a **fetus**?
  - Referred to as Embryo until 9th week of pregnancy.
  - Referred to as Fetus after 9th week of pregnancy.

Embryonic Membranes



- The outer membrane of the **blastocyst** is known as **CHORION**.
  - Produces **HCG**
- The inner membrane is the **AMNION**.
  - Fluid filled embryonic membrane
  - Develops above the embryo
  - Serves **several functions** including cushioning the embryo from impact to the mother, temperature control of the embryonic environment, protection of the fetus from infection and enhancing muscle development, joint development, and neural connections by allowing the fetus to move more freely.

- The **yolk sac** does not supply nutrients to a mammalian embryo as it does in birds, reptiles and amphibians.
    - Forms in week 4
    - Several important functions in humans → it is an early source of red blood cells before the embryo produces its own, it forms a portion of the digestive tract and it is the source of the primordial germ cells.
- Cells of the fetus and endometrium comprise the **placenta**.
    - Essential to the survival and growth of the embryo/fetus
    - Produces important **hormones** (eg. HCG, estrogen, progesterone)
    - Provides the membrane **surface for exchange** of nutrients, minerals, hormones, antibodies, gases and wastes between the fetal blood supply and the maternal blood supply.
        - **Nutrients** and **oxygen** diffuse from the mother's blood into the fetus
        - **Waste** diffuses across the placenta into mother's blood stream
        - What else can diffuse across the placenta into the fetal blood supply? (hint: it is responsible for FAS!)
    - At same time, acts as a **barrier** between the fetal and maternal blood supplies.
    - Site where many **teratogens** (environmental agents that induce developmental abnormalities) cross over from the maternal blood supply to the embryo/fetal blood supply.

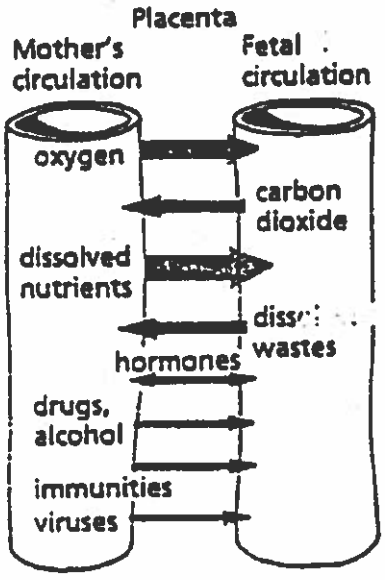


Figure: The placenta forms a barrier between the fetus and the mother which prevents blood cells and large proteins from crossing from one system to the other. The blood vessels of the two systems are so closely associated in the placenta that nutrients and other needed substances can easily pass intothe fetal circulation. Waste products can also pass from the fetal blood into the mother's blood for excretion.

- A third membrane provides blood vessels in the placenta →**Allantois** – does not envelop the fetus.
- The **umbilical cord** connects the embryo to the placenta.

THE THREE TRIMESTERS OF PRENATAL DEVELOPMENT

First Trimester

- Fertilization to 3 months (up to 12 weeks)
- Called an **embryo** for the first 8 weeks
- End of 3rd week after fertilization, embryo has developed into a three-layered disc.
- Process of forming the 3 germ layers is called **gastrulation** and involves the migration of cells between the two layers of cells found in the blastocyst.
- Three-layered disc gives rise to the various tissues and organs of the embryo.
    - **Ectoderm** – outer layer gives rise to the epidermis (skin, hair, etc) and the nervous system.
    - **Mesoderm** – middle layer, gives rise to the muscle, bone and blood vessels.
    - **Endoderm** – inner layer, gives rise to the linings of the digestive and respiratory tracts.
- **Development of organ systems** occurs primarily from the **4th to 8th week** – time period when fetus is most likely to develop abnormalities as a result of exposure to **teratogens.**
    - 4 weeks: heart beat, limb buds, 0.62 cm, "tadpole"
- 9 weeks: **FETUS** – 4 cm, fingers, toes, movement
- 12 weeks: 9 cm, body organs are well formed

Second Trimester

- 4 to 6 months (13 to 24 weeks)
- grows to 35 cm
- eyelids and eyelashes form, hair covers body
- sex can be determined
- End of 6th month is the earliest the baby could be born and live outside the uterus **(has technology changed this??)**

Third Trimester

- 7 to 9 months (40 weeks total)
- body mass increases – fat is deposited
- organs develop (lung development is sufficient by 26 to 28 weeks for a premature infant to survive).
- can hiccup and cry, taste, respond to light and sound
- at birth, average length is 53 cm long and weighs about 3.4 kg (7.5 pounds)

NOTE: Alcohol and other **teratogens** can still cause mental retardation late in pregnancy!

Stages in Fetal Development

AN OVERVIEW

- After fertilization occurs in the Fallopian tube, the **zygote** cleaves to produce two identical cells.
- Mitotic division continues, and a mass of cells moves down the Fallopian tube to the uterus.
- The mass of cells develops a hollow core and starts to be called the **blastocyst** at about the time that it implants itself in the uterus.
    - The blastocyst will eventually form embryonic tissues and early embryonic membranes (chorion, yolk sac, amnion).
- The blastocyst is a critical stage of development that can be used to illustrate the importance of timing in normal human development.
    - For example, if the chorion does not form and begins to secrete HCG, then a spontaneous abortion will occur.
- The **chorion** is the embryonic portion of the placenta.
- The **placenta** is essential to the survival and growth of the embryo/fetus.
    - It produces important hormones (e.g. HCG, estrogen, progesterone).
    - It provides the membrane surface for exchange of nutrients, minerals, hormones, antibodies, gases and wastes between the fetal blood supply and the maternal blood supplies.
    - It is also the site where many **teratogens** (environmental agents that induce developmental abnormalities) cross over from the maternal blood supply to the embryo/fetal blood supply.
- The **yolk sac** does not supply nutrients to a mammalian embryo as it does in birds, reptiles, and amphibians.
    - It does however, have several important functions (e.g. it is the early source of red blood cells before the embryo produces its own, it forms a portion of the digestive tract, and it is the source of the primordial germ cells).
- The **amnion** will eventually surround the embryo, enclosing it in a fluid-filled sac. This fluid-filled sac serves several functions including:
    - cushioning the embryo from impact to the mother,
    - temperature control of the embryonic environment,
    - protection of the fetus from infection, and
    - enhancing muscle development, joint development, and neural connections by allowing the fetus to move more freely.

- At the end of the third week after fertilization, the embryo has developed into a **three-layered disc**. The process of forming the three layers is called **gastrulation** and involves the migration of cells between the two layers of cells found in the blastocyst.
- It is this three-layered disc that gives rise to the various tissues and organs of the embryo.
    - The **ectoderm**, or outer layer, gives rise to the epidermis (skin, hair, etc) and the nervous system.
    - The **mesoderm**, or middle layer, gives rise to the muscle, bone, and blood vessels.
    - The **endoderm**, or inner layer, gives rise to the linings of the digestive and respiratory tracts.
- Development of the organs and organ systems from the three embryonic layers involves three main processes:
    - **growth**;
    - development of body form (**morphogenesis**), which includes precisely timed mass cell movements and their interaction; and
    - **differentiation** that results in the formation of functional organs and organ systems.
        - The development of organ systems occurs primarily from the 4th to 8th week of human development (during the first trimester).
        - This is the time period when the fetus is most likely to develop abnormities as a result of exposure to teratogens.
        - *Please refer to the teratogens chart and their possible affects on embryonic development.*
- The timing of events in human development allows researchers to determine the approximate range of time that exposure to a particular teratogens may have occurred to produce a developmental abnormality. In many cases, the damage occurs before a woman is aware that she is pregnant.
    - Examples of abnormalities:
        - Formation of facial features – cleft palate caused by exposure to the teratogens vitamin A (used as an acne treatment) or as a result of inherited factors.
        - Formation of abnormal limbs due to exposure to the teratogens thalidomide, or of extra digits on limbs as a result of a dominant inherited gene.
        - Formation of the nervous system – mental retardation due to fetal alcohol syndrome, toxoplasma gondii (a parasite that also infects cats), or the rubella virus (German measles), spina bifida (which has been linked to several environmental and nutritional factors)
        - Formation of the eye – cataracts due to the rubella virus
        - Formation of the heart – abnormalities due to exposure to vitamin A.

- The **second** and **third trimesters** of development are primarily periods of growth.
  - Important development of some key structures, including the lungs and nervous system, continues to occur.
  - Alcohol and other teratogens can still cause mental retardation late in pregnancy.
  - Babies born at the end of the second trimester can survive.
  - Lung development is sufficient by 26 to 28 weeks for a premature infant to survive.
  - In the third trimester, fat is deposited.

Birth

Did you know? "Stumpies" (a type of lizard) give birth to young that are 35% of the mother's body weight. That is equivalent to a human giving birth to an average 6 year old. OUCH!! In addition, stumpies do not expand in size during pregnancy, so for the last four weeks of pregnancy, they eat almost nothing, are unable to breath properly, and move very little. Obviously, they find it hard to exercise, forage for food or escape predators. And we thought we had it rough!

- Approximately 266 days / 40 weeks / 9 months after implantation the **uterus begins to contract** and **LABOR** begins.

- **Birth** or **Parturition** consists of three stages.

1. Dilation of the Cervix

- **Opening up** and **thinning** of the cervix, ending with complete dilation – can take from 8-24 hours.
- Uterine contractions begin to push the head toward the cervix.
- Amniotic membrane often bursts → this lubricates the birth canal (process often referred to as "breaking of the water").

2. Regular Contractions and the Expulsion of the Fetus

- Continuous strong contractions force the fetus down and out of the uterus and vagina.
- Umbilical cord is cut and clamped
- Duration: minutes to hours

3. Delivery of the Placenta

- aka afterbirth

HORMONES INVOLVED IN LABOR

- **Relaxin**
  - ➔ Hormone produced by the placenta prior to labor
  - ➔ Causes ligaments within the pelvis to relax (loosen)
  - ➔ Provides a more flexible passageway for the baby during delivery
- **Oxytocin**
  - ➔ From posterior pituitary
  - ➔ Causes strong uterine contractions **(+ve feedback)**
- **Prostaglandins**
  - ➔ Produced by mother (in mother's blood before labor)
  - ➔ Trigger strong uterine contractions
- **Progesterone**
  - ➔ Decreased production may signal onset of labor.

Lactation

- ➔ Elevated levels of estrogen and progesterone prepare the breast for milk production.
- ➔ Each breast contains 20 lobes of glandular tissue, supplied with a tiny duct that carries fluids to the nipple.

- ➔ **Prolactin**
  - o a hormone produced by the pituitary
  - o is responsible for **milk production**
  - o causes the production of **colostrums** ("pre-milk" – proteins and sugar but no fats)
- ➔ **Oxytocin**
  - o a hormone produced from the posterior pituitary
  - o causes weak contractions of smooth muscles within breast which forces milk into the ducts **"milk letdown"**
- ➔ A woman can produce as much as **1.5 L** of milk each day.
- ➔ Breast milk is advantageous because it contains all the nutrients plus many antibodies needed by the baby.
- ➔ Breast-feeding mothers have to replace **2 to 3 g** of **calcium phosphate** each day.
  - o Failure to do so results in a **progressive deterioration** of the skeleton and teeth.

Known Human Teratogens

Teratogens are environmental agents that induce developmental abnormalities.

MEDICATIONS

Teratogen	Most Common Congenital Anomalies
Thalidomide (tranquilizer & sedative)	Limb reduction defects, ear anomalies, heart defects.
Aminopterin and methotrexate (tumour inhibiting chemicals)	Inhibits mitosis in rapidly dividing cells resulting in serious defects. Pregnancy loss, malformation of the CNS (including absence of most of the brain), craniofacial abnormalities.
Streptomycin (antibiotic)	Hearing loss
Tetracycline (antibiotic)	Exposure in the second or third trimester: yellow-stained teeth, other tooth enamel defects.
Isotretinoin (Rentinoic acid or vitamin A used in acne treatment)	Exposure at three to five weeks: pregnancy loss, neural tube defects, brain defects, small or absent thymus, heart defects, craniofacial abnormalities (small ears, small jaws, cleft palate).
Antithyroid drugs and potassium iodide found in cough mixtures	Hypothyroidism (cretinism), goiter
Androgens and high doses of norprogesterone	Exposure in the first trimester: masculinization of external female genitalia
ACE inhibitors (antihypertension agents)	Low volume of amniotic fluid, fetal death, renal dysfunction, skull ossification defects
Lithium (manic-depression treatment)	Heart and major blood vessel anomalies

MATERNAL INFECTIONS

Teratogen	Most Common Congenital Anomalies
Rubella virus (German measles)	Exposure in the first trimester: heart and blood vessel anomalies, small brain, hearing loss, eye defects (glaucoma and cataracts), post-natal growth delay
Varicella (chickenpox)	Exposure in the first trimester: kin scarring, limb reduction defects, muscle atrophy, mental retardation, rudimentary digits
Syphilis (microorganism)	Abnormal teeth and bones, mental retardation
Cytomegalovirus	Exposure in the first trimester: fatal to most embryos Exposure later in pregnancy: growth and developmental retardation, small brain, hearing loss, ocular abnormalities, cerebral palsy
Herpes	Pregnancy loss, growth retardation, eye abnormalities, transmission to infant most commonly occurs at delivery

CHEMICAL

Teratogen	Most Common Congenital Anomalies
Organic mercury (often found in contaminated fish)	Cerebral atrophy, spasticity, mental retardation, blindness Minamatu disease: characterized by neurological and behavioural disturbances that resemble cerebral palsy
Lead	Pregnancy loss, central nervous system damage
Polychlorobiphenyls (PCBs) ingested	Low birth weight, skin discolouration

MATERNAL DISORDERS

Teratogen	Most Common Congenital Anomalies
Diabetes mellitus (if poorly controlled)	Congenital heart defects, neural tube defects, limb defects, vertebral anomalies, pregnancy loss
Hypo/hyperthyroidism	Goiter, growth and developmental retardation
Phenylketonuria (PKU) left untreated	Pregnancy loss, small brain, mental retardation, facial abnormalities, congenital heart defects
Hypertension	Intrauterine growth retardation
Autoimmune disorders	Congenital heart block, pregnancy loss

OTHER REPRODUCTIVE TOXINS

Teratogen	Most Common Congenital Anomalies
Cigarette smoking	Pregnancy loss, low birth weight
Hyperthermia	Neural tube defects
Chronic alcoholism or binge drinking	Fetal alcohol syndrome (FAS): growth and developmental retardation, abnormal facial features (widely spaced eyes, thin upper lip)
Therapeutic radiation	Growth and developmental retardation, small brain, spina bifida, retinal pigment changes, cataracts, cleft palate
Cocaine	Pregnancy loss, placental abruption, growth retardation, small brain, neurobehavioural disturbances, urogenital anomalies