Based on lecture and text material, you should be able to do the following:

Reproductive system:

- describe the common functions of the male and female reproductive systems
- describe the structure and function of the testes, and explain the importance of their location in the scrotum
- describe the location, structure and function of the accessory ducts and glands of the male reproductive system
- describe the location, structure and function of the ovaries
- describe the location, structure and function of each of the organs of the female reproductive system
- discuss the structure and function of the mammary glands
- define meiosis and contrast it with mitosis
- outline the events of spermatogenesis
- describe the process of oogenesis and compare it to spermatogenesis
- discuss the hormonal regulation of testicular function and the physiological role of testosterone on the male reproductive system (and secondary sexual traits)
- describe the phases of the ovarian cycle and relate them to the events of oogenesis
- describe the regulation of the ovarian and menstrual cycles]

- discuss the physiological effects of estrogens and progesterones
- note the significant events of puberty and menopause

Pregnancy and Development:

- describe the process of capacitation and discuss it=s importance in the ability of the sperm to fertilize the egg
- explain the mechanisms underlying the fast and slow blocks to polyspermy
- define fertilization
- describe the process of implantation and placenta formation
- describe the functions of the placenta
- describe the changes that occur in the reproductive, cardiovascular, urinary, and respiratory systems of the mother during pregnancy
- note the effects of pregnancy on maternal metabolism
- explain how labour is thought to be initiated and describe the three stages of labour
- outline the events leading to the first breath of a newborn
- describe the changes that occur in the fetal circulation after birth
- explain how the breasts are prepared for lactation and nursing

I. INTRODUCTION

All cells in the body except for a special group in the reproductive organs (gonads) divide by the process of mitosis. In this process, two cells are formed which are identical to the original cell. These cells are referred to as somatic cells.

Within the reproductive glands are a special group of cells called germ cells. These cells are unique in that they have the ability to undergo meiosis. In meiosis, the cells produced following cell division have only one half of the chromosomes of the original cell. As such they are said to be haploid (diploid refers to the original condition). These haploid cells are called gametes. For the original chromosome number to be re-established, two gametes must fuse together. Because this results in genetic material from two different individuals coming together in the new fertilized cell, this is referred to a sexual reproduction.

II. PHYSIOLOGY OF THE MALE REPRODUCTIVE SYSTEM

In the male, the gamete produced is sperm and the process of producing sperm is called spermatogenesis.

A. SPERMATOGENESIS

The immature germ cell in the male is referred to as the spermatogonium. These cells are located just under the basement membrane of the seminiferous tubules, between adjoining sustentacular (Sertoli) cells. Since sperm production continues throughout adult life and at the peak, 100-200 million sperm can be produced daily, the spermatogonia are constantly renewed. The first step in spermatogenesis is a mitotic division of the spermatogonium. One of the daughter cells remains, to replace the original spermatogonium, while the other cell (now called a primary spermatocyte) undergoes meiosis. The first meiotic division yields two secondary spermatocytes. Usually, these secondary spermatocytes do not fully separate during cell division, leaving a direct cytoplasmic connection between the cells. Following the second meiotic division (again, an incomplete division), the cells are known as spermatids (see figure 28.4 in the text). As the germ cells are undergoing meiosis, they are also migrating through the Sustentacular cell towards the lumen of the seminiferous tubule. As they approach the lumen, they shed much of their cytoplasm. They are attached to the Sustentacular cells, *via* specialized junctions, which provide nutrients. When the spermatids reach the lumen, they remain embedded within the sustentacular cells, where they undergo tail development, acrosome formation and nuclear condensation. Finally, the fully-formed spermatozoa are shed into the lumen of the seminiferous tubule, where they are carried to the epididymus. This whole process takes between 60 and 70 days.

Ducts

The spermatozoa traverse the epididymus in 2 to 4 weeks. During this time, they lose most of the remaining cytoplasm, as well as increase in mobility. The epithelial cells which line the epididymus secrete proteins which bind to the sperm cell membranes, to enhance their forward mobility and ability to fertilize an ovum. The sperm migrate into the ductus (or vas) deferens, where they can be stored for several months. The vas deferens runs up through the spermatic cord, conducting the sperm to the prostate gland. The end of each ductus deferens (two) enlarges to form ampullae, where sperm are stored until ejaculation. The prostate contains the first part of the urethra (prostatic urethra) which is where the ejaculatory ducts merge with the urethra. The urethra exits the prostate, penetrated the urogenital diaphragm and runs the length of the penis.

B. MALE SEXUAL RESPONSE

1. Erection

The first phase of the male sexual response is erection of the penis, which allows it to penetrate the female vagina. This occurs when the erectile tissue of the penis becomes engorged with blood. When a male is not sexually aroused, the arterioles supplying the erectile tissues are constricted. During sexual excitement, a parasympathetic reflex is triggered that causes these arterioles to dilate. As a result, the vascular spaces of the penis fill with blood causing the penis to become enlarged and rigid. Expansion of the penis also compresses the veins retarding the outflow of blood and further contributing to the swelling of the penis. This reflex is initiated by a variety of stimuli ranging from thought to touch.

2. Ejaculation

When the stimuli provoking erection become strong enough, a spinal reflex is initiated which produces a massive sympathetic discharge to the genital organs. As a result, the reproductive ducts and accessory glands contract peristaltically discharging their contents into the urethra. The muscles of the penis undergo a rapid series of contractions propelling semen from the urethra. This is followed by muscular and psychological relaxation and vasoconstriction of the arterioles serving the penis, which causes the penis to become flaccid again.

3. Role of the Accessory Glands

The bulbourethral glands are paired glands that secrete a small amount of thick clear mucus. This secretion is released prior to ejaculation and is believed to neutralize traces of acidic urine in the urethra.

The seminal vesicles are paired glands that produce about 60% of the semen. Their secretions contain fructose sugar, ascorbic acid and prostaglandins. These are sac shaped glands, approximately 5 centimeters long, which lie along side the ampullae of the ductus deferens. They each empty into a short duct, the ejaculatory duct, which merges with the terminal end of the ductus deferens. These, in turn, fuse with the prostatic urethra which runs from the bladder through the prostate gland. The alkalinity of the fluid serves to neutralize the normally acidic environment in the distal urethra and in the vagina. The fructose is supplied as an energy source for the sperm, and the prostaglandins serve to stimulate smooth muscle contractions in the vagina and cervix. This is thought to facilitate the uptake of sperm into the uterus.

The prostate gland is a single gland, which secretes about one third of the semen volume. It secretes a milky, slightly acidic fluid containing citrate, acid phosphatase and several proteolytic enzymes. These enzymes are probably involved in breaking down the mucus plug in the cervix. They also appear to contribute to the motility and viability of the sperm

4. Semen Production

Remember, Sperm + seminal fluid = semen.

Semen provides a transport medium for the sperm. It also provides nutrients for the sperm and chemicals that protect them, activate them and facilitate their movement. The amount of semen released during ejaculation is relatively small, about 2-6 ml but it contains 50-100 million sperm per ml.

C. HORMONAL REGULATION OF MALE REPRODUCTIVE FUNCTION

1. Brain-Testicular Axis

Spermatogenesis is under hormonal control and involves interactions between the hypothalamus, anterior pituitary gland and the testes, a relationship sometimes called the brain-testicular axis.

Recall that the hypothalamus produces a hormone called gonadotropin-releasing hormone (GnRH), which controls the release of a pair of anterior pituitary hormones called gonadotropins.

The gonadotropins are the luteinizing hormone (LH) and the follicle-stimulating hormone (FSH).

LH binds to interstitial cells in the testes, cells found between the sperm-producing seminiferous tubules, and stimulates them to secrete testosterone (T). Most of T diffuses through to the seminiferous tubules while the rest enters the general circulation.

FSH, on the other hand, stimulates the Sertoli cells of the seminiferous tubules to release a protein called androgen-binding protein (ABP).

ABP binds to T, which increases concentration of T within the testes. This is important as T stimulates and is absolutely required for spermatogenesis.

T also acts on the hypothalamus in a negative feedback fashion to turn off GnRH release and may act directly on the anterior pituitary to inhibit gonadotropin release.

The Sertoli cells are also sensitive to the rate of spermatogenesis and when the sperm count is high, they release a protein hormone called inhibin.

Inhibin acts on the anterior pituitary to inhibit FSH (but not LH) release and may also directly inhibit GnRH release by the hypothalamus.

In summary, GnRH, gonadotropins, and testosterone are all required for normal testicular function. In their absence, the testes atrophy and sperm and testosterone production are greatly reduced.

2. Mechanism and Effects of Testosterone Activity

Testosterone is a cholesterol based steroid hormone. It enters cells freely by diffusing through the phospholipid bilayer. If there are receptors present in the cytoplasm, it will bind with them and act to regulate RNA transcription of specific genes to enhance the synthesis of certain proteins in the target cells. In different target cells, this leads to different effects. In many, it leads to growth.

II. PHYSIOLOGY OF THE FEMALE REPRODUCTIVE SYSTEM

OOGENESIS

This process is the equivalent of spermatogenesis in the male. However, the two processes are vastly different. In females, much of the process occurs during fetal development. The primitive germ cells undergo numerous rounds of mitosis, which produces millions of oogonia (2n). Most of these oogonia are resorbed (through a process called atresia). However, a few hundred thousand begin meiosis and enter prophase I. These are now referred to as primary oocytes. There are no oogonia present in the adult female. The primary oocytes are arrested in prophase I and become quiescent until puberty. As will be discussed later, cyclical changes in LH and FSH will trigger three or four primary oocytes to finish meiosis each uterine cycle. During the two meiotic divisions, all the cytoplasm will stay with a single daughter cell, which is destined to become the ovum. The other three daughter cells simply develop as small polar bodies that are eventually degraded and resorbed.

C. HORMONAL REGULATION OF THE OVARIAN CYCLE

The normal ovarian cycle involves the interactions of a number of hormones, notably GnRH released from the hypothalamus, FSH and LH released from the anterior pituitary and estrogen and progesterone released from the ovary.

Establishment of the Ovarian Cycle

During childhood, the ovaries grow and produce small amounts of estrogen (E), which acts on the hypothalamus to inhibit the release of GnRH.

As puberty nears, the hypothalamus becomes less sensitive to estrogen and this relatively small concentration of estrogen is no longer sufficient to inhibit GnRH release.

The release of GnRH gradually triggers the release of LH and FSH, which begin to act on the ovaries. Gonadotropin levels continue to increase slowly for several years and eventually become high enough to set the cycle in motion.

2. Hormonal Interactions During the Ovarian Cycle

FSH, LH and estrogens control follicle growth and oocyte maturation in tandem.

(1) On day one of the cycle, GnRH from the hypothalamus stimulates increased production and release of FSH and LH by the anterior pituitary. This is the start of the follicular phase of the ovary.

(2) FSH and LH stimulate follicular growth and maturation. FSH primarily stimulates follicle cells while LH, at this time, primarily stimulates thecal cells. As the follicles grow, LH prods the thecal cells to produce androgens, which diffuse through to the granulosa cells where the FSH stimulates the granulosa cells to convert them to estrogens.

(3) As estrogen levels rise in the plasma, they inhibit the anterior pituitary to slow down the release of FSH and LH (the granulosa cells may also release some Inhibin, which will do the same Within the ovary, the estrogens

intensify the effect of FSH on the growth and maturation of the follicle. This stimulates even more production of estrogen.

(4) Although low levels of estrogen in the blood cause reduced release of gonadotropins, high levels of estrogen have the opposite effect on the release of these compounds. Thus once estrogen levels become high enough they trigger a positive feedback cycle. Now the FSH and LH are released leading to the production and release of more estrogen, which leads to the production and release of more FSH and LH. His signals the end of the follicular phase and the start of the ovulation phase.

(5) The sudden flush of LH stimulates the resumption of meiosis in the primary oocyte causing it to complete the first meiotic division. LH also triggers the events that cause the bulging ovarian wall to rupture at or around day 14. At this time there is a rapid accumulation of follicular fluid in the antrum. Blood flow to the externally protruding part of the follicular wall stops and that part of the wall thins, bulges and then ruptures, releaseing the oocyte (now called the ovum) into the peritoneal fluid. The role of FSH in this process is unknown. Estrogen secretion rapidly declines, probably due to the damage done to the follicle. Ovulation (the release of the ovum)

signals the end of the ovulatory phase and the start of the leuteal phase.

(6) The LH surge also promotes transformation of the ruptured follicle into the corpus luteum. This is why it is called luteinizing hormone. LH now stimulates the corpus luteum to secrete progesterone and smaller amounts of estrogens.

(7) As progesterone and estrogen levels continue to rise in the blood, they inhibit the release of FSH and LH from the anterior pituitary. As these levels fall, the development of any other follicles is inhibited.

(8) As LH levels fall, the stimulus for corpus luteum activity also falls and the corpus luteum begins to degenerate. As a result, the levels of progesterone and estrogen also fall and the inhibition of GnRH and the release of FSH and LH are removed and the cycle begins again.

D. UTERINE CYCLE

The functional layer of the endometrium undergoes physical changes throughout the ovarian cycle and these changes are controlled by ovarian hormones. The most obvious change occurs during the menstrual phase,

which is triggered by the end of the luteal phase in the ovary. Progesterone levels drop rapidly as the corpus luteum degrades. This drop causes the arteries which serve the functional layer of the endometrium (THE SPIRAL ARTERIES) to constrict, cutting off the blood flow to the functional layer. Soon after, the functional layer becomes necrotic and is sloughed off, passing out through the cervix and vagina. This is known as menstruation. This process usually takes 3-5 days. During this period, the smooth muscle of the uterus can become irritable and often undergo spontaneous contractions. The contractions (which can be felt as cramps) serve to facilitate sloughing of the necrotic tissue.

Once the previous functional layer has been sloughed, the uterine lining begins to proliferate. This is triggered by the rising estrogen levels of the ovarian follicular phase. The blind ends of the uterine or endometrial glands (which terminate in the basal layer of the endometrium) begin to grow. As well, there is significant angiogenesis as the spiral arteries begin to grow. This phase is know as the proliferative phase of the uterus and it is characterized by a general thickening of the functional layer of the endometrium, in preparation for implantation of a embryo.

Just after ovulation, the progesterone levels start to rise as the corpus luteum becomes functional in the ovary. The progesterone stimulates a change in the endometrium. It stops proliferating and the uterine glands begin secreting a watery, glycogen-rich fluid which will serve to nourish any developing embryo until it can implant in the wall of the uterus. This phase is known as the secretory phase.

E. FEMALE SEXUAL RESPONSE

The female sexual response is similar to that of males. Sexual excitement is initiated by similar stimuli, from thought to sight, smell and touch. It is accompanied by engorgement of the clitoris, vaginal mucosa and breasts with blood; erection of the nipples and increased secretory activity of the vestibular glands that lubricate the vestibule and facilitate entry of the penis. These events are mediated along the same autonomic pathways as in men.

The final phase of the female sexual response, orgasm, is not accompanied by ejaculation although it does give rise to muscle spasm and uterine contractions. This is not associated with ovulation and is not required for conception in humans.

III. DEVELOPMENTAL ASPECTS

A. PUBERTY

Males

Development of male reproductive structures depends on prenatal secretion of male hormones. Thus the levels of these hormones are high in the prenatal period and for some time after birth. They then decline and remain low throughout childhood.

As puberty approaches, the threshold for hypothalamic inhibition rises and, since much higher levels of testosterone are now required to turn off the production of GnRH, blood levels of testosterone rise. This rise in threshold is a slow process and it takes about three years for a new steady state to be reached. This rise in testosterone leads to the onset of spermatogenesis.

It also has multiple anabolic effects throughout the body. It now is in levels high enough to stimulate cells of all the accessory reproductive organs - glands, ducts, and the penis - causing them to grow and assume adult functions. It also stimulates cells that give rise to the appearance of pubic, axillary and facial hair and a deepening of the voice as the larynx enlarges.

The skin thickens and becomes oilier; bones grow and increase in density and skeletal muscle increase in size and mass. Metabolic rate increases also and testosterone also stimulates the sex drive. Levels must remain high for these accessory organs to retain their size and function. If testosterone levels fall for any reason, sterility and impotence follow.

Females

As the levels of gonadotropins slowly rise at puberty, they eventually become high enough to trigger an ovarian cycle. The first menstrual period is referred to as menarche. During the next one to two years, many of the cycles are still anovulatory, i.e. no oocytes are released. It is not until the third year that the cycle becomes regular and the luteal phase reaches its normal duration of 14 days.

As estrogen levels rise during puberty and they promote oogenesis and follicle growth, they also exert anabolic effects. The uterine tubes, uterus and vagina grow larger and become functional. The uterine tubes and uterus exhibit motility, the vaginal mucosa thickens and the external genitalia mature and become lubricated. Estrogens also induce the secondary sexual characteristics of females. These include : 1) growth of the breasts, 2) increased deposit of subcutaneous fat especially in the hips and breasts, 3) widening and lightening of the pelvis, 4) the appearance of axillary and pubic hair.

V. PREGNANCY AND DEVELOPMENT

A. FROM EGG TO EMBRYO

Pregnancy begins at the time of fertilization of the egg. This is also referred to as conception. The time during which development occurs is referred to as the gestation period and is officially the time from the last menstrual period until birth.

The fertilized egg begins to undergo cell division and then differentiation to begin to form the different tissues and organs that will make up the new individual. In human development, during the first two weeks, the developing individual is referred to as the pre-embryo or conceptus. From the third week through the eighth week it is referred to as an embryo. From the ninth week on it is referred to as a fetus.

1. Accomplishing Fertilization

For fertilization to occur, a viable sperm must meet a viable secondary oocyte. Sperm live for only 48 to 72 hours after ejaculation. The secondary oocyte lives for only 12 to 24 hours after ovulation unless fertilization occurs. Consequently, for fertilization to occur, coitus must occur no more than 72 hours before ovulation and no later than 24 hours after ovulation.

Sperm Transport and Capacitation

Of the millions of sperm that are deposited in the vagina during intercourse, only 500 to a few thousand actually reach the fallopian tube. Millions leak from the vagina after being deposited there. Millions more are destroyed by the acidic environment despite the alkaline secretions that make up the ejaculate. Millions more fail to make it through the cervix.

The changes in the cervical mucus associated with the production of estrogens during the proliferative phase of the uterine cycle make it easier for sperm to penetrate the cervix. Those that manage to enter the uterus then encounter the uterine contractions associated with the female sexual response. This disperses them throughout the uterus. Here many encounter resident phagocytic leukocytes that destroy them. Of those that remain, many will enter the wrong uterine tubule.

During the process of travel through the female reproductive tract, the sperm undergo capacitation - their membranes become thin, fragile, and very "fluid" due to depletion of cholesterol.

This process occurs over 6 to 8 hours and is necessary for the sperm to be able to release their hydrolytic enzymes from the acrosome. This is required for fertilization to occur so that even if sperm reach an ovum immediately following ejaculation, they must wait in the fallopian tube until capacitation is completed.

Acrosomal Reaction and Sperm Penetration

As capacitation occurs, the acrosomes of the sperm begin to break down and release their hydrolytic enzymes. This is the acrosomal reaction and it occurs when the sperm are in

the vicinity of the oocyte.

For a sperm to reach the oocyte membrane, the corona radiata must first be broken down by the hydrolytic enzymes.

Thus, the first few hundreds of sperm to reach corona radiata breach a path for latter sperm to reach the oocyte.

In the end, receptors in the membrane of the oocyte sense the presence of sperm and pull the nucleus of the sperm into the cytoplasm of the oocyte.

Blocks to Polyspermy
A number of events now occur which prevent the oocyte from being fertilized by more than one sperm.

Plasma membranes of one sperm and the oocyte contact each other \ sodium channels in the oocyte membrane open, allowing extracellular sodium to enter the cell and depolarize the membrane.
This electrical event somehow prevents other sperm from fusing with the oocyte and is often referred to as "fast block to polyspermy".

Next, the cortical reaction occurs.
The depolarization causes calcium ions to be released into the cytoplasm of the oocyte \ vesicles (called cortical granules) release their contents into the extracellular space beneath the zona pellucida. These chemicals bind water and swell detaching all other sperm still in contact with the oocyte cell membrane (slow block to polyspermy).

Completion of Meiosis II and Fertilization
The release of calcium also stimulates the oocyte to complete the 2nd meiotic division. A second polar body is formed and the oocyte now has a haploid nucleus.

The ovum and sperm nuclei swell and approach each other and mitotic spindle forms between them.

The nuclear membranes then rupture and the male and female chromosomes combine to form the diploid zygote. These chromosomes replicate almost immediately and the first mitotic division of the preembryo begins.

2. Pre-embryonic Development
Cleavage and Blastocyst Formation
Cleavage is the period of rapid cell division following fertilization. Because division is so fast, there is not enough time for the daughter cells to grow back to full size between divisions and hence, during this period, the individual cells become smaller and smaller. This cell mass is still descending down the fallopian tubule and around day 5 it enters the uterus. At this point the mass has increased to about 100 cells.

The zona pellucida breaks down at this point and the cell mass which emerges is called a blastocyst. This cell mass is not solid but is fluid filled and consists of a single outer layer of flattened cells called trophoblast cells and a small cluster of cells inside called the inner cell mass. The trophoblast cells will help form the placenta and will also act as an endocrine organ while the inner cell mass will give rise to the embryo.

Implantation

The blastocyst usually floats free in the uterus for two to three days while the uterus continues to develop in the proliferative phase. The cells of the uterine endometrium will begin to produce a chemical signal when the endometrium has developed sufficiently, which is sensed by the trophoblast cells of the blastocyst. This induces the trophoblast cells to adhere to the endometrium and begin to secrete digestive enzymes that break down the outer cells of the uterine endometrium.

The trophoblast cells also begin to divide and form two cell layers. The inner layer is called the cytotrophoblast. The outer layer has its plasma membranes broken down by the digestive enzymes also and forms a multinucleate cytoplasmic mass called the syncytiotrophoblast. This mass invades the endometrium and digests the uterine cells it contacts. As the endometrium is eaten away, the blastocyst burrows into the thick proliferative wall of the uterus and becomes surrounded by the syncytiotrophoblast and a pool of blood leaked from degraded endometrial blood vessels.

The proliferating endometrial cells eventually completely cover over the blastocyst. This process takes about a week and, thus, is completed at about day 14 after ovulation, right about the time that the endometrium of the uterus is usually sloughed off and menstruation begins.

This does not happen if fertilization has occurred because the trophoblast cells of the blastocyst secrete an LH like hormone called human chorionic gonadotropin (HCG), which acts on the corpus luteum and stimulates it to continue to produce progesterone and estrogen. Thus it takes over from LH, which is decreasing in concentration at this time due to the inhibitory effects of estrogen and progesterone secretion on the hypothalamus.

Placentation

This refers to the formation of the placenta, which is the next stage in development of the link between the developing embryo and the mother.

The cytotrophoblast divides to produce a layer of tissue that is called the chorion. This chorion develops fingerlike chorionic villi which protrude out into the space formed by the syncytiotrophoblast and the digested endometrial cells. These spaces, called lacunae or intervillus spaces are blood filled because the eroded endometrial blood vessels do not clot. Thus a space is formed in the maternal uterine wall which receives blood from maternal arteries and drains into the maternal veins. This space surrounds the chorionic villi.

Embryonic blood vessels form in the villi, which anastomose and eventually connect to the fetal circulation through the umbilical artery and vein. This interwoven complex is the placenta.

Initially, the placenta forms on all sides of the embryo but as the embryo grows, the tissue on one side expands to accommodate the growing embryo, which fills and stretches the uterine cavity. The villi on this side are compressed and their blood supply is reduced. Consequently, these villi degenerate. As this happens, the villi on the other side proliferate and a pancake shaped placenta is formed.

The placenta is fully formed by the end of the third month of pregnancy. It is functional long before this. It acts as a nutritive, excretory and gas exchange surface for the fetus and also acts as an endocrine organ.

Recall that placenta is derived from trophoblast cells, which have been secreting HCG all along. This has been stimulating the corpus luteum in the ovary to continue to produce estrogens and progesterone.

With time, the placenta begins to secrete estrogens and progesterone itself and stops producing HCG. As a result, the corpus luteum degenerates.

Estrogen and progesterone produced by the placenta continue to inhibit GnRH release from the hypothalamus resulting in no LH and FSH release from the pituitary and, therefore, no maturation of new follicles.

The levels of estrogen and progesterone slowly increase throughout pregnancy and encourage growth and further differentiation of the mammary glands preparing them for lactation. The placenta also produces other hormones, which will be described later.

V. EFFECTS OF PREGNANCY ON THE MOTHER

A. ANATOMICAL AND METABOLIC CHANGES

As pregnancy progresses a large number of anatomical changes occur in the mother, only some of which we will list here: The female reproductive organs become increasingly vascularized and engorged with blood (uterus; vagina (Chadwick's sign = the vagina takes on a purplish hue); breasts).

There is increased pigmentation of facial skin (nose and cheeks) (chloasma "mask of pregnancy"), enlargement of the uterus due to the formation of the placenta and the growth of the fetus, displacement of the abdominal cavity, displacement of the thoracic cavity (flaring of the ribs), change in center of gravity and increased curvature of the lumbar spine.

Relaxin released form the placenta causes the pubic symphysis and pelvic ligaments to widen and become more flexible. This aids in delivery but also tends to produce a waddling gait.

B. PHYSIOLOGICAL CHANGES

Breasts

The developing placenta also secretes a hormone called **human placental lactogen** (HPL also called human chorionic somatomammotropin (HCS)). This hormone works co-operatively with estrogens and progesterone to stimulate maturation of the breasts for lactation. It also exerts a glucose sparing effect on the mother and causes the mother to use fatty acids for energy metabolism and leave the blood glucose for the developing fetus.

Gastrointestinal System

The elevated levels of estrogen and progesterone cause excess salivation and the nausea associated with morning sickness during early pregnancy. The displacement of the uterus into the abdominal cavity as the placenta and fetus grow gives rise to heartburn (regurgitation through the pyloric sphincter) and constipation due to decreased digestive tract motility.

Urinary System

Since the mother is also disposing of the fetal wastes, there is an increase in urine formation. The compression on the bladder due to the growing uterus also leads to more frequent and more urgent urination.

Respiratory System

Nasal mucosa also is engorged with blood leading to congestion and nose bleeds. Compression of the thoracic cavity leads to a decrease in residual volume, an increase in breathing frequency and difficulty breathing in late pregnancy.

Cardiovascular System

Total body water rises by 25 to 40% due to increases in plasma volume to accommodate the needs of the fetus. Cardiac output also increases by 25 to 40% and blood pressure also rises.

VI. PARTURITION

Parturition refers to giving birth while labour refers to the series of events that expel the infant from the uterus, i.e. the events that cause parturition.

The precise mechanism that initiates labour is not known. There are several theories.

Several events and three hormones seem to be involved in the process.

During the last few weeks of pregnancy, E levels reach their highest value, which may be due to stimulation of the placenta by adrenocortical hormones released from the fetus.

The very high E levels stimulate the uterine muscle cells to produce abundant receptors for a hormone oxytocin. This antagonizes the effect of progesterone on the uterus and the myometrium becomes irritable and begins to contract.

As birth nears, the fetus begins to secrete oxytocin, which acts on the placenta to produce and release prostaglandins. Both hormones are powerful stimulants of uterine muscle contraction.

Since the myometrium produced receptors for the oxytocin in response to the surge of estrogen, it will now respond to the oxytocin. As a result, contractions become more numerous and more vigorous.

Emotional and physical stresses induce the hypothalamus of the mother to stimulate her posterior pituitary to release oxytocin also and this induces even more vigorous contractions, which give rise to the rhythmic, expulsive contractions of true labour.

Once the hypothalamus is involved and the uterine contractions begin to move the fetus down into the cervix, a positive feedback system is set in motion.

Pressoreceptors in the cervix are stimulated. These send afferent impulses to the hypothalamus, which in turn stimulates the posterior pituitary to release more oxytocin, which in turn stimulates more forceful contractions.

VII. ADJUSTMENTS OF THE INFANT TO EXTRAUTERINE LIFE

A. FIRST BREATH

The first problem faced by the newly born infant is breathing. No one knows exactly what triggers the first breath but the building levels of CO_2, falling levels of O_2, the change in temperature as well as stress and the physical activity associated with birth are all thought to play a role.

The first breath requires considerable effort since the lungs are still fluid filled and the surface tension must be overcome to fill the lungs. As discussed in earlier lectures, with the first breath, surfactant is distributed throughout the alveolar fluid and subsequent breathing becomes much easier.

B. CARDIOVASCULAR CHANGES

The umbilical arteries and vein constrict during birth. The outer segments fibrose and are eventually sloughed off. The inner segments are either re-routed to serve as functional vessels to parts of the body cavity or collapse and are eventually converted into ligaments.

Several important shunts exist in the developing fetus that allow blood to bypass the pulmonary circulation since the lungs are not functional in utero. It is important at birth that these now be sealed. Thus the foramen ovale closes and seals to become the fossa ovalis, the ductus arteriosus constricts and is converted to a ligament, the ligamentum arteriosum.

IX. LACTATION

Lactation is the production of milk by the mammary glands.

Rising levels of estrogen, progesterone and placental lactogen (hPL) toward the end of pregnancy stimulate the hypothalamus to continually release prolactin-releasing hormone. This stimulates the anterior pituitary to release prolactin.

After birth, the continuous release of prolactin drops off but milk secretion will continue as long as there is mechanical stimulation of the nipples from suckling.

Mechanoreceptors in the nipples send afferent impulses to the hypothalamus stimulating the release of PRH. Thus PRH is now released in bursts and stimulates the glands to secrete milk for the next feeding.

The same afferent impulses also prompt the hypothalamus to release oxytocin from the posterior pituitary via a positive feedback mechanism.

Oxytocin causes the "let down" reflex that actually causes the release of milk from the glands.

The binding of oxytocin to the receptors of the myoepithelial cells surrounding the glands causes them to contract and expel milk from the nipples (of both breasts). The positive feedback cycle ends when the baby stops suckling and removes its mouth from the nipple. Termination of the stimulus stops secretion of oxytocin.

STUDY QUESTIONS
REPRODUCTIVE SYSTEM

The spermatid is haploid but it is not a functional gamete. Name and describe the process during which a spermatid is converted to a motile sperm, and describe the major structural (and functional) regions of the sperm.

Oogenesis in the female results in one functional gamete, the egg or ovum. What other cells are produced? What is the significance of the fact that only one functional gamete is produced instead of four as is the case with sperm production in males?

Describe the events and possible consequences of menopause. Define menarche. What does it indicate?

The life span of the ovarian corpus luteum is extended for nearly three months after implantation, but otherwise it deteriorates. a) Explain why this is so. b) Explain why it is important that the corpus luteum remains functional following implantation.

What is the physiological importance of the fact that the male testes descend to reside in the scrotal sac?

The oocyte on ovulation is released into the peritoneal cavity. By what means does it (usually) enter the fallopian tubule?

Describe the composition and functional roles of semen.