INTRODUCTION

Reproduction is the process by which animals produce offspring for the purpose of continuing the species. The process begins with the mating of a male and female of the species, a process called copulation. During copulation, sperm cells (spermatozoa) are transferred from the male reproductive tract to the female reproductive tract. In the female reproductive tract, the sperm unite with the egg cell (ovum) produced by the female to form an embryo. The embryo attaches to the wall of the uterus of the female reproductive tract where it is protected, receives nourishment, and develops until the new offspring is delivered from the female reproductive tract in a process called parturition. For a complete understanding of the reproductive process, a basic knowledge is required of the reproductive tract structure and function.

STRUCTURE AND FUNCTION OF THE MALE REPRODUCTIVE SYSTEM

Male Macrostructure and Function

The major function of the male reproductive system is the production, storage, and deposition of sperm cells. It also functions by producing male sex hormones and serves as a passageway for expelling urine from the urinary bladder. The male reproductive tract is made up of several organs, glands, and muscles, each having a specific function.

Testes

The testes are paired, ovoid-shaped organs that produce sperm cells and the male sex hormone testosterone. Testosterone causes the development of secondary male characteristics and sex behavior (libido). The testes are suspended from the body by the spermatic cord. The spermatic cord is a protective fibrous sheath consisting of smooth muscles, blood vessels, and nerves. The scrotum protects and supports the testes. The spermatic cord extends through the inguinal ring and attaches to the testes to suspend them within the scrotum. The cremaster muscle, spermatic cord, and tunica dartos muscle in the wall of the scrotum raise or lower the testes to maintain a constant testicular temperature of
approximately four to six degrees below body temperature, because sperm must develop under conditions cooler than body temperature.

*Epididymis*

The epididymis is a coiled tube connected to each testis and is responsible for the maturation, storage, and transportation of sperm cells. The deferent duct (vas deferens) originates from the epididymis and serves as a passageway for sperm to the urethra. The urethra is the passageway or tube that extends from the bladder to the end of the penis and serves as the transportation route for semen and urine. The ampullae are enlargements of the deferent ducts that open directly into the urethra. The location of the testes varies among the different livestock species, and as a result, the position of the epididymis varies as well.

*Accessory Glands*

Accessory glands are responsible for the production of secretions that contribute to the liquid noncellular portion of semen known as the seminal plasma. Semen and ejaculate are terms given to the sperm plus the added accessory fluids. The vesicular glands (seminal vesicles) are paired accessory glands that secrete seminal fluid that adds fructose and citric acid to nourish the sperm and functions as a protection and transportation medium for sperm upon ejaculation. The prostate gland secretes a thick, milky fluid that mixes with the seminal fluid and also provides nutrition and substance to the ejaculate. Just prior to ejaculation, the bulbourethral glands (Cowper’s glands) secrete a fluid similar to the seminal fluid, which cleanses and neutralizes the urethra from urine residue that can kill sperm cells.

*Penis*

The penis is the organ that allows for deposition of semen into the female reproductive tract. The penis of the bull, ram, and boar are termed fibroelastic. The penis of the stallion is termed vascular. The stallion’s vascular type of penis has less connective tissue and depends on the engorgement of blood within certain tissues for erections to occur, and it forms no sigmoid flexure when relaxed. The penis of the bull, ram, and boar are termed fibroelastic because they are primarily composed of connective tissue and depend little upon blood for erections. When the penis is in a relaxed state in species with the fibroelastic penis type, the rear portion of the penis forms an S-shaped curve or sigmoid flexure. This curve allows for the retraction and protection of the front portion (glans) of the penis. The retractor penis muscles of the penis contract during the retraction of the penis, while the muscles relax and extend the
penis upon sexual excitement. The sheath is the external portion of the male reproductive tract that serves to protect the penis from injury and infection.

**Male Microstructure and Function**

Within the testes are microscopic cellular parts that function in the production of sperm cells and the male hormone testosterone. The development of sperm cells, called spermatogenesis, is a process of cell division and maturation that begins with stationary cells called spermatogonium and ends with motile spermatozoa.

*Seminiferous Tubules*

The seminiferous tubules are tubular structures that coil throughout the testes. The process of spermatogenesis takes place within the seminiferous tubules. The resulting spermatozoa, or sperm cells, are motile and tadpole-like. Once the maturation process has completed, the sperm cells proceed to the epididymis where they are stored until ejaculation or are absorbed by the body. Unusual climatic conditions (extremely high temperatures) or stress on a male can temporarily halt sperm cell production causing reproductive failure upon breeding.

*Interstitial Cells*

Between the seminiferous tubules are groups of interstitial cells (cells of Leydig) that function in the production of the male sex hormone, testosterone. Testosterone is an androgen hormone that directs the development of secondary male characteristics and influences libido. Secondary male characteristics include coarse hair, horns that are long and large at the base, a deep voice, and pronounced muscularity.

**STRUCTURE AND FUNCTION OF THE FEMALE REPRODUCTIVE SYSTEM**

**Female Macrostructure and Function**

The purpose of the female reproductive system is to produce the eggs (ova) to be fertilized by sperm. It also serves as a receptacle for the penis during copulation and houses and nourishes the fetus until parturition. The female reproductive tract is made up of several organs, each having a specific function.
Ovaries

Two ovaries function to produce eggs and the female hormones, estrogen and progesterone. The ovaries, along with the remainder of the female reproductive tract, are supported in the abdominal cavity by the broad ligaments. The arteries, veins, and nerves of the ovaries are also located in these ligaments.

Oviducts

The oviducts (fallopian tubes) are the paired tubes that transport the eggs from the ovaries to the uterus. The oviduct is the site where the sperm and the ova meet and where fertilization occurs. Two funnel-like openings, called infundibulums, pick up the eggs at ovulation and direct them into the body of the oviducts.

Uterus

The uterus consists of a body and horns. The embryo attaches to the uterine body, or to the wall of the uterine horn, depending on the species of the animal. The uterus varies in shape among livestock species from long uterine horns in the sow to relatively short uterine horns in the mare. The uterus functions as a passageway for sperm during copulation, incubates the embryo during pregnancy, and contracts to expel the fetus during parturition. It is in the uterus that the embryo receives nourishment and develops until parturition.

Vagina

The vagina serves as the receptacle for the penis during copulation and as the birth canal at parturition. The vagina also serves as a passageway for expelling liquid wastes, as the urethra joins the bladder to the vagina prior to the opening at the vulva. The cervix is a thick-walled mass of connective tissue with a small tube-like opening that joins the uterus and the vagina. The cervix serves as a passageway for the semen from the vagina to the uterus at copulation. It also contains glands that secrete a waxy-like substance that seals off the uterus during pregnancy and between heat periods to protect against infection, disease, or entrance of foreign matter.

The vulva is the external portion of the female reproductive tract that serves to protect the internal system from infection, to initially receive the penis at copulation, and to act as a passageway for urine. Just inside the vulva is a sensory erectile organ called the clitoris.
Female Microstructure and Function

Just as the male testes produce sperm cells, the female ovaries produce ova in the process of **oogenesis**. Cells called oogonia develop in the ovaries of a **fetus**. By the time of birth, these oogonia have matured into oocytes. There are thousands of oocytes at the time of birth; however, only a small proportion of these develop into ova or reach ovulation.

**Follicle**

The follicle appears as a clear blister-like on the surface of the ovary. The function of the follicle is to hold the growing ovum and to produce and store the hormone estrogen. Estrogen is secreted from the follicle as a signal to the remainder of the reproductive anatomy to prepare for the ovulation of an ovum. The follicle remains relatively hard throughout the development of the ovum, but it becomes very soft, ruptures, and expels the ovum at the time of ovulation. The ovum enters the **infundibulum** and then the oviduct to await fertilization.

**Corpus Luteum**

After ovulation, the ruptured follicle collapses and a small hemorrhage occurs. This blood-clotted area is called a corpus hemorrhagicum and only lasts two to three days. This area begins to be filled by a yellow mass of cells. This yellow body is called the corpus luteum. Its cells have the primary purpose of producing the female sex hormone, **progesterone**. Production of progesterone prepares the female reproductive anatomy for pregnancy and lasts approximately twelve days unless the ovum is fertilized (in which case the corpus luteum remains until parturition). A degenerating corpus luteum becomes covered by connective tissue and is called a corpus albicans. The function of the corpus albicans is to remove the yellow cells of the corpus luteum and return the ovary to its normal shape and function.

The process of oogenesis is a part of the estrous cycle. This cycle includes estrus, a period in which a female shows outward signs of receptivity to breeding as a result of the hormones secreted; this period is also referred to as “heat.” A cow or mare normally produces one ovum per cycle. A ewe produces two ova, and a sow produces eight to fifteen ova.

**STRUCTURE AND FUNCTION OF THE MALE REPRODUCTIVE SYSTEM IN POULTRY**

The male reproductive anatomy of poultry differs when compared to that of other animal species. The poultry anatomy consists of two testes (each with an epididymis and vas deferens) that lead to papillae and a rudimentary copulatory organ.
The testes are unique in that they are located along the backbone within the abdominal cavity. The epididymis is small in relation to the size of the testes, but still functions in sperm storage. The vas deferens extend from the epididymis to the cloaca and are located on each side of the vertebral column. They function in transportation of sperm and as sperm reservoirs. The cloaca is the portion of the lower end of the avian digestive tract that provides a passageway for products of the urinary, digestive, and reproductive tracts.

The copulatory anatomy consists of two papillae and the rudimentary copulatory organ called the phallus. The papillae are located at the end of the vas deferens and on the floor of the cloaca. They are the organs that emit semen into the cloaca. The rudimentary copulatory organ is primarily used for sex identification in young chicks, but it is more developed and becomes engorged with lymph during mating in ducks and geese. During copulation, the sperm is passed from the papillae into the oviduct opening or cloacal wall of the female.

Androgen is the male sex hormone produced by the testes. It not only directs sexual activity and the production of sperm, but it also controls secondary sexual characteristics of the male. Social rank or “peck order” is also influenced by the rate of androgen secretion. The secondary sexual characteristics include comb growth, crowing or gobbling, spur development, and male feathering.

**STRUCTURE AND FUNCTION OF THE FEMALE REPRODUCTIVE SYSTEM IN POULTRY**

The functional parts consist of an ovary, an oviduct, and the cloaca. The female of most animal species has two functional ovaries, but mature female poultry have only one functional ovary. Before the bird reaches sexual maturity, the right ovary and oviduct degenerate and cease function. The ovary appears as a cluster of tiny, gray balls that are oocytes. At maturity, the ovary contains up to 4,000 tiny oocytes from which yolks or ova (ovum) may develop over time. An ovum develops by collecting lipid particles from the blood to form the yolk.

The yolk contains fat for energy and some protein and other nutrients needed by the developing embryo, as well as a small, white dot called the blastodisc that contains the genetic information supplied by the female.

Each oocyte is enclosed in a thin sac called the follicle and is attached to the ovary by a vascular stalk. The oocyte will mature in the follicle to become a yolk. When the yolk is mature, it is released from the
follicle and then engulfed by the funnel-like infundibulum. The yolk enters a coiled oviduct that is about 25 inches long and consists of five clearly defined parts. The first part is the infundibulum. The infundibulum functions in receiving the yolk and is the site of fertilization. The second part is the magnum that secretes the thick white or albumen. Third, the isthmus adds the two shell membranes. Then fourth, the uterus secretes the thin white, the shell, and the shell pigment. Last is the vagina that holds the egg until it is laid. The egg passes from the oviduct to the cloaca and then out of the body through the vent at the time of laying.

Estrogen is the female sex hormone produced by the ovary. The ovary also secretes the hormone androgen. This hormone stimulates comb growth and works with other hormones in egg production. Estrogen stimulates the growth of the oviduct and causes the cloaca to increase in size during egg laying. It also modifies the feather shape and pigmentation of the female. Estrogen increases the level of fat, phosphorus, and calcium in the blood, as this is necessary in egg production.

THE REPRODUCTIVE PROCESS IN MAMMALS

The estrous cycle is measured as the time between two consecutive estrus periods. This time differs among the various species of livestock. The estrous cycle begins with the ovulation of a follicle. When the follicle erupts and releases the egg to the oviduct, the follicle becomes a corpus hemorrhagicum and then a corpus luteum that secretes the hormone progesterone. The corpus luteum develops, matures, and eventually regresses if the female’s ovum is not fertilized. During the regression of the corpus luteum, a new developing follicle on the ovary begins to release estrogen. Estrus will occur in response to the increasing amount of estrogen produced by the maturing follicle, and also by the decreasing amount of progesterone produced by the regressing corpus luteum. Estrus ends with ovulation of the maturing follicle and the estrous cycle starts again.

Different species of livestock show outward signs of estrus in various ways. For example, cows and ewes will stand to be mounted by other animals of their species, sows will stand still when pressure is placed on their loin area, and mares will act nervous and urinate frequently. The length of the heat period is also determined by the species of animal.

After ovulation has occurred, the egg or ovum is received by the infundibulum and funneled into the oviduct. If the female has been bred during the heat period and a viable sperm reaches the fallopian tube and fertilizes the ovum, then the result is pregnancy. If fertilization occurs, the corpus luteum persists on the ovary and produces progesterone throughout the pregnancy so that an estrus period does not occur.
until after the pregnancy has terminated. The hormone progesterone also helps to implant and nourish the embryo and to develop the mammary system of the female.

Fertilization is the union of the sperm and the ovum and is the actual beginning of pregnancy. During estrus, the female is either bred naturally or artificially inseminated. When bred naturally, the semen containing the sperm is deposited into the vagina of the female. The sperm make their way through the cervix into the uterine body, both uterine horns, and finally into the oviducts. If the sperm were deposited into the reproductive tract at the proper time in relation to ovulation, the sperm and ovum should unite and fertilization will occur.

The fertilized ovum, or zygote, begins a process of cellular division and becomes an embryo. The embryo floats freely for a time in the uterus where it obtains its nourishment from the fluids secreted by the uterine walls. After about twenty days in cattle (this period differs with each species of livestock), the embryo will attach to the wall of the uterus and begin to take a recognizable form, at which time it becomes a fetus. The embryo is encompassed in a fluid filled membrane called the amnion that protects the embryo from mechanical disturbances. The amnion is surrounded by the chorion that functions as a protective coat and point of nutritive exchange. The chorion develops raised button-like nodules on its surface called fetal cotyledons. At the time of attachment to the uterus, these nodules attach themselves to raised prominences in the uterine wall that arise from caruncular regions in the uterus. During fetal development, the fetus is nourished by the mother through these attachments. The membranes that surround the embryo and attach to the uterus during pregnancy are known as the placenta.

In some species of mammals, several ova are produced and fertilized during a single cycle resulting in multiple births. If two or more ova are fertilized, the resulting offspring are called fraternal twins and are no more genetically alike than are full brothers and sisters resulting from single births. Sometimes two offspring are produced from a single ovum fertilized by a single sperm resulting in maternal (identical) twins.

A normal pregnancy is terminated by birth. At the time of parturition, the fetus is expelled from the uterus and passes through the cervix and vagina out of the reproductive tract. The membranes that had formed around the fetus are also expelled at birth and are collectively called the afterbirth. After parturition, the corpus luteum on the ovary begins to regress, a developing follicle on the ovary begins to release estrogen, estrus occurs, and the estrous cycle begins once again.
THE REPRODUCTIVE PROCESS IN POULTRY

Poultry reproduction begins when sperm are introduced into the oviduct in the cloacal wall of the female by the papillae of the male. The sperm move up the oviduct to the infundibulum where fertilization takes place. Eggs that are already forming in other parts of the oviduct upon mating are not fertilized. Therefore, the first few eggs that are laid after mating may not be fertile. Sperm cells will remain in the oviduct for two to three weeks, though viability decreases as time passes.

As each yolk is released from the ovary of the hen, it falls into the infundibulum of the oviduct where the female germ cell on the outer edge of the yolk is fertilized by sperm. The fertilized yolk or embryo then moves through the reproductive tract, acquiring the normal egg components (albumen, shell membranes, thin white, and shell). With the proper temperature and humidity after the egg is laid, the embryo continues to develop. The embryo is nourished by the egg contents during incubation and for three to four days after the chick has hatched.

REPRODUCTION FAILURES IN LIVESTOCK

Sterility, either permanent or temporary, may be caused by a number of reasons. Specific physical defects, particular diseases, environmental factors, or nutritional aspects can halt or hinder reproduction.

Anatomical Factors

Cryptorchidism – this is the failure of one or both of the testes to descend into the scrotum. The testes are retained in the abdominal cavity resulting in complete sterility. Sometimes only one testis is retained and the defect is referred to as unilateral cryptorchidism. This does not cause complete sterility but results in a reduction in the number of viable sperm produced.

Scrotal hernia – this condition may not cause sterility but can cause an animal not to breed. If the hernia is large enough to allow part of an intestine to drop through, it can be very dangerous.

Malformed penis – results from an injury or birth defect, the penis can be malformed to the extent that copulation cannot be performed.

Ovarian Dysfunction

Freemartin – in the case of twin calves born of opposite sex, the female calf is sterile 90% of the time. The female reproductive tract does not completely develop in a freemartin.
Infantile or absence of ovaries – sometimes during development, because of a hormone imbalance, the ovaries fail to develop enough or will not function. In some cases, they may be absent.

Endocrine disturbances – some female reproductive disturbances are hormonal or glandular in nature, often the result of cystic ovaries in which one or both ovaries contain one or more cysts that may alternatively grow and regress but fail to ovulate. The cysts cause the female to exhibit abnormal estrous or anestrus.

**Diseases**

**Bacterial and Protozoal Infections of the Reproductive Tract**

Brucellosis – also known as “Bang’s disease.” Brucellosis causes the destruction of the cotyledons of the uterus and may result in abortion in the latter months of gestation. Affects cattle, swine, sheep, goats, dogs, horses, and some wildlife. Vaccinations are an effective means of prevention. Animals with the disease must be slaughtered.

Vibriosis (Campylobacteriosis) – a venereal disease found in cattle that causes infertility, early embryonic death, and abortion. Recovery is often spontaneous. Vaccinations are an effective means of prevention. A similar type of organism can also infect sheep.

Trichomoniasis – a venereal protozoal disease of cattle characterized by early embryonic death and abortion. A vaccine is available but is not always an effective means of prevention.

Leptospirosis – Causes loss of body weight, hemolytic anemia, and abortion. Affects cattle, swine, sheep, goats, dogs, and horses. Vaccinations are an effective means of prevention.

**Viral Infections of the Reproductive Tract**

Infectious Bovine Rhinotracheitis (IBR) – a respiratory viral disease that causes pneumonia, fever, infertility, impaired fetal circulation, and eventually abortion. Vaccinations are an effective means of prevention.

Bovine Viral Diarrhea (BVD) – a viral disease that causes ulcerations throughout the digestive tract, fever, and diarrhea. Abortion is caused by infection of cotyledons. Vaccinations are an effective means of prevention.
Environmental Factors

Mechanical injury – physical damage to reproductive organs. Injuries usually occur because of improper handling, unsafe facilities, fighting among animals, or complications during parturition or copulation.

Stress – severe climatic conditions (primarily extreme heat), high population density, rough handling, and other stressful environmental factors can cause reproductive distress.

Other Factors Affecting Reproduction

Nutritional deficiencies – reproductive failure can be caused by insufficient levels of feed intake and quality of nutrients needed to meet the high demands put on the body’s metabolism due to fertility requirements, pregnancy, lactation, and other events involved in reproduction. Lack of condition or obese condition usually reduces reproductive efficiency. During periods of low nutrition, the body lacks the energy stores necessary for reproductive activities. During periods of obesity, fatty deposits collect in and around the reproductive organs, impairing function and productivity.

Certain quantities of vitamins and minerals are essential for efficient reproduction. The following vitamins and minerals, if not balanced in the animal’s diet, are known to affect reproduction in the following ways:

- Vitamin A – shortened periods of gestation, higher incidence of retained placentas, stillbirths, abortions, mastitis, calves born blind and uncoordinated.
- Vitamin E – poor conception rates, higher incidence of stillbirths and newborn mortality.
- Phosphorus – poor conception rates, delayed puberty, lower weaning rates, erratic heat.
- Calcium – increased calving difficulty, uterine prolapse, retained placenta.
- Cobalt – poor conception rates, general reproductive failure.
- Iodine – retained placentas, delayed puberty, arrested fetal development, irregular or suppressed heat, abortion, stillbirths; calves that are blind, hairless, and have enlarged thyroid glands.
- Copper – delayed puberty, abortion, retained placentas.
- Iron – general reproductive failure, anemic young.
- Manganese – irregular or suppressed heat.
Ingestion of toxic plants – poisonous plants can also cause reproductive stress or abortion. Ingestion of locoweed, ponderosa pine needles, and snakeweed can cause abortion and birth defects in cattle. Ingestion of lupines, sweet clover, and onion grass can cause abortion in sheep and goats.

Genetic factors – some bloodlines are known to have a high genetic factor or weakness for sterility or low productivity. Inbreeding also may result in lowered fertility.