MODULE 1

00:01
Module one, the female and male reproductive systems.

00:06
The module objectives for Module one are to review the structures of the female and male reproductive organs, to outline the process of oocyte and sperm development, introduce the hormones involved in the control of the reproductive system and the regulation of the ovarian menstrual cycle and spermatogenesis and finally to review the stages of embryo development.

00:31
Let's start with female reproductive anatomy.

00:36
The key components of the female reproductive system are the internal reproductive structures, the ovaries, fallopian tubes, uterus, cervix and vagina, and the structures of the endocrine system, the hypothalamus and the pituitary gland. The reproductive system is regulated by the endocrine system.

00:56
In his interior view of the female reproductive system, we see the structures of the vagina, the cervix, which is the opening to the uterus, the uterus, fallopian tube and ovary.

01:12
The sagittal view, which shows the female reproductive system in relation to other structures in the pelvis, such as the bladder, the pubic bone, and the rectum.

01:24
Also, we see the normal, or the most common position of the uterus, which is anteverted and other possible positions that can be found, such as anteverted and anteflexed, retrograded, retroverted and retroflexed.

01:43
The ovary where oocyte development occurs is a three to five centimeters, both the size of an unshelled almond and is regulated by follicle stimulating hormone (FSH) and luteinizing hormone (LH) released by the anterior pituitary. These are also known as gonadotropins as they stimulate the ovaries. The main reproductive functions in response to Gonadotropins are ovulation and the production of estrogen and progesterone.

02:18
The fallopian tube is about 10 centimeters long and at the distal end have fimbriae, which encourage or more or less capture the oocyte as it's ovulated or release from the follicle and the fimbriae exhibit pulsatile and sweeping movements at the time of ovulation and within the fallopian tube are cilia, which also facilitate transport.

02:44
Follicular development, which occurs in the ovary, ie, is females are born with two million eggs, with four hundred thousand remaining by puberty, from puberty to menopause, only four hundred to five hundred eggs will be ovulated. After puberty waves of primordial follicles, which you'll see in this diagram, develop into primary and secondary follicles. This process is believed to take about one hundred days and is largely FSH independent.

03:16
Antral or tertiary follicles then grow in response to FSH and LH allows antral follicles to produce estrogen and the LH surge triggers ovulation. In natural cycles usually only one egg is released every month.

03:39
The uterus, the uterine cavity is the site of implantation and fetal development. The urine wall is composed of three layers: the perimetrium, which is the thin outer layer, the myometrium, the middle muscular layer and the endometrium, which is the inner uterine lining that undergoes cyclic changes during the menstrual cycle and actually has two layers. The stratum functionalis is the top layer, which is shed during menses. Following implantation, the trophoblast cells and other adjacent cells proliferate rapidly and form the placenta.

04:23
Here we see the endometrium during the menstrual cycle. There are a series of changes where the uterine lining is shed, rebuilds and prepares for implantation. Although the average length of a menstrual cycle is 28 to 30 days, it may range from 21 to 35 days in women of reproductive age. Phases of the cycle are associated with the production of hormones, estrogen and progesterone by the ovaries.

04:56
In summary, for female reproductive anatomy, the ovaries, fallopian tubes, uterus and vagina are key internal anatomic structures for successful reproduction in females. The ovaries are regulated by gonadotropin (FSH and LH), they are carried within the bloodstream to control the menstrual cycle and cyclic release of oocytes from the ovaries. The endometrium undergoes a series of cyclic changes in response to progesterone and estrogen in order to prepare the lining for implantation.

05:30
An understanding of female reproductive anatomy is important for the diagnosis and treatment of infertility. We will continue with Module 1 looking at the male reproductive system.

05:43
The key anatomic structures of the male reproductive system are the external genitalia, which include the penis, testes and scrotum. Internal structures, including seminal vesicles, epididymis, Vas deferens and prostate gland and the structures of the endocrine system, the hypothalamus and the pituitary gland. And, as with the female reproductive system, the male reproductive system is regulated by the endocrine system.

06:15
In the sagittal view of male reproductive anatomy, we see the testes and the male gonads that lie behind the penis in a pouch of skin called the scrotum. Testes are the site of sperm production, and also the site of testosterone production. Each testes is attached to the body wall by a thin cord called the spermatic cord that passes through the lower abdominal wall into the pelvis. The sperm leaves the epididymis via muscular layers that propel spermatozoa through the vas deferens, prostate and urethra during ejaculation.

06:58
The testes where spermatogenesis occurs measure 1.5 centimeters times 1 centimeter and have a volume of 4 millilitres at puberty. Normal adult testes are ovoid and measure 3 centimeters times 2.4 centimeters and 3 to 5 centimeters in length with a volume of 12.5 to 19 millimeters. The size of the testes decreases with age. Within the testes are approximately 700 seminiferous tubules in each testes each the length of an arm and the width of a few hairs. And this is a site of spermatogenesis. During spermatogenesis the sperm are carried to the rete testes which drains into the epididymis through 10 to 15 efferent ductules and the epididymis is a single duct through which all spermatozoa pass, mature and gain fertilizing capability.

08:06
Within the seminal vesicles are the Sertoli cells and the Leydig cells. Sertoli cells provide an environment to support spermatogenesis, they surround the spermatids and promote their development by providing nutrients and chemical stimuli. FSH secreted by the anterior pituitary gland stimulate Sertoli cells in the testes to assist in the production of spermatozoa. The Leydig cells are dispersed throughout the testes, and LH secreted by the anterior pituitary gland stimulates Leydig cells to produce testosterone. Testosterone is necessary for the production of sperm.

08:50
And here we see a diagram of spermatogenesis as it occurs in the seminiferous tubules. There is a mitotic division of spermatogonium into primary spermatocytes, then 2 rounds of meiosis to generate secondary spermatocytes and spermatids. Spermiogenesis results in the completion of the final sperm structure.

09:20
And here we see a diagram of a normal sperm, so we see the head, the nucleus, which contains the chromosome material, so which contains 23 chromosomes, and the acrosome layer which aids in fertilisation, mitochondria in the neck of the sperm, which provides the energy for propulsion, and also the tail which is necessary for propulsion of the spermatozoa.

09:54
And just to note that normal semen volume is 1.5 to 5 millimeters per ejaculation and contains 15 million spermatozoa, as you saw in the diagram, per ML or more.

10:10
In summary, male reproductive anatomy, the function of the testes are controlled primarily by FSH and LH secreted from the pituitary gland under control of the hypothalamus. This regulatory system is referred to as the hypothalamic-pituitary-gonadal axis. The seminiferous tubules in the testes are the site of sperm production. Spermatogenesis is a multi-step process involving a mitotic division of spermatogonium into primary spermatocytes, 2 rounds of meiosis to generate secondary spermatocytes

and spermatids and spermiogenesis results in completion of the final sperm structure. The accessory glands, which include the seminal vesicles, prostate and bulbourethral glands are responsible for the generation of the ejaculate.

11:07
Endocrine system.

11:10
The endocrine system of male and female are similar in that the hypothalamus and pituitary glands are important part of the endocrine system in terms of reproduction. However, differentiate as the hypothalamus and pituitary glands act on the ovaries in female and on the testes in male.

11:35
Now, here we see in the diagram, if you look at the red spot you will see the hypothalamus and the hypothalamus is responsible for gonadotropin releasing hormone, otherwise known as GnRH. The pituitary gland, which is below the red dot on the diagram. The anterior pituitary produces follicle stimulating hormone and luteinizing hormone, which are critical in reproduction and other hormones such as prolactin, thyroid stimulating hormone, ACTH and growth hormone. The posterior pituitary gland produces oxytocin, an anti-diuretic hormone. The gonads, the ovaries and testes produce androgens, estrogen, progesterone and testosterone. We'll discuss this in more detail.

12:31
The female endocrine system.

12:36
So for the control of LH, sorry, FSH and LH we will work through the menstrual cycle and show you that to start with GnRH is released by hypothalamus. In turn the GnRH stimulates the production and secretion of FSH and low amounts of LH by stimulating the anterior pituitary. FSH stimulates follicular development. Developing follicles secrete estrogen in response to LH.

And elevated estrogen stimulates an accumulation of LH around day 14, the LH surge triggers ovulation. At ovulation estrogen levels fall transiently, but then rapidly rise as the corpus luteum, which is the ruptured follicle that releases the oocyte, produces both estrogen and progesterone. Elevated estrogen and progesterone levels suppress GnRH secretion.

If pregnancy does not occur, the corpus luteum degenerates after 12 to 14 days, progesterone levels decline, GnRH secretion increases and a new cycle begins. And this is to do with the negative feedback system.

14:01
If we look at gonadotropins in the ovarian cycle or otherwise the menstrual cycle, we'll see that FSH and estrogen are at lower levels at menses, then rise closer to ovulation. The LH surges, which triggers ovulation, and then due to the corpus luteum, we have an elevation of progesterone and estrogen.

So just to show you again, estrogen and progesterone although at the beginning of the cycle, FSH rises in the early follicular phase, causing ovarian follicle growth in response to FSH and LH, follicles secrete

estrogen, which cause the uterine lining to grow. Rising estrogen stimulates the release of LH and LH triggers ovulation on day 14. During the luteal phase, LH triggers the development of the corpus luteum which secretes progesterone and maintains the urine lining. Estrogen levels are high during the luteal phase, but FSH and LH are inhibited.

15:19
We look at the impact of gonadotropins on the follicle, we see that in the follicular phase, there's a recruitment of multiple follicles, but growth of a dominant follicle at ovulation, this dominant follicle will mature and there will be follicular rupture releasing the oocyte. In the luteal phase will be the ruptured follicle now known as the corpus luteum which is responsible for progesterone secretion. And this lasts about 14 days.

15:54
Here we see the endometrium and during the menstrual phase, we see when the hormone levels are low, estrogen is low, we have menstrual bleeding and the sloughing of the top layer, the stratum functionalis in the proliferative phase of the endometrium, the estrogen rising estrogen stimulates the endometrial gland and stroma proliferation and the thickening of the stratum functionalis.

In the secretary of secretory phase, which happens after ovulation, there's significant changes in the endometrium which is preparing for implantation in response to the increasing progesterone levels.

16:40
And here we see the relationship between follicular development, gonadotropins and the endometrial activity during the menstrual cycle.

16:53
In vivo fertilization and embryo development.

17:00
After ovulation, also known as luteal phase 0, the ovum or oocyte enters the fallopian tube where fertilization occurs. The dividing embryo moves progressively through the fallopian tube and reaches the uterus about day 4. Early cell divisions, also called cleavage stage occur and the embryo generally enters the uterus at the morula stage.

Mean number cells in the blastocyst range from 50 to 100 on day 5 to 100 to 200 on day 6. Implantation of the blastocyst occurs approximately 5 to 7 days after ovulation. The uterine endometrium must become receptive for implantation of the blastocyst to occur.

17:56
And here we see in this diagram we see a blastocyst, which typically will be at this stage at 5 to 6 days after fertilization. The blastocyst wall is one cell thick except for the embryonic pole or what is also called the inner cell mass, which is 3 to 4 cells thick. The embryonic pole will develop later into the fetus. The embryo hatches around day 6 to 7 post fertilization.

Within 1 to 2 days of implantation trophoblast cells develop around the blastocyst, the trophoblast goes on to become the placenta and 6 to 7 days after ovulation and fertilization implantation will occur and the blastocyst implants in the wall of the uterus after hatching.

Trophoblast cells proliferate rapidly and form the placenta, which produces hCG, which is a determinant or a diagnostic level we see when we do serum testing to determine pregnancy. After the 8^{th} week of after fertilization, the embryo is now considered a fetus.

19:20
Hatching. Hatching of the embryo, which is the thinning and rupture of the outer coating of the embryo, which is called the zona pellucida, typically occurs within the uterus between luteal day 6 and 7 and must occur for implantation to occur.

Studies have shown that the zona pellucida can be substantially thicker in older women. That is in the 38 plus age group.

19:49
Male endocrine system.

19:57
Similar to the female endocrine system the hypothalamus secretes GnRH in response to low testosterone level. The hypothalamus secretes the hormone GnRH in a pulsatile fashion every 1 to 3 hours. The GnRH stimulates the pituitary gland to release LH and FSH. FSH targets Sertoli cells of the seminiferous tubules and promotes spermatogenesis also produces estrogen and inhibin. LH stimulates the release of testosterone from the Leydig cells.

Testosterone exerts a negative feedback on the hypothalamus. Inhibin inhibits FSH production by the pituitary gland, and estrogen exerts a negative feedback on the hypothalamus.

20:52
In summary, for the endocrine system, the GnRH that is released by the hypothalamus stimulates the release of FSH and LH from the anterior pituitary. FSH and LH regulate the function of the gonads in both males and females. In the male FSH targets Sertoli cells of the seminiferous tubules and promotes spermatogenesis, a process that takes roughly 74 days. In the female FSH causes follicular development, the recruitment of multiple follicles, one of which will develop into the dominant follicle containing the oocyte.

In response to LH and FSH the developing follicles produce estrogen. Ovulation occurs in response to the LH surge during the luteal phase, the secretion of progesterone from the corpus luteum prepares the endometrium for implantation of the embryo. The embryo develops into the blastocyst 5 to 7 days after fertilization, and this is the final structure prior to implantation.

22:05
Module one summary.

22:10
Human reproduction is dependent on the complex interplay of a number of endocrine tissues, hormonal mediators and reproductive organs. These systems are involved in the production of gametes such as oocytes and sperm, as well as preparation of the endometrium for implantation. The ovarian and menstrual cycle is controlled by FSH, LH, estrogen and progesterone. These hormones are involved in the development of a dominant follicle, ovulation, luteinization, endometrial receptivity and menstruation. After successful fertilization in the fallopian tube the embryo undergoes successive rounds of cell division to generate a blastocyst by day 5 or day 6. Implantation of the blastocyst occurs approximately 7 to 10 days after ovulation and fertilization.

Section completed. Please access the online classroom portal Digital Chalk to review and complete the exercises related to this content section.