

Male and female reproductive system of cattle

CUTM1144(1-2-0)

Session: 17



Centurion
UNIVERSITY

Centurion University of Technology and Management, Village Alluri Nagar,

R.Sitapur, Odisha 761211

1. Reproductive female tracts: anatomy and function

Two essential organs of reproduction are located within the head of the animal.

The hypothalamus controls several body processes and behaviors along with reproductive processes. Body temperature, concentration and components of body fluids and the drive to eat and drink are just a few functions of the hypothalamus. It is classified as a neuroendocrine gland since it sends and receives neural signals through the nervous system and hormonal messages through the endocrine system.

The second organ, the pituitary small gland located at the base of the brain. The pituitary is about half an inch in diameter and weighs about 1 gram. Physiologically, the pituitary is divided into two distinct regions: the anterior and posterior pituitaries. Each region secretes various hormones that direct body processes. Some of these hormones are responsible for reproductive events, while others control growth, metabolism and water balance.

We can distinguish three fundamental functions of female reproductive tract :

1. production of reproductive cells (eggs or ovum),
2. providing an anatomical place for the fertilized ovum to develop,
3. productions the hormones estrogen

These female steroid hormones are involved in controlling the estrous cycle and pregnancy

The reproductive organs of the cow with the exception of the vulva are located within the abdominal cavity. These organs are a series of tubes that receive semen, transport sperm to the ovum so it can be fertilized, nourish the fertilized ovum (embryo), and allow the calf to be birthed. The parts are located within the abdominal cavity, include the vagina, cervix, uterus, uterine horns, oviducts (also called Fallopian tubes), which each have a funnel-shaped opening called the infundibulum. These organs are located beneath the rectum and can be manipulated by rectal palpation (Figure 1).

The ovary, or female gonad, is the primary organ of reproduction in the female and is responsible for two basic functions:

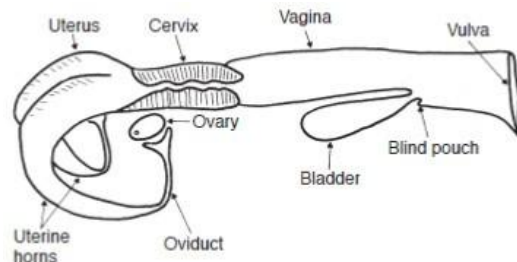


Figure 1 : Diagram of the reproductive tract of the cow

1. Production of the female gamete,
2. Production of two primary reproductive hormones, estrogen and progesterone.

A cow has two bean-shaped ovaries that are around 3 cm long and are suspended from the broad ligament near the end of the oviducts. The size of the ovaries varies with stage of the reproductive cycle and age of the female. The ovary consists of an inner part, the medulla, and an outer part, the cortex. The medulla part contains blood vessels, nerves and connective tissue. The cortex part contains the germinal epithelium and produces the ovum by a cyclic process called oogenesis.

The ovary

The ovary contains several thousand tiny structures called primary follicles. Each primary follicle consists of a germ cell surrounded by a layer of cells. This germ cell has the potential to mature into an ovum if the follicle completes development (known as the Graafian follicle). However, most of the primary follicles never develop. Rather, they die, are absorbed by the ovary, and are replaced by newly formed primary follicles. So a cow will generally ovulate less than 100 since only one ovum is released at each cycle. By the injection of hormones, a cow can be induced to release more than one ovum at each estrous cycle. This technical is used in embryo transfer.

After puberty a Graafian follicle is generally produced every 21 days until the cow becomes pregnant. The Graafian follicle can be palpated through the rectal wall. At maturity the ovum and follicular fluid are released from the ovary in the process called ovulation. After ovulation the wall of the follicle collapses and forms the corpus luteum, commonly referred to as CL or yellow body. The yellow body gets its name from its deep yellow color in the cow due to the presence of β -carotene.

The oviduct

The oviduct begins as a funnel-shaped tube that engulfs the ovary. This funnel portion of the oviduct is called the infundibulum. When ovulation occurs, the ovum is picked up by the infundibulum and channeled into the oviduct (also called Fallopian tube), where fertilization takes place if viable sperm are present. The infundibulum has a fringed border, the fimbria, which helps to pick up the ovum from the ovary. Into the oviduct the ovum remains capable of fertilization for only a short time. Thus it is essential that sperm be present in the oviduct near the time of ovulation. The ovum moves through the oviduct into the uterine horn within the next three to four days. If the ovum is fertilized, it then begins embryological development; if not, it degenerates and disappears and the next estrous cycle ensues.

The uterus

The uterus consists of two parts, the body and horns. The uterus is suspended from the broad ligaments. The body of the uterus of the cow is short and poorly developed, while the uterine horns are relatively long and well developed. The developing of the fetus takes place in the uterine horns. During most artificial insemination procedures, semen is placed in the body of the uterus. If semen is placed in the horn opposite the ovary from which the ovum was released, the chances of fertilization are very low.

The embryo

The fertilized embryo moves from the oviduct into the uterine horn, where fetal and maternal membrane development begins. This newly developing fetus grows within a layer of membranes called the placenta. There is no direct blood connection between the fetus and the dam, but rather a complex system that selectively allows certain molecules to pass from the maternal side of the placenta to the fetal side and vice versa. It also provides nutrients and carries waste products from the fetus. The endometrium (lining) of the uterus becomes very vascular after fertilization, in preparation for the implantation of the fertilized ovum. The uterus develops the maternal side of the placenta to protect and nourish the developing fetus. The caruncles (about 100) of the uterine endometrium interlock with the cotyledons of the fetal placenta and provide a passageway for the nutrients from the cow to the fetus and for the waste products to be removed from the fetus. Villi of the embryonic cotyledons fit into crypts of the maternal caruncles to form placentomes, the functional units of exchange.

The developing embryo sets up its own placental membranes, which consist of the chorion (outer membrane), the amnion, the yolk sac and the allantois. The amnion contains a cavity that surrounds the embryo and becomes filled with liquid that serves as a protective cushion to the fetus. The yolk sac supplies nutrients to the fetus during early development but functions for only a short period of time. The chorion contains a rich source of blood vessels and gives rise to the cotyledons. The allantois is an outpouching of the hind gut of the fetus and serves as a urinary receptacle for the fetus.

The cervix

The cervix is a thick-walled structure about 10 to 11 cm long and 2.5 to 5 cm in diameter located between the uterine body and the vagina. In effect the cervix is the neck of the uterus. The cervix contains ridges called annular folds. These folds must be manipulated through the wall of the rectum during artificial insemination in order to pass the insemination rod into the uterus. An opening in the cervix, through the annular folds, allows a passageway for sperm at mating (or insemination rod) and expulsion of the fetus at the time of birth.

The cervix produces a mucus secretion that is usually thick, however this secretion fluidized at the time of estrus to facilitate the movement of sperm to the uterus. This fluid can be seen as part of the discharge from the vulva at estrus. During pregnancy, the thick mucus secretion is called cervical plug, which protects the uterus from infections entering from the vagina. The cervical plug is expelled and the cervical opening begins to dilate in the days prior to calving.

So the major function of the cervix is to restrict access to the uterus. The cervix and its secretions thus form a physical barrier and protect the uterus against microorganisms (bacteria, virus) and other foreign material.

The vagina

The vagina, which is about 18 cm long and located between the cervix and the vulva, serves as a receptacle for the penis during service. In the cow, the semen is deposited in the vagina near the cervix during natural mating with the bull. When artificial insemination is used, the insemination rod is threaded through the vagina and cervix and semen is deposited at the uterine side of the cervix. In addition, the vagina serves as a birth canal during parturition. The vaginal epithelium secretes fluids, which along with the fluids of the cervix, inhibit growth of bacteria and thus provides a line of defense against bacteria invasion of the uterus.

Urine is discharged from the urinary bladder through the urethra, which opens into the base of the vagina. The region behind the urethral opening is called the vestibule and is a common passageway for both the urinary and reproductive systems. Care must be taken during artificial insemination because the insemination rod can be introduced into the urethral opening.

The vulva forms the external opening of the reproductive tract and consists of thickened folds of skin (vaginal lips). The vulva is sensitive to changes in blood estrogen, which causes an increase in blood flow to the vulva and results in redness and swelling. These signs can be a help in estrus detection.

2. The hormones of female reproduction

Normal reproduction in the female is controlled by numerous hormones secreted from specialized glands called endocrine glands. The hormones are chemical substances developed by specialized tissues often acting at a distance and at very low concentrations on specific tissues to produce specific effects. As mentioned above these hormones are produced by the pituitary, the ovary and its structures, and the uterus. The hormones pass into the blood and lymph systems for transport to specific parts of the body where they produce their function. Reproductive hormones may originate in hypothalamus, pituitary, ovary, uterus, or placenta.

- The ovary by means of Graafian follicle produces estrogens, of which estradiol is the most important in the dairy cow. Estradiol has several effects:
- The development and function of the secondary sex organs (mammary gland);
- The onset of behavioral estrus, i.e., the period of sexual receptivity (commonly referred to as heat);
- The rate and type of growth, especially deposition of fat;
- The development of prepuberal heifers and the regulation of post-partum cow for onset of cyclic sexual activity.

After ovulation the remaining cells in the follicle form the corpus luteum, which produces the hormone progesterone. Progesterone suppresses the further development of follicles and the

secretion of estrogens. High levels of progesterone and low levels of estrogens are responsible for stopping the sign of estrus. Progesterone is necessary for preparing the lining of the uterus to receive the fertilized ovum and then for the implantation of the fetus, maintaining the lining of the uterus during pregnancy.

Estradiol and progesterone are not completely separate in their functions since both must be present for certain processes to occur. For example, estradiol/progesterone concentration ratio dictates the onset and duration of behavioral estrus. Development of the uterus is initiated by estradiol and completed by progesterone. Estradiol causes contraction of the uterus near the time of estrus and ovulation, which help in sperm transport. Progesterone has a quieting effect on the uterus so that there are no contractions which might disturb pregnancy. If fertilization takes place, the corpus luteum and the production of progesterone persist throughout pregnancy; otherwise, the corpus luteum regresses and another follicle develops.

The production of ovarian hormones is under direct influence of gonadotropic hormones produced by the anterior portion of the pituitary. Follicle-stimulating hormone (FSH) and luteinizing hormone (LH) are secreted from the pituitary and travel through the blood to the ovary. The release of FSH and LH is mediated by gonadotropin-releasing hormone (GnRH) produced by the hypothalamus to signal FSH and LH release from the pituitary. The hypothalamus is part of the brain and is located just above the pituitary gland. The release of FSH stimulates the growth, development and function of the follicle, while LH cause the follicle to rupture during ovulation and causes the subsequent development of the corpus luteum, and initiates progesterone production.

Many body tissues, but especially the uterus, produce the prostaglandins. The prostaglandin primarily affecting the cow's estrous cycle is prostaglandin F_{2α} (PGF_{2α}), which is produced by uterus. PGF_{2α} causes the natural regression of the luteal cells of the corpus luteum at the end of the estrous cycle or pregnancy. This effect allows a new estrous cycle to be initiated in the nonpregnant cow. In a pregnant cow, a signal is sent from the developing embryo to the uterus to prevent PGF_{2α} release, which allows the corpus luteum to persist throughout pregnancy. Maternal recognition of pregnancy is believed to occur between days 16 and 17 after fertilization. Injecting cows or heifers with PGF_{2α} between days 6 and 16 of the estrous cycle will cause premature regression of the corpus luteum, with the best results achieved among females injected on days 10 to 16.

Injecting PGF_{2α} during the first five (1-2) and last five (17-21) days of the estrous cycle will generally not cause luteal regression. The luteolytic response allows the use of PGF_{2α} in estrus synchronization programs in cow herds and initiates abortion in feedlot heifers.

The posterior portion of the pituitary produces the hormone oxytocin, which causes the contraction of the uterine wall to expel the calf at parturition. The oxytocin plays a role in the contraction of the myoepithelial cells during milk ejection.

Near the end of gestation the ovary produces the hormone relaxin. The relaxin is responsible for

expansion of the uterus and relaxation of the cervix in preparation for parturition.

3. Estrous cycle

This cyclic process is called the estrous cycle and consists of a definite sequence of events, both physiological and behavioral. The estrous cycle of the cow starts after puberty and occurs approximately every 21 days (17 to 24 days) except for pregnancy, reproductive disease or hormonal disorder. During estrous cycle, the reproductive tract is prepared for estrus or heat (the period of sexual receptivity) and ovulation (ovum release). The cycle is divided into four parts: proestrus, estrus, metestrus and diestrus.

Definition

Proestrus is the period between the regression of the corpus luteum of the previous cycle and estrus. The period proestrus translated the follicular development. Figures 2 and 3 outline the sequence of anatomical and hormonal changes that occur during a typical 21-day cycle in which pregnancy does not occur.

Estrus is the period when high amount of estrogen is presents in the blood. The estrogen produces the behavioral signs of estrus, such as the mounting of other cows, the willingness to stand while mounted by other cow, and general increase of activity.

Estrus is followed by a 3 to 4 day period referred to as **metestrus**. During this period the corpus luteum develops under the influence of LH and

starts to produce increasing amounts of progesterone.

The period between metestrus and the beginning of the regression of the corpus luteum is referred to as **diestrus**.

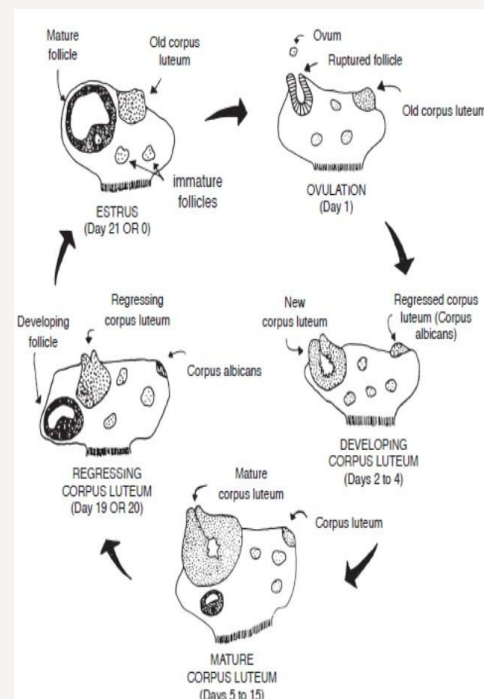


Figure 2 : The ovarian changes during a normal estrous cycle (21 days) without pregnancy. The development and regression of the Corpus Luteum are continuous process.

3.1. Description

Day 0: *The cow is in estrus (standing heat) due to an increased concentration of estrogen for 18 hours (range 12 to 24 hours). As estrogen levels reach a certain threshold level, a surge of LH is released by the pituitary. About 12 hours after the end of standing heat, the mature Graafian follicle ovulates (ruptures) in response to LH released.*

Days 1–2: *The cells that formerly lined the follicle change and become the luteal cells of the corpus luteum. This change in cell form is caused by hormonal action, primarily the action of LH.*

Days 2–5 *The corpus luteum grows rapidly in both size and function. At this stage, numerous follicles may be seen on the ovary, but by day 5 they have begun to regress.*

Days 5–16: *The corpus luteum continues to develop and typically reaches its maximum growth and function by day 15 or 16. It secretes the hormone progesterone, which inhibits LH release by the pituitary gland. During this period, the ovaries are relatively inactive except for the functional corpus luteum. No follicles reach maturity and/or ovulate because of high concentrations of progesterone.*

Days 16–18: *Increased follicular growth and accompanying estrogen secretion by the ovary stimulate PGF2 α secretion by the uterus, causing rapid regression of the corpus luteum.*

Days 18–19: *The corpus luteum is almost nonfunctional and progesterone release is suppressed, removing the blocking action of progesterone on LH and FSH. Of the several follicles that are initially recruited, one becomes dominant by a surge in rapid growth and activity. As this Graafian follicle grows, it secretes increasing amounts of estrogen, and the smaller follicles regress.*

Days 19–20: *With the increase in estrogen release by the Graafian follicle and a corresponding decrease in progesterone by the regressing corpus luteum, estrus or heat will occur (cycle has now returned to day 0). The high estrogen concentration in the blood triggers a release of LH near the onset of heat. Following this surge in LH blood concentrations, the mature follicle ruptures to release the ovum, and the cellular tissue left behind becomes luteinized and forms a new corpus luteum (cycle has now returned to days 1–2). Progesterone again becomes the dominant hormone.*

The sequence of events that occur during the estrous cycle showed above is based on a full cycle in which pregnancy does not occur. If the ovum is fertilized and begins developing in the uterus, the corpus luteum does not regress but continues to function and secrete progesterone. During pregnancy, no follicles develop to maturity and heat does not normally occur. Increased concentrations of progesterone promote uterine dormancy, providing the most favorable conditions for the developing fetus.

Any condition that prolongs the period of time when blood concentrations of progesterone

remain high (such as implanting, injecting, or feeding progestins for estrus synchronization) will keep the female from exhibiting estrus. Occasionally, the corpus luteum does not regress normally even though the animal does not become pregnant (pseudo-pregnancy).

Occasionally, abnormally short estrous cycles (7–11 days) occur. This condition appears to occur because either no corpus luteum is formed or, if one is formed, it is non-functional and progesterone concentration remains too low to sufficiently suppress the release of gonadotropins (FSH and/or LH) from the anterior pituitary.

Cows also have periods of anestrus (noncycling). For example, an anestrus period is commonly observed in cows following calving. Low levels of nutrition can contribute to the duration of anestrus, especially in young cows nursing calves.

Estrus is not always accompanied by ovulation. Heat without ovulation (anovulatory heat) will not result in pregnancy, even if the female is bred. Ovulation without the external signs of heat (quiet or silent heats) is not uncommon in cows, especially the first few weeks after calving. Such females will generally not “stand” to be bred by a bull.

4. Pregnancy

One of the key for reproductive efficiency is a good observation of the signs of the estrus. Cows observed in estrus in the afternoon must be inseminated the next morning. Cows observed in estrus in the morning must be inseminated in the afternoon. The reason is because artificial insemination, or mating, performed in the later part of estrus tends to increase the conception rate, due the brief life of the ovum in the female reproductive tract.

Sperm travel from vagina to the oviduct in 10 to 15 minutes. However sperm undergo a series of biochemical reactions before they are able to fertilize an ovum. These reactions are called capacitation and six hours are required to complete the capacitation. Sperm will wait in the ampulla, which is a part of oviduct, at the time of ovulation so that fertilization can take place. Sperm can live in the female reproductive tract for 24 hours and the unfertilized ovum can live 6 to 12 hours. An ovum not fertilized will be resorbed by reproductive tract and an ovum fertilized will move to the horn of the uterus, which takes about three days. Development of the fetal and uterine membranes then takes place, during which time the developing embryo must live on the nutritive secretion that is produced uterine glands especially.

This nutritive secretion is known as uterine milk, a substance that is produced during the early phases of mammalian gestation and that nourishes the embryo prior to implantation. Attachment of the fetus to the uterine wall begins day 28 of pregnancy and is completed by day 45. Then the blood progesterone will remain high and the cycle activity will be blocked. The embryo produces a protein known as interferon. The interferon is detected by the uterus and gives the first pregnancy signal and allows maintaining the integrity of the corpus luteum; thus there is continued production of progesterone.

Even though fertilization takes place and the development of the fetal membranes proceeds

normally, in some cases pregnancy is terminated and the developing fetus is absorbed, mummified or expelled. If the termination is in early pregnancy, it is called early embryonic mortality, whereas it is called abortion in later pregnancy. Many embryonic deaths are unavoidable because they may be due to genetic abnormalities and it is nature's way of eliminating unfit genotype at a low biological cost.

The gestation is a period from fertilization to the birth of the calf (or parturition). This period is average about 283 day (around 9.4 months), however there is breed variations. Male calves require 1.5 days more than female calves. Primiparous cows have a slightly shorter gestation period than multiparous cows.

5. Calving

Calves grow very fast in the three months of pregnancy and the end of pregnancy the fetus shifts position in the uterus and its head lies between the front feet and points toward the cervix. During normal birth the front feet and head are delivered first. Relaxation of the pelvic ligaments occurs during gestation and a marked relaxation can be seen visually shortly before calving by a dropping of the tailhead. Shortly before calving the cervix and vagina enlarge. The cervix starts to open, and a partial decalcification of the pelvic bones occurs in order to enlarge the birth canal. As explain above, these events are under the control of the hormone relaxin. At calving the fetus is pushed from the uterus through the cervix and vagina by the contractions of the muscles in the walls of the uterus (myometrium) and by some conscious straining of the abdominal walls by the cow. The oxytocin is responsible by the contractions of the uterine walls.

A calf at birth lacks diseases protection because antibodies (immunoglobulins) do not pass across the placenta from the dam to the circulatory system of the fetus. Then the calf needs to drink the first milk produced by the cow, which is high in nutrients and antibodies. This milk is the colostrum. Two liters of colostrum should be fed within 4 hours after birth (ideally within 30 minutes). Time is critical because the calf's digestive tract allows antibodies (large protein molecules) to pass directly into the blood within being broken down for only 24 hours. After 24 hours, antibodies cannot be absorbed intact by the small intestine (called closure).

6. Puerperal period of cows

The puerperal period is the period between birth and complete uterine involution, which is around 40 days postpartum for cows. Progesterone levels decline rapidly during the last 48 hours before parturition and remain at very low levels throughout the early post calving period. This decline is related to regression of the corpus luteum of pregnancy. Shortly after calving, the uterus is very large, which the weight represents between 8 to 10 kg. The most part of uterine involution takes place between calving and day three post calving. Vasoconstriction and peristaltic contractions allow a rapid decrease in size. Uterine involution is also characterized by a necrosis of caruncular stalk, breakdown of the superficial layer of the caruncle and formation of the lochial discharge. This event is completed about 12 days after

calving and normally is an aseptic process. However, puerperal infections can occur when massive bacterial growth in the lochia. In this case cows have more predispositions to manifest gynecological troubles as placenta retention and metritis.

7. Reproductive male tracts: anatomy and function

The primary organ of reproduction in the male is **the testicles**, of which the bull has two, as is the case in most animals. Secondary sex organs and three accessory sex glands are part of reproductive male tracts. All reproductive organs work in concert for formation, maturation and transport of spermatozoa, which are eventually deposited in the female reproductive tract.

The secondary sex organs are **the epididymis, vas deferens and penis**. The three accessory sex glands include the seminal vesicles, prostate and bulbourethral gland (Cowper's gland). The reproductive male anatomy is shown in Figure 3

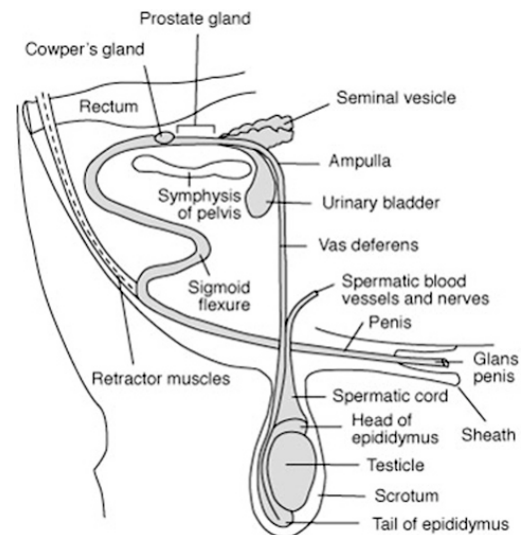


Figure 3 : Reproductive tract of the bull

The testicles

The testicles are located outside the body cavity in the scrotum (external oval sac) and have two vital functions: producing the spermatozoa, and producing the testosterone (male hormone). Location of the testicles exterior to the body cavity is essential for normal sperm formation, which occurs only at 1 to 4°C cooler than body temperature. The scrotum provides physical protection to the testicle and helps regulate the temperature for optimum spermatozoa development. This regulation is done by coordination of three structures: a temperature-sensitive layer of muscle (tunica dartos) located in the walls of the scrotum, which relaxes when hot and contracts when cold; the external cremaster muscle within the spermatic cord, which controls the proximity of the testicle to the body by lengthening or shortening depending on environmental temperature; and a counter-current temperature exchange regulated by a blood flow process known as the pampiniform plexus, which is a coil of testicular veins that provide an effective mechanism for cooling arterial blood entering the testicle and transferring its heat to the venous blood leaving the testicle.

One or both testicles occasionally fail to descend into the scrotum during embryological

development and are retained in the body cavity. This condition is known as chryptorchidism. Hormone production by chryptorchid males is near normal and the male develops and behaves like a normal male, however will generally be subfertile. This condition is genetically inherited, therefore such males should not be used for breeding.

The seminiferous tubules are lined with germinal epithelium, the spermatogonia. The tubes seminiferous are formed by many long, tiny, coiled tubes, within which the sperm are produced and begin to mature. Specialized cells, known as Sertori cells, localized in the tubes seminiferous are responsible to provide nutriments to the spermatozoa. Scattered throughout the loose connective tissue surrounding the seminiferous tubules are other kind of specialized cells, the interstitial cells of Leydig, that produce testosterone. There are hundreds of individual seminiferous tubules in the body of the testicle which unite with one another to form a few dozen tubules that exit from the testicle and pass into the epididymis.

The epididymis

The epididymis is a compact, flat, elongated structure closely attached to one side of the testicle. It is divided into three regions, the head, body and tail. The many tubules entered the head of the epididymis from the testicle unite to form a single tubule. An epididymis bull has approximately 35 meters long and this tubule is convoluted and packed into 18 cm. Four major functions occur in the epididymis, including the transport of the developing sperm cells from the testicle to the vas deferens; the concentration of the sperm by absorption of surplus fluids; the maturation of the developing spermatozoa; and the storage of viable sperm cells in the epididymis tail. If sexual activity is slowed, resorption of sperm cells from the epididymis tail occurs.

The epididymis serves as an outlet for all the sperm produced in the testicle and any blockage of this tube will cause sterility. Temporary blockage due to swelling following an injury or infection (epididymitis) will result in short-term infertility. If the swelling or infection results in formation of scar tissue in the tubule, it may permanently block the passage of sperm. If blockage occurs in both epididymides, the bull will no longer be useful as a breeder. Surgical removal of the tail of the epididymis (epididectomy) is frequently used as a means of sterilization for teaser (Gomer) bulls for estrus detection. Epididectomized bulls will mate cows in the usual manner, because they still produce testosterone from cells Leydig, however will not deposit sperm in the female reproductive tract.

The vas deferens

The vas deferens, also known as ductus deferens, emerges from the tail of the epididymis as a straight tubule and passes as part of the spermatic cord through the inguinal ring into the body cavity. Spermatozoa are transported further along the reproductive tract to the pelvic region through the vas deferens by contraction of the smooth muscle tissue surrounding this tubule during ejaculation. Bulls may also be sterilized by a vasectomy in which a section of the vas deferens is removed so that sperm cannot pass to urethra and go to outside of the body.

The urethra is a single tube that communicates with two vas deferens. Anatomically the urethra is the channel passing through the penis. The urethra serves as a common passageway for semen from the reproductive tract and urine from the urinary tract.

As mentioned above, the bull has three sets of accessory glands. Semen is made up of the fluids from accessory glands and the sperm (mature spermatozoa). The volume of ejaculate is very variable, 1 to 15 ml. The concentration will also vary considerably, however the usual is 1 to 1.8 billion sperm per ml. Since only one sperm is required to fertilize an ovum, considerable dilution of the semen can be done.

Two of accessory glands, the seminal vesicles and prostate, are located in the region where the vas deferens unite to become the urethra. Secretions from these glands make up most of the liquid portion of the semen. In addition, the secretions activate the sperm to become motile. The seminal vesicles consist of two lobes about 10 cm long in the bull, each connected to the urethra by a duct, which the main role is the production of nutrients for spermatozoa. The prostate gland is located at the neck of the urinary bladder where it empties into the urethra. The prostate is relatively small in the bull, as compared to other species, and does not produce a very large volume secretion, which is rich in enzymes for spermatozoa metabolism.

The third accessory gland, the Cowper's glands, are small, firm glands located on either side of the urethra. The clear and buffered secretion that often drips from the penis during sexual excitement prior to service is largely produced by these glands and serves to flush and cleanse the urethra of any urine residue that may be harmful to spermatozoa. The secretion from Cowper's glands assures an optimizer pH for the semen. This is a protection against an eventual low pH of female reproductive tracts and pH decrease due the spermatozoa metabolism.

One of the accessory glands may occasionally become infected, resulting in semen samples that are yellow and cloudy and which contain puss cells. It is not uncommon in bulls for the seminal vesicles to be so affected (seminal vesiculitis). Antibiotic treatment is sometimes necessary, but time will generally correct the problem.

The penis

The penis of bulls has sigmoid flexure. This is an anatomical structure that provides a means by which the penis is held inside the sheath except during time of mate. Strong retractor muscles hold the penis in the "S" shaped configuration. Occasionally these muscles are too weak to function properly and a portion of the penis and sheath lining protrude at all times. This exposes the male to the danger of injury and this characteristic should be avoided when selecting a herd bull.

The penis is the organ of insemination. Spongy-type material within the penis is filled with blood during sexual arousal, resulting in erection of the organ. The end of the penis is the glans penis and is richly supplied nerves, which are stimulated during copulation to induce ejaculation.

The normal functions of male reproduction are largely controlled by hormones that are secreted from the endocrine glands. The testicle functions as an endocrine gland because of its production of the male hormone, testosterone, by the interstitial cells (cells Leydig).

The major functions of testosterone are:

- It is largely responsible for development and maintenance of the male reproductive tract;
- It causes the development and maintenance of the secondary sex characteristics associated with masculinity, such as the crest and heavily muscled shoulders of a bull;
- It is a major factor in the normal sex drive and
- behavior of the male; It increases muscular and skeletal growth, and
- It is essential for normal sperm formation.

The same gonadotropic hormones that regulate ovarian functions in the cow also regulate testicular functions in the bull. LH and FSH are released from the pituitary gland and cause the testicle to secrete testosterone, which then acts on the germ cell lining of the seminiferous tubules to stimulate formation of primordial sperm cells. The maturation of spermatids into fully developed sperm cells requires the presence of FSH. Normal functioning of the male accessory glands requires testosterone.

Not only is hormone production of the testicle regulated by hormones released by the anterior pituitary, but the reverse is also true. The level of testosterone in the blood regulates the secretion of gonadotropic hormones from the anterior pituitary via a feedback system. A proper balance of all hormones is vital to successful reproductive functions.

In dairy systems, knowledge about: reproductive female tract, estrous cycle, gestation, calving, puerperal period and reproduction male tract are a requirement to a good dairy management. In this module you have found the principles of dairy bovine physiology. This distance learning course would help you to understand and to improve the reproduction in dairy systems.