

## Reproductive Anatomy and Physiology of the Cow\*

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The ability of a cow to successfully mate, conceive, give birth to and raise a healthy calf each year is paramount to economical beef production. A good understanding of anatomy and physiology of both the male and female is beneficial to successful management of reproduction. Causes for failures in reproduction must be identified and overcome. Man's quest to more fully understand science and biology have led to development of numerous techniques for manipulating the reproductive processes of animals. Use of these techniques in beef production provides many options to the modern beef producer to accomplish his management goals.

### Anatomy

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 of the hypothalamus' functions. 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 gland*, sits at the base of the brain. The pituitary is about one-half inch in diameter and weighs about one gram. Physiologically, the pituitary is divided into two distinct regions: the anterior and posterior pituitaries. Each region secretes various hormones which direct body processes. Some of these hormones are responsible for reproductive events, while others control growth, metabolism and water balance.

The female reproductive organs consist of the ovary, uterus, cervix, vagina, and vulva. A sketch of the reproductive tract of the cow is shown in Figure 1.

Female reproductive tracts of various farm animals are similar to the cow, but differ primarily in the shape of the uterus and cervix.

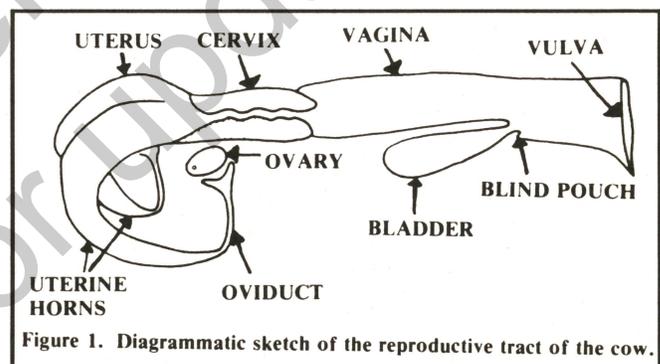


Figure 1. Diagrammatic sketch of the reproductive tract of the cow.

**Ovary.** The ovary, or female gonad, is responsible for two basic functions: 1) production of the female gamete, the egg or ovum, and 2) production of two primary reproductive hormones, estrogen and progesterone. A cow has two bean-shaped ovaries located within the abdominal cavity. Size of the ovaries varies with stage of the reproductive cycle and age of the female, but generally are 1 to 1 1/2 inches long.

**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 known as the *Fallopian tube*) where fertilization takes place if viable sperm are present. Here 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

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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.

**Uterus.** The body of the uterus of the cow is short and poorly developed, while the *uterine horns* are relatively long and well developed. 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, through which nourishment from the dam diffuses. There is no direct blood connection between the fetus and the dam, 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.

**Cervix.** The cervix is, in effect, the neck of the uterus. It has thick walls and a small opening which softens and relaxes to allow a passageway for sperm at mating and expulsion of the fetus at the time of birth. During pregnancy, the cervix is filled with a thick mucus secretion known as the *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.

**Vagina.** The vagina serves as a receptacle for the male's 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, an insemination instrument is threaded through the vagina and cervix and semen is deposited at the uterine side of the cervix. 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 passage-

way for both the urinary and reproductive systems. The external opening of the vagina is called the *vulva*.

## Physiology

The cyclical events of the estrous cycle are depicted in Figure 2.

The ovary produces the egg by a process called *oogenesis*. In contrast to spermatogenesis in the bull which is continuous, oogenesis is cyclic. This cycle of egg development in cattle is called the estrous cycle and is typically 20 to 21 days in length. During the estrous cycle, two prominent structures are present within the ovary, the *follicle* and *corpora lutea*.

Each of these structures undergo a development and subsequent regression phase during the estrous cycle. Follicles begin within the ovary as one of several thousand *primary follicles*, which consist of a germ cell surrounded by a layer of flattened cells. This germ cell has the potential to mature into an egg if the follicle completes the development phase. However, only a small percentage of primary follicles continue through the *secondary* and *tertiary* follicular phases and ultimately undergo ovulation. Primary follicles that never complete development die and are replaced by newly formed primary follicles.

The relatively few primary follicles which complete development do so through a series of phases. Many layers of cells are added to the single layer of cells surrounding the egg in the primary follicle, and a central cavity forms. The follicle and cavity within the follicle grow larger and the egg becomes attached to a stalk of cells on the side of the follicle opposite the future site of ovulation. As the follicle continues to grow larger, the outer layer of the follicle becomes thinner. This follicle is mature and called a *Graafian follicle*. The outer layer of the follicle ruptures at the appropriate time and the egg and contents of the follicular cavity are released. Follicular development occurs in concert with other reproductive and behavioral functions so that near the time of ovulation the uterus is prepared to receive both the egg from the female and sperm from the bull.

Following ovulation, the cells that developed within the follicle undergo a differentiation process by action of pituitary hormones. This process is called *luteinization* and gives rise to the second ovarian structure, the *corpora lutea* (pl. *corpus luteum*). This structure is often referred to simply as the CL and has the important function of secreting the hormone progesterone.

The CL goes through a maturation and regression cycle much the same as the follicle. A blood clot-type structure known as a *corpora hemorrhagicum* forms in the cavity left by the ruptured follicle and is transformed into a CL by Day 5 of the cycle (Day 0 = estrus). The CL is fully functional from Day 5 to Day 15 of the cycle and then begins to regress if the female does not become pregnant. The CL regresses and no longer secretes progesterone as the follicle of the next estrous cycle begins to develop. As the CL regresses further, it becomes

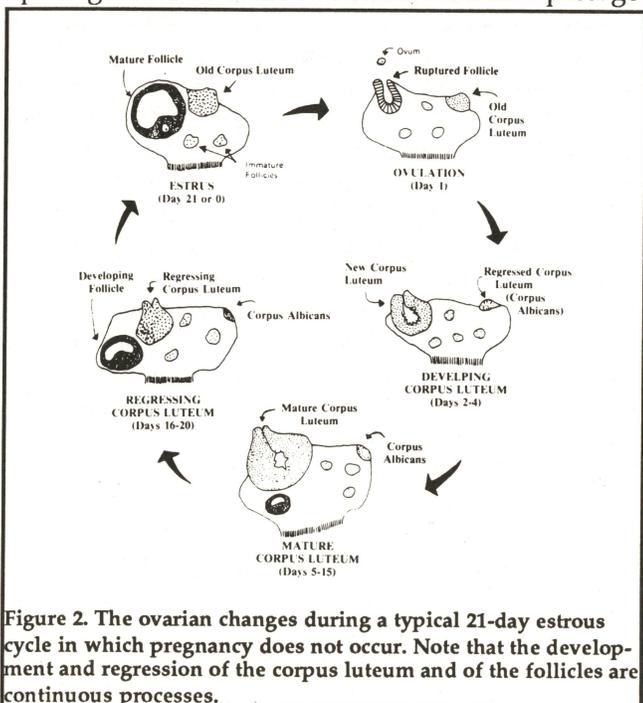


Figure 2. The ovarian changes during a typical 21-day estrous cycle in which pregnancy does not occur. Note that the development and regression of the corpus luteum and of the follicles are continuous processes.

known as the *corpus albicans* and remains visible on the ovary for several subsequent cycles.

Figure 2 illustrates the changing structures on the ovary during a typical 21-day estrous cycle. The dynamic development and regression of the corpus luteum and follicles are a continual process in the normal cycling cow until she becomes pregnant. In a pregnant female, CL regression does not occur and the cyclic activity stops until after calving. Following calving, a cow generally remains anestrous (does not cycle) for an average of 60 days before estrous cycles are once again established. The length of the postpartum anestrous period can be affected by nutrition, lactation, environmental stress and numerous other factors. Management to control the length of this interval is a main consideration in successful cow-calf programs since to produce a calf on a yearly interval a cow must rebreed within 85 days after calving.

Any condition that prolongs the period of time that blood levels of progesterone remain high will have the same effect as pregnancy in stopping the regular 21-day cycle. Occasionally the CL does not regress normally (persistent CL) even though the animal does not become pregnant. This requires diagnosis and treatment by a veterinarian.

Abnormally short estrous cycles (7 to 11 days) can occur. This condition appears to be caused by either no corpora lutea being formed, or if one is formed, it is nonfunctional and progesterone levels remain low. An estrous cycle can be shortened intentionally by injecting a hormone called prostaglandin which causes the CL to regress. Prostaglandin injection is one method used in estrous synchronization.

Estrus heat is not always accompanied by ovulation, nor ovulation by estrus. Heat without ovulation (anovulatory heat) will not result in pregnancy even though the female is bred. Ovulation without behavioral estrus (silent heat) is not uncommon in cows, especially the first few weeks after calving. Such females will not accept service from a male.

There are wide differences between the species of mammals in the various characteristics of the estrous cycle. Some species have only one heat period each year and are called monoestrous. The cow is in a group that exhibits heat more than one time per year and is called polyestrous. Even though cows will cycle at any time during the year, recent research has shown that day length may have an effect on cow fertility. Slightly lower fertility has resulted during the short day length period of the year.

## The Hormones of Female Reproduction

Reproduction in the female is controlled by numerous hormones secreted from specialized glands called endocrine glands. These secretions are produced in the glandular cells and pass into the blood and lymph systems for transport to specific parts of the body where they produce their function.

The female hormone, *estrogen*, is produced by the Graafian follicle. Estrogen has among its varied effects: (1) the development and function of the secondary sex organs; (2) the onset of behavioral estrus, i.e., the period of sexual receptivity; (3) the rate and type of growth, especially deposition of fat; and (4) it prepares the prepuberal heifer and post-partum cow for onset of cyclic sexual activity.

*Progesterone*, secreted by the corpora lutea, suppresses the further development of follicles and the secretion of estrogen. High levels of progesterone and low levels of estrogen prevent a cow from coming into heat. Progesterone is necessary for preparing the uterus to receive the fertilized egg and maintains the proper uterine environment for continuation of pregnancy.

Estrogen and progesterone are not completely separate in their functions since both must be present for certain processes to occur. For example, estrogen/progesterone concentration ratio dictates the onset and duration of behavioral estrus. Development of the uterus is initiated by estrogen and completed by progesterone. Estrogen causes contraction of the uterus near the time of estrus and ovulation which aid in sperm transport. Progesterone has a quieting effect on the uterus so that there are no contractions which might disturb pregnancy.

The production of ovarian hormones is under direct influence of *gonadotropic hormones* produced by the anterior pituitary. *Follicle stimulating hormone* (FSH) and *lutening hormone* (LH) are secreted from the pituitary and travel through the blood to the ovary. FSH and LH are mediated by *gonadotropic releasing hormone* (GnRH) coming from the hypothalamus to signal their release from the pituitary. 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.

The cyclic rise and decline of the reproductive hormone concentrations is graphically illustrated in Figure 3. This cyclic process continues every 20 to 21 days in a normal-cycling cow, but changes if conception occurs. Following pregnancy and a period of anestrous (no estrus cycles) the estrous cycle once again continues. Figure 3 shows diagrammatically the female hormones during a typical estrous cycle.

## The Estrous Cycle

The reproductive cycle of the cow consists of a series of events which occur in a definite order over a period of days. In the cow, this cycle averages 21 days in length (range is 17 to 24 days) and is concerned with preparing the reproductive tract for estrus or heat (the period of sexual receptivity) and ovulation (the release of the egg).

Figures 2 and 3 show the ovarian changes and sequence of events in a typical 21-day cycle in which pregnancy does not occur.

Days 0-1. The cow is in for estrus (standing heat) on Day 0 for an average of 18 hours (range 12 to 24 hours). About 12 hours after the end of the standing heat, the mature Graafian follicle ruptures (ovulates) in response to a surge of LH released by the pituitary gland.

Days 1-2. The cells that formerly lined the follicle change and become the lutein cells of the corpus luteum. This change in cell forms is caused by hormonal action, primarily that of LH.

Days 2-5. The corpus luteum grows rapidly in both size and function. Numerous follicles may be seen on the ovary at this stage, but by Day 5 they have begun to regress.

Days 5-16. The corpus luteum continues to develop and reaches its maximum growth and function about Day 10. It secretes the hormone progesterone which inhibits (blocks) 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 the existence of the high levels of progesterone.

Days 16-18. The corpus luteum regresses rapidly due to some luteolytic activity of the uterus. Evidence is increasing that this may be a prostaglandin.

Days 18-20. The corpus luteum is almost nonfunctional and this releases the blocking action of progesterone. Of the several follicles that commence growth, one becomes more prominent by a surge in rapid growth and activity. As the Graafian follicle grows, it secretes increasing amounts of estrogen. The remainder of the follicles regress.

Day 21 or 0. 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 level in the blood triggers a release of LH near the end of heat. Following this surge in blood levels of LH, the mature follicle ruptures to release the egg and the cellular tissue left behind becomes luteinized in response to the stimulation of a hormonal complex to

form a new corpus luteum (cycle has now returned to Days 1-2). Progesterone again becomes the dominant hormone.

It must be noted that the timing given for the preceding events is only approximate and differs for different cycle lengths.

The discussion of events occurring during the previous cycle was based on a full cycle in which pregnancy does not occur. If the egg is fertilized and begins development in the uterus, the corpus luteum does not regress but continues to function by secreting progesterone. No follicles develop to maturity and heat does not occur. Progesterone keeps the uterus quiet and thus provides the most favorable conditions for the developing fetus.

