CHAPTER 6

Outcomes

Students will learn about the following topics.

1. The basic anatomy and physiology of reproductive systems in mammals and poultry.
2. The role of hormones in the regulation of animal reproductive processes and behaviour.
3. Factors limiting the fertility of farm animals.
4. Management techniques used by farmers to manipulate reproductive processes in farm animals.

Students will be able to demonstrate their learning by carrying out these actions.

1. Describe the anatomy of reproduction in mammals and poultry.
2. Describe the physiology of reproduction in mammals and poultry.
3. Label a diagram of the reproductive tract of a mammal and a bird.
4. Describe reproduction in birds.
5. Label a diagram of the reproductive tract of a bird.
6. Describe the role of hormones in reproduction.
7. Explain the interaction of hormones and an animal’s oestrous cycle.
8. List the major factors that affect fertility in animals.
9. Explain how a farmer can manipulate the following factors to increase reproductive efficiency: genetics, nutrition, climate, disease and management.
10. Describe the techniques used by farmers to manipulate reproductive performance in animals.
11. Evaluate the various techniques used to manipulate reproductive performance in animals.
anatomy the study by dissection of the structure of the body of an organism

dissection the act of cutting an organism into parts to show its structure

dystochia a difficult birth

dystrophic mortality the death of an embryo

definition the union of male and female sex cells; in plants, the union of the male and female sex cells in the ovule

gestation period the period of pregnancy

hormone a chemical substance secreted by the ductless, or endocrine, glands directly into the bloodstream to control body actions or processes

mammal the class of animal that nourishes its young with milk from the mammary glands

maturity the state of being fully developed

neonatal mortality the death of a young animal soon after it has been born

oestrogen a hormone produced by the ovary and responsible for the development of female sexual characteristics; also responsible for the signs of heat

parturition the act of giving birth

physiology the way in which organisms, or parts of organisms, function

polyoestrus in some non-pregnant animals oestrus recurs again and again throughout the year (e.g. pigs, cattle)

puberty the age at which a young animal’s reproductive organs are functional (sexual maturity)

reproduction the formation of new individuals by the fusion of two sex cells to form a zygote

seasonally polyoestrus describes the situation where animals usually breed during particular months of the year (e.g. goats, sheep, horses)
Introduction

The rate at which animals reproduce will affect the profitability of a farming system. To control the breeding of animals, the farmer must understand the anatomy and physiology of reproduction, and the factors that affect fertility in farm animals.

A farmer can increase reproductive efficiency by manipulating the following factors: genetics, nutrition, environment, pests and disease and management.

There are a number of ways of improving reproductive performance in animals. These include pregnancy diagnosis, artificial insemination, synchronisation of oestrus, embryo transfer and techniques for increasing the ovulation rate.

Anatomy and mammalian reproduction

The female

The female reproductive tract of a mammal consists of the ovaries, fallopian tubes (or oviducts), uterus, cervix, vagina and vulva (Fig. 6.1).

There are two ovaries, located one on each side of the abdominal cavity. Each ovary has two main functions – the production and release of ova, or eggs, and the secretion of hormones (oestrogen, progesterone and relaxin) required for conception and pregnancy.

The fallopian tubes, or oviducts, are the fine tubes that carry the ova from the ovary to the uterus, where development of the embryo takes place. In farm animals the anterior end of the oviduct is expanded into a funnel, or fimbria, which guides eggs shed from the adjacent ovary.

The uterus, or womb, consists of a body and two horns. Eggs enter the uterus 3 or 4 days after the time of egg release, or ovulation. If fertilised, the embryo attaches to the wall of the uterus, where it stays for the duration of pregnancy.

The cervix is a muscular and fibrous tube connecting the body of the uterus to the vagina. During pregnancy it is sealed to protect the foetus from infection. At around the time of mating and ovulation the cervix opens to allow sperm to pass through its narrow passage way. The cervix also dilates at birthing time.

The vagina is the connection between the cervix and the vulva. The urethra, which carries urine from the bladder, opens into the floor of the posterior part of the vagina. The vulva is the entrance to the reproductive system. There are two muscular folds, which are normally closely opposed, keeping the inner surface of the vagina clean. Swelling and/or colour change, especially in sows, indicate the animal is on heat or ready for mating.

Figure 6.1 The female reproductive organs (ewe)

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The male

The male reproductive tract consists of the testes, epididymis, vas deferens (seminal ducts), accessory glands, urethra and penis (Fig. 6.2).

![Diagram of male reproductive organs](image)

**Figure 6.2** The male reproductive organs (ram)

- The testes develop inside the abdomen and then descend into the scrotum. Each testis contains seminiferous, or sperm-producing, lobules. The testes have two functions – the production of sperm and the secretion of sex hormones. The scrotum is the skin-covered pouch that contains and supports the testes. Its main function is to keep the temperature of the testes at several degrees below body temperature.
- The epididymis consists of three parts – a head, body and tail. The sperm produced by the testes are stored in the epididymis until mating. Water is also reabsorbed through the walls of this structure, thus concentrating the sperm.
- The vas deferens (seminal ducts) are thin tubes connecting the epididymis to the penis. It is through the vas deferens that the sperm pass.
- The accessory sex glands are situated behind the neck of the urinary bladder. They consist of the seminal vesicle, the prostate gland, Cowper’s gland and the glands of the ampulla. At ejaculation, seminal fluid from these accessory glands is released into the urethra and mixed with sperm from the testes. The penis is the organ of copulation. It has two functions – depositing semen into the female reproductive tract and emptying the bladder during urination.

**Physiology of mammalian reproduction**

The female

Reproduction involves three cycles in the female. These are the lifecycle, the annual breeding cycle and the oestrous cycle.
- The lifecycle follows the pattern of prenatal life, birth, infancy, puberty, the prime of life, senility and death. The period of reproductive activity is confined to the prime of life.
- The annual breeding cycle is the yearly rhythm that animals go through during the prime of life. The breeding cycle is controlled by environmental influences. The main one is the seasonal rhythm of the increase or decrease in the hours of daylight. The decreasing daylight hours in autumn are a trigger for the start of the breeding season in sheep. Some animals, such as dogs and cats, only have one period of sexual activity per cycle; for example, female dogs come on heat once every 6 months. These animals are called monoestrous animals. Other animals such as pigs or rabbits are called polyoestrous and can breed the whole year round. **Seasonally polyoestrous** animals include sheep, cattle and goats and for them, breeding is confined to one season during the year, although there are many heat periods during this season.
The oestrous cycle occurs in the breeding cycle of females; each oestrous cycle consists of a period of sexual activity followed by a period of sexual inactivity. If the female does not become pregnant, these cycles continue throughout the breeding season. Details of the oestrous cycle change with different species. For mares the length of the oestrous cycle is 21 days with egg release 1 day before the end of the heat period. Ewes have a 16–17 day cycle, sows 21 days with egg release 36–48 hours after the onset of heat and cattle 21 days with egg release 13–15 hours after the end of heat.

The female reproductive system produces ova. Further, it provides a suitable environment for fertilisation and the development of the embryo and foetus. The stages of reproduction are puberty, the oestrous cycle, ovulation, fertilisation, pregnancy and birth.

**Puberty**

The first step in this series of processes is the reaching of puberty. Puberty is the age at which the young animal’s reproductive organs are functional. The age at which puberty occurs is affected by the weight of the animal. Although the female may become pregnant after reaching puberty, sexual maturity is not reached until sometime later.

**The oestrous cycle**

The female reproductive organs work in repetitive cycles called oestrous cycles, which are different for each species. The female will accept the male for only a limited period of each oestrous cycle. At this time the female is said to be in oestrus, on heat or in season. Table 6.1 shows reproductive characteristics of some animals.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Onset of puberty (months)</th>
<th>Gestation period (days)</th>
<th>Length of oestrous cycle (days)</th>
<th>Length of heat or oestrus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doe</td>
<td>4 – 8</td>
<td>150</td>
<td>20</td>
<td>36 hours</td>
</tr>
<tr>
<td>Ewe</td>
<td>6 – 12</td>
<td>147</td>
<td>17</td>
<td>30 hours</td>
</tr>
<tr>
<td>Sow</td>
<td>4 – 9</td>
<td>114</td>
<td>21</td>
<td>48 hours</td>
</tr>
<tr>
<td>Cow</td>
<td>6 – 18</td>
<td>280</td>
<td>21</td>
<td>18 hours</td>
</tr>
<tr>
<td>Mare</td>
<td>10 – 24</td>
<td>336</td>
<td>21</td>
<td>6 days</td>
</tr>
</tbody>
</table>

**Ovulation**

Ovulation is the shedding or release of an egg, or eggs, from the ovary. As ovulation approaches, one (or more) of the Graafian follicles (mature follicles) enlarges rapidly and inside it, the egg develops to maturity. During or shortly after oestrus the large follicle ruptures to release an egg, which enters the fimbria or funnel of the fallopian tube. The cow releases only one egg; the ewe and doe, one, two or three; and the sow, up to 20. For this reason, twins are scarce in cattle but common in sheep, and pigs usually produce litters with a large number of piglets.

**Fertilisation**

After mating, or joining, the sperm rapidly swim through the uterus to the fallopian tubes. Fertilisation occurs when a single sperm penetrates one egg. The external membrane of the egg changes and becomes impenetrable to other sperm. Fertilisation usually occurs in the upper one-third of the fallopian tube. The fertilised egg, or zygote, undergoes cell division and passes into the uterus. After further cell division it develops into an embryo. At first the embryo lies free within the uterus and can move about. The developing membranes then become attached to the wall of the uterus. This is called implantation.

Following implantation the placental membranes develop. The main purposes of these membranes are to carry nutrients and oxygen to the foetus and to take away waste products. The length of pregnancy, or gestation period, varies with the species, as shown in Table 6.1.
Birth

Birth, or parturition, is under the control of hormones. Towards the end of pregnancy, changes in the hormone content of the blood cause the passage through the cervix and vagina to enlarge. Continuous contractions of the uterine wall then force the foetus through the cervix into the vagina and finally through the vulva. Parts of the placenta, or ‘afterbirth’, are then expelled.

The male

The male reproductive system produces semen. This fluid has two components – the sperm and seminal plasma. Sperm are produced in the testes during the reproductive life of the male. Seminal plasma is the secretions from the accessory glands, and it is added to the sperm at ejaculation.

Puberty

The age of puberty and sexual maturity varies between species. Bulls are capable of producing semen at 9 months of age, but the quantity and quality are often poor. They should not be mated on a regular basis until several months after puberty. A young ram is capable of producing fertile semen at 6 months of age, and a young boar at 7 months.

Spermatozoa production

Sperm are formed within the long coiled seminiferous tubules, which lie in segments of the testes (Fig. 6.4). The sperm are formed from groups of cells that line the tubules. Sperm made in the seminiferous tubules then enter the epididymis for storage.

Seminal plasma or fluid

Seminal plasma varies in volume and composition between species and contains several substances. Nutrients such as fructose are secreted from the vesicular glands, or seminal vesicles, and provide the sperm with energy. Secretions from the prostate gland excite the sperm to swim and secretions from Cowper’s gland help lubricate the end of the penis.


**Libido**

Male sexual drive, or libido, is the desire and ability to mate with a female. Good semen production and strong libido are both essential if females are to be effectively mated. Libido is affected by age, body weight, temperature and recent sexual activity.

**Reproduction in birds**

(avian reproduction)

**The male**

In the male bird the testes are paired and attached to the kidneys. They do not descend into a scrotum as in other farm animals. In proportion to body size, the testes of male birds are larger than other farm animals. Thin tubes take sperm from the testes to the cloaca, where sperm may be stored in small pouches. There is no penis, and semen is deposited by the extension of the cloaca.

**The female**

In the hen the reproductive organs are also paired, but only the organs of the left side develop properly. The left ovary of a hen is different from a mammalian ovary. It consists of two lobes, and each follicle is attached to the ovary by a long stalk. The follicles are also different because nearly all the space inside them is taken up with the relatively large ova. Each ovum takes approximately 10 days to mature under the control of the follicle-stimulating hormone.

Ovulation occurs when the fully developed ovum breaks out from the follicle. The ovum then begins its passage down the oviduct. The oviduct is a long tube with elastic walls, consisting of five distinct regions (Fig. 6.7 on page 97). As the ovum passes through the oviduct, the egg white, or albumen, shell membranes and shell are added.
Following is an outline of what happens in each of the regions of the oviduct.

1. **Infundibulum.** The ovum first passes through the short infundibulum, or funnel, in which it may be fertilised by sperm and in which the anchoring cords, or chalazae, are attached.

2. **Magnum.** The ovum then passes into the magnum, which has thick glandular walls. Here it receives the albumen coating (a white substance).

3. **Isthmus.** As the ovum passes through the isthmus, the two shell membranes are added around the albumen.

4. **Shell gland.** The ovum then enters the shell gland where the shell is added.

5. **Vagina.** Finally, the egg passes through the vagina where it receives the ‘bloom’ that seals the pores of the egg shell.

The whole process of egg formation in the average hen takes approximately 26 hours, most of which is spent in the shell gland (approximately 20 hours).

### The role of hormones

Hormones in mammals are chemical substances secreted by the ductless, or endocrine, glands directly into the bloodstream to control body actions or processes.

The main endocrine glands controlling reproduction are the pituitary gland (sometimes called the master endocrine gland), the gonads and, in pregnant females, the placenta. The pituitary gland is located in a bony depression at the base of the skull. It has two distinct areas – the anterior and posterior pituitary. The gonads include the ovaries and testes.

### The pituitary gland

The anterior pituitary secretes several hormones, including three that are concerned with reproduction (Fig. 6.8).

1. **Follicle-stimulating hormone (FSH)** stimulates the growth and development of follicles in the ovary. In the male it stimulates production of spermatozoa in the testis.

2. **Luteinising hormone (LH)** in the female acts upon the mature follicle (called a Graafian follicle), causing it to rupture, releasing an ovum, and to develop into a corpus luteum. In males LH stimulates the production of testosterone (the male sex hormone) in the testis.

3. **Lactogenic hormone (prolactin)** is concerned with the maintenance of lactation in the females of some animals.

   The posterior pituitary gland produces one hormone that affects reproduction. This is oxytocin and it has two roles. It stimulates the letdown of milk in the lactating animal, and it stimulates muscular contraction of the uterus at mating and at birth to help expel the foetus.

### The gonads

The gonads are the sex glands (the ovaries in the female and the testes in the male) that produce the sex hormones.

### Ovaries

The ovaries produce three main hormones of reproduction.

1. **Oestrogen** is produced by the maturing follicle and has three main functions:
   - the stimulation of oestrus, or heat, so that the female will accept the male
   - the promotion of growth of the uterus, enlargement of the vulva and secretion of mucus from the glands in the cervix
   - the promotion of growth and development of ducts and tissue in the mammary gland in conjunction with progesterone.
Figure 6.8 The endocrine system – the anterior pituitary acts as a master gland, controlling the activities of other endocrine glands.

2 Progesterone is produced by the corpus luteum, which develops within the ruptured follicle after an egg has been released (called ovulation). Progesterone has a number of functions:
   i  the maintenance of pregnancy
   ii the stimulation of development of the wall of the uterus
   iii the prevention of oestrus and ovulation by the inhibition of FSH production.
3 Relaxin is produced mainly by the ovaries. It causes the pelvic ligaments to relax at birth.

Testes
The testes produce one main hormone of reproduction – testosterone. The production of testosterone is constant after puberty as males do not exhibit cyclic breeding activity, and most show no seasonal breeding activity. Testosterone is responsible for:
   • the development and maintenance of the sexual organs and accessory glands (prostate, seminal vesicle, Cowper’s gland and ampulla)
   • the later stages of sperm production
   • regulating libido (sex drive).
Hormones and the oestrous cycle

The anterior pituitary gland produces follicle-stimulating hormone (FSH), which stimulates a follicle containing an ovum (egg) to mature in the ovary. This mature follicle is called a Graafian follicle. The Graafian follicle produces the hormone oestrogen, which causes the female animal to stand for mating by the male (oestrus). Oestrogen triggers the release of luteinising hormone (LH) from the anterior pituitary gland. Luteinising hormone causes the Graafian follicle to rupture and release the mature ovum (egg). This is called ovulation. In the ruptured follicle the corpus luteum develops and produces progesterone. Progesterone blocks the production of FSH by the anterior pituitary gland so that no further follicles mature while the female animal is pregnant. If the female does not become pregnant the uterus produces prostaglandin, which causes the reduction in size of the corpus luteum and thus the amount of progesterone production. The reduced level of progesterone in the blood stimulates the anterior pituitary gland to start producing FSH again and so the cycle begins again. Prostaglandin can be injected into cows to synchronise heat.

Reproductive behaviour in male and female animals is influenced by the action of hormones. In females oestrogen will cause the female on heat to stand for mating by the male. Testosterone stimulates mating behaviour in males by the regulation of libido, or sex drive.

Factors affecting fertility

Fertile animals are those that reproduce efficiently. They are able to ovulate successfully, become fertilised and produce young. Most of the factors that influence fertility are under the control of the farmer, and therefore knowledge of these factors will help in reducing infertility.

Infertility is the failure of animals to reproduce. There are many factors affecting the fertility of farm animals. They can be conveniently considered under the following headings – genetics, nutrition, environment, pests and disease, and management. More information on dairy cattle infertility can be found at the following websites.

Genetics

There are genetic differences in fertility between species of animals. For example, a sow produces two litters per year, with approximately 11 piglets in each litter, producing a total of 22 offspring per year. A ewe produces one or two lambs per year. A cow usually produces one calf per year.

There are also genetic differences between breeds of the same species. Some breeds of sheep, such as the Border Leicester, have a higher percentage of twins than other breeds, such as the Merino. Some animals are infertile because they have a genetic abnormality in the anatomy of the reproductive or endocrine glands.

Nutrition

The rate of development of the reproductive organs and the onset of puberty are determined more by body weight than age.

Mature female animals on a low plane of nutrition and below normal body weight (Fig. 6.9) will have irregular oestrous cycles, lower ovulation rates and decreased fertility. If such animals are pregnant their offspring will tend to be smaller and weaker.

Ewes are often given more feed shortly before and during the joining period. This is known as flushing and will increase the ovulation rate and fertility if it causes an increase in body weight and condition. The effect of flushing is only noticeable if ewes are in poor condition before the joining period.

Feeding ewes a high plane of nutrition in the later stages of pregnancy increases foetal growth and may result in higher birth weights. However, overfeeding may lead to oversized lambs, which leads to dystocia (difficult birth) and the loss of young and sometimes the mother.

The effects on reproduction of poor nutrition in males are less evident than in females. A deficiency of vitamin A prevents normal sperm formation in bulls and rams. Overfeeding and excessive fatness may reduce libido.

16 Define the term ‘hormone’.
17 What is the function of FSH?
18 State two functions of oxytocin.
19 Where is progesterone produced?
20 What is the function of testosterone?
21 Explain the interaction between hormones in the animal’s oestrous cycle.
22 Name five factors affecting the fertility of farm animals.
23 Explain the term ‘infertility’.
24 What is flushing?
Environmental factors – climate

Two main aspects of the climate affect reproduction: temperature and day length.

Temperature

High temperatures increase embryonic mortality (death of the embryo) and reduce birth weights in piglets and lambs. Lambs with a low birth weight are weak and have a greater chance of death. This is one cause of low survival of lambs until marking (ear tagging, castration of males, tail docking) in Australia.

High temperatures also have a harmful effect on sperm production. The number of sperm is reduced and many sperm are abnormal. Rams that are to be joined during a hot summer should be provided with adequate shelter and water, and they should carry some cover of wool.

A combination of low temperatures and wet and windy weather will lead to high neonatal mortality in newborn lambs. This combination occurs in the high country of New South Wales and Victoria.

Day length

The breeding season, which depends on day length, is less marked in rams than ewes. In British breeds there is a marked decline in semen volume and quality out of season. In several wild animals there is a distinct mating season called the rut, or rutting period.

In some non-pregnant animals oestrus recurs again and again throughout the year. These species are called polyoestrous, and include pigs and cattle. Others, including goats, sheep and horses, usually only breed during particular months of the year and are seasonally polyoestrous.

The stimulus that controls breeding activity in seasonal breeders is the change in the ratio of hours of daylight to hours of darkness. The length of the breeding season in sheep differs between breeds and can be related to the latitude of their country of origin.

Pests and disease

Any disease that affects the health and vitality of an animal may reduce its reproductive capacity. Certain diseases may affect the reproductive organs themselves. Some types of infection may stop the production of either sperm or ova, or prevent the passage of the sperm or the ova along the reproductive tract. Other diseases may result in lack of implantation of the embryo or abortion of the foetus during pregnancy.

Venereal diseases often reduce the fertility of flocks and herds. They include:
1. *vibriosis*, which is caused by the bacterium *Vibrio foetus*, and results in infertility and abortion in ewes and cows.
2. *leptospirosis*, which is caused by organisms in the *Leptospira* genus, and produces high fever and abortion in cows.

Pests, such as sheep blowfly (which causes fly strike), and internal parasites, such as worms, can reduce the vigour of the animal and therefore reduce its fertility.

A major disease affecting the fertility of sheep is oestrogenic infertility. It occurs if ewes eat oestrogenic pasture, usually some types of subterranean clovers. The ewes fail to conceive.

Management

An animal is fertile if it produces an offspring, but it does not show fecundity until it produces a number of offspring. Farmers can improve the fertility and fecundity of their animals, and thereby increase the efficiency of reproduction, by using the following management practices.

1. Accurately detect whether they are on heat when trying to inseminate cows, ewes or sows.
2. Selectively cull to remove infertile cows, ewes or sows and infertile bulls, rams or boars.
3 Determine the optimum mating time so that the rams are joined to ewes at the time of the year when their breeding activity is at its highest (March, April and May, and August, September and October). This practice works well providing the market can support it. It is best to adopt a whole systems analysis with any farm activity and to consider all of the factors that can influence a management decision. Climatic influences, market conditions and social demands for the product often affect the timing of a particular farm-management decision, such as when to mate animals.

4 Prevent and control pests, disease and parasites through vaccinating, drenching and dipping.

5 Provide animals with adequate nutrition – the relevant types and quantities of feed.

6 Provide sufficient male animals so that all females are mated – for sheep the ratio is three rams for every 100 ewes, and for beef cattle a similar ratio applies.

Techniques for improving reproductive performance

A number of techniques are available for increasing the rates of reproduction and the rate of use of superior genotypes or genes. The techniques include pregnancy diagnosis, artificial insemination, multiple ovulation, flushing, synchronisation of oestrus, embryo transfer and increasing the ovulation rate.

Pregnancy diagnosis

Diagnosing or testing early after mating, or joining, enables more efficient stock management. Pregnant animals can be given better pastures or supplementary feeding, which will facilitate optimum foetal growth. Non-pregnant animals can be checked and mated again or culled.

Pregnancy diagnosis can be carried out by a number of methods. In cattle the procedure is rectal palpation. This involves placing a gloved hand in the rectum (45 to 60 days after mating) and feeling through the rectal wall for the foetus and placental attachments. Another method is to use a blood test. The blood sample (Fig. 6.11) is sent to a laboratory for analysis. In both cattle and sheep an ultrasound device is used to detect the presence of a foetal skeleton.

25 How does temperature affect embryonic mortality in pigs and sheep?

26 List the management practices used by farmers to increase the efficiency of reproduction.

27 Name two venereal diseases that often reduce the fertility of flocks and herds.
Artificial insemination

Artificial insemination (AI) is the act of using instruments to deposit semen in the female reproductive tract with the aim of achieving pregnancy.

In Australia, AI is used extensively with dairy cattle (Fig. 6.12) and to a lesser extent with beef cattle, sheep, pigs and goats. The benefits of using AI include:

- the widespread use of superior sires
- accurate sire selection for AI enables the widespread testing of unproven bulls over many herds in many different areas
- the eradication or prevention of venereal diseases
- the introduction of new bloodlines from other countries through the use of ‘overseas’ bulls
- the allowance for simple crossbreeding with one or several breeds, without the expense of keeping a number of bulls of different breeds.

![Figure 6.12 The technique for artificial insemination of a cow](image)

![Figure 6.13 Cross-section through an artificial vagina](image)

The disadvantages of using AI include:

- heat detection and yarding cows for insemination takes extra time
- damaged semen or poor inseminator technique will reduce fertility
- inseminators careless with hygiene can easily spread disease from one cow to another.

When AI is to be used, semen is collected from bulls using a container called an artificial vagina (Fig. 6.13). The semen is then examined for its quality and fertilising ability. Fertility is determined by the semen’s colour, volume, sperm concentration and motility.

A special diluent is added to the semen. It consists of skim milk, glycerol, fructose and antibiotics. The semen is then placed in plastic straws. Each straw is identified with the bull’s name and date of collection. The straws are slowly frozen in liquid nitrogen and transferred to large storage vats. The semen is stored at −196°C.
Synchronisation of oestrus

Synchronisation of oestrus involves bringing all the animals in a herd or flock into oestrus at the same time. In Australia most commercial sheep and beef cattle properties are extensive enterprises and heat detection is difficult. Without using oestrus synchronisation it would be necessary to inseminate every day for approximately 20 days with sheep or 30 days with cattle, to make sure each animal was fertilised. In dairy cattle it is relatively simple to observe oestrus as cows are handled twice each day for milking. There are signs, or symptoms, of oestrus in dairy cattle.

• The vulva is moist and red.
• There is a clear mucus discharge from the vulva.
• The cow stands to be ridden.

The benefits of oestrus synchronisation are several.

• If all animals in a flock or herd are brought into oestrus on a chosen day, they can be yarded and artificially inseminated together.
• Lambing and calving can be condensed into a shorter period.
• Lambs or calves can be sold as an even pen or lot.

Oestrus synchronisation involves treating the females to be inseminated with hormones so that they will all come into oestrus and ovulate at about the same time. There are two common methods.

1 Progesterone treatment. A progesterone-releasing intravaginal device (PRID) attached to a plastic coil is inserted into each cow’s vagina on the same day and removed 10–12 days later. Insemination occurs 56 hours after withdrawal of the coil. In sheep a pessary (sponge) containing progesterone is placed in the ewe’s vagina and removed after 14–16 days. The ewe is then inseminated 48–60 hours later.

2 Prostaglandin injection. With this method oestrus and ovulation occur after giving two doses of prostaglandin. The injections are given 10–12 days apart. The cow is then inseminated 48 hours later.

The disadvantages of oestrus synchronisation include:

• synchronisation is expensive (for injections or implants)
• the farmer needs to have high level organisational skills, especially when carrying out an embryo transfer program.

Embryo transfer

The embryo transfer (ET) technique enables embryos to be transferred from one female to another. It enables greater use of superior females in breeding programs.

Normally a cow will produce six or seven calves in her lifetime. She usually produces a single egg, and thus a single calf, each time she ovulates. By the use of hormones she can be superovulated, or made to produce several eggs (multiple ovulations). These can be collected and implanted into several foster mothers, or recipient cows. Using this method a single cow might produce 50 calves in her lifetime. Figure 6.14 on page 104 shows the steps in embryo transfer. Further information can be found on the Steps in embryo transfer website.

There are various benefits associated with embryo transfer.

• It is a method of obtaining many more calves, far more quickly, from particularly valuable or prized cows than is possible by the normal reproductive processes.
• The embryos can be frozen, stored and used later.
• The frozen embryos can be transported from place to place or country to country.
• The embryos can be split to give four or more new embryos.
• The embryos can be sexed so that, for example, in the dairy industry only female embryos are implanted.
• Herd genetic improvement is rapid compared with AI or paddock mating where a bull runs in a paddock with a herd of cows.
Disadvantages include the following points.

- Specialised and expensive labour is needed to carry out the procedure or practice (usually a veterinarian specialising in ET).
- Embryo implantation rates and calving percentages can be low.
- Recipient cows need their oestrous cycles to be synchronised so that they are ready to receive an embryo.

**Increasing the ovulation rate**

In some intensive areas of sheep production it is often desirable to increase the number of lambs born per 100 ewes joined. There are a number of ways of increasing the number of multiple births in sheep. Each method acts to increase the ovulation rate.

The ovulation rate can be increased permanently in future generations by:

- crossing with other breeds that have a naturally higher incidence of multiple births (twins, triplets)
- selectively breeding within one flock, by breeding animals that are born as multiples or have given birth to multiples.

The ovulation rate can be increased temporarily by:

- injecting ewes (or cows) with small doses of pregnant mare serum (PMS), which is a source of FSH
- treating ewes with a vaccine that immunises them against certain of their own gonadal hormones, such as progesterone
- placing the female animal on a high plane of nutrition prior to mating or joining (this procedure is known as flushing).

**Figure 6.14 The steps in embryo transfer**

1. **Superovulation of donor with hormones**
2. **Artificial insemination (5 days after initiating superovulation)**
3. **Non-surgical recovery of embryos (6-8 days after mating) using a Foley catheter**
4. **Foley catheter for recovery of embryos**
5. **Isolation and classification of embryos**
6. **Storage of embryos indefinitely in liquid nitrogen or at room temperature for a few hours**
7. **Transfer of embryos to recipients surgically or non-surgically**
8. **Pregnancy diagnosis by palpitation through the wall 1–3 months after embryo transfer**
9. **Birth (9 months after embryo transfer)**

**Questions**

28 How is pregnancy diagnosis performed in sheep?
29 List five benefits of using AI.
30 At what temperature is semen stored?
31 Explain the term ‘synchronisation of oestrus’.
32 Briefly describe the two common methods of oestrus synchronisation.
33 What is the main advantage of embryo transfer?
Chapter review

Things to do

1. Examine the reproductive tract from a ram, boar or bull. Draw and label the main organs.
2. Examine the reproductive tract from a ewe, sow or cow. Draw and label the main organs.
3. Observe the dissection of a hen. Draw and label the reproductive organs.
4. Observe semen samples using a monocular microscope (magnification x400).
5. Observe the calving, lambing, kidding or farrowing process.
6. Describe the devices used for heat detection in sheep and cattle; for example, the raddle for rams and the chin-ball headstall for vasectomised bulls.
7. Discuss the use of the chemicals and equipment used for heat synchronisation in cattle; for example, the PMS injection and the progesterone coil.
8. Observe the AI of a cow.
9. Draw and label the equipment used for AI – the AI gun, straw and sheath.
11. Describe the equipment used for castration of lambs and calves.
12. Use records from the school farm or neighbouring property to calculate the age of the cows at first mating, their age at first calving and calving intervals.

Things to find out

1. Outline the function of the cervix in a female reproductive tract.
2. Name three structures through which sperm pass from the time they are formed in the testes until they are released from the penis.
3. Several million lambs die each year on Australian sheep properties. Find out how these lambs die and suggest how the losses could be reduced.
4. Why does embryo transfer have only a limited application on commercial cattle properties, but an extensive application on stud properties?
5. Determine which synthetic hormones are used for manipulating animal reproduction in your district.
6. Research how semen and embryo sexing is carried out.

Extended response questions

1. Compare and contrast the structural and functional features of mammalian and avian reproductive tracts.
2. Describe the role of reproductive hormones in the regulation of the physiology and behaviour of farm animals.
3. Describe how the following factors affect the fertility of farm animals: genetics, nutrition, environment and climate, disease and management. Illustrate each factor with an example.
4. Describe and explain the interaction between hormones in an animal’s oestrous cycle.
5. The following techniques can be used to manipulate the reproductive performance of a herd: oestrus synchronisation, artificial insemination and embryo transfer.
   a. Describe why a cattle producer would use each of the techniques.
   b. Discuss any problems or disadvantages with these techniques.
6. ‘Increased productivity in the livestock industries is dependent on improvements in reproductive efficiency.’ Discuss this statement.
7. Evaluate two management techniques that are used by farmers to manipulate reproduction in farm animals; for example, AI or ET. For each technique:
   a. briefly describe the technique
   b. list the advantages of the technique
   c. list the disadvantages of the technique
   d. outline your judgement about these techniques.