Learning unit 8: Animal reproduction

8.1 Introduction

To complete the learning unit, you will need to refer to pages 1055–1078 chapter 45 in Campbell et al. (2015)

The survival of each species relies pretty much upon its members to produce new individuals to replace those that die. The ability to reproduce and perpetuate its species is a basic characteristic of living things.

As human, we tend to think of reproduction in terms of the mating of males and females and the fusion of sperm and eggs. Animal reproduction, however, takes many different forms. For example, in some species, individuals change their sex during their lifetime; in other species, such as sea slugs, an individual is both male and female. There are animals that can fertilise their own eggs, as well as others that can reproduce without any form of sex. For certain species, such as honeybee, only a few individuals within a large population reproduce.

In this learning unit, we will compare some major features of animal reproduction that have evolved among animals. Thereafter, we will focus on the mammalian reproduction, with an emphasis on the well-studied example of humans. We will conclude the learning unit focusing on reproduction mostly from the parents' perspective.

8.2 Learning outcomes

By the end of this learning unit you should be able to

- demonstrate your knowledge of animal structure and function
- describe the relationship between animal structure and function
- describe the different types and characteristics of cells and explain how they are organised to form tissues

8.3 Both asexual and sexual reproduction occur in the animal kingdom

Recommended reading: pages 1056–1058 of chapter 45 in Campbell et al. (2015)

There are two modes of animal reproduction that is **asexual** and **sexual**. **Asexual reproduction** involves the formation of individuals whose genes come from a single parent. There is no fusion of sperm and egg. **Sexual reproduction** is the formation of offspring by the fusion of haploid gametes to form a diploid zygote. The female gamete, the unfertilised egg, or ovum, is usually large and non-motile. The male gamete is the sperm, which is usually small and motile. Sexual reproduction increases genetic variation among offspring by generating unique combinations of genes inherited from two parents.

8.3.1 Mechanisms of asexual reproduction

Many invertebrates can reproduce asexually by fission, in which a parent separates into two or more approximately equal-sized individuals. **Budding** is also common among invertebrates. This is a form of asexual reproduction in which new individuals split off from existing ones. Also common among invertebrates is **fission**. In f*ragmentation*, the body breaks into several pieces, some or all of which develop into complete adults. Reproducing in this way requires *regeneration* of lost body parts. Many animals can also replace new appendages by regeneration.

Asexual reproduction has a number of advantages

-It allows isolated animals to reproduce without needing to find a mate.

-It can create numerous offspring in a short period of time.

-In stable environments, it allows for the perpetuation of successful genotypes.

Parthenogenesis is the process by which an unfertilised egg develops without being Fertilised. Parthenogenesis plays a role in the social organization of some bees, wasps, and ants. Male honeybees (drones) are haploid, and female honeybees (queens and workers) are diploid. Several genera of fishes, amphibians, and lizards reproduce by a form of parthenogenesis that produces diploid "zygotes." Fifteen species of whiptail lizards reproduce exclusively by parthenogenesis. There are no males in this species, but the lizards imitate courtship and mating behaviour typical of sexual species of the same genus.

8.3.2 Reproductive cycles

Most animals exhibit cycles in reproductive activity, usually related to changing seasons. This allows animals to conserve resources and reproduce when more energy is available and when environmental conditions favour the survival of offspring. Reproductive cycles are controlled by a combination of environmental and hormonal cues. Environmental cues may include seasonal temperature, rainfall, day length, and lunar cycles. Animals may reproduce exclusively asexually or sexually or they may alternate between the two modes, depending on environmental conditions. *Daphnia* reproduce by parthenogenesis under favourable conditions and sexually during times of environmental stress.

8.3.3 Variation in patterns of sexual reproduction

For many animals, sexual reproduction presents a problem for sessile or burrowing animals or parasites that may have difficulty encountering a member of the opposite sex. One solution to this challenge is **hermaphroditism,** in which one individual functions as both a male and a female. Some hermaphrodites can self-fertilise, but most mate with another member of the same species. In such mating, each individual receives and donates sperm. This results in twice as many offspring as would be produced if only one set of eggs were fertilised. In **sequential hermaphroditism,** an individual reverses its sex during its lifetime. In some species, the sequential hermaphrodite is female first. In other species, the sequential hermaphrodite is male first.

8.3.4 Activity 8.1

Do this activity and add it to your portfolio.

Refer to your textbook and answer the following questions:

b. What are the differences in sexual and asexual reproduction?

8.3.5 Feedback on activity 8.1

Sexual reproduction requires a union of gametes and provides a unique diploid individual. It produces diversity and allows for more than one offspring at a time.

Asexual reproduction requires one parent. There is not a union of gametes. It usually creates only one offspring at a time.

8.4 Fertilisation

Recommended reading: pages 1058–1061 of chapter 45 in Campbell et al. (2015)

The mechanisms of **fertilisation**, the union of sperm and egg, play an important part in sexual reproduction. In **external fertilisation,** eggs are released by the female into a wet environment, where they are fertilised by the male. In species with **internal fertilisation,** sperm are deposited in or near the female reproductive tract, and fertilisation occurs within the tract. A moist habitat is almost always required for external fertilisation, both to prevent gametes from drying out and to allow the sperm to swim to the eggs. In species with external fertilisation, timing is crucial to ensure that mature sperm encounter ripe eggs. Environmental cues such as temperature or day length may cause gamete release by the whole population. Individuals may engage in courtship behaviour that leads to fertilisation of the eggs of one female by one male. Internal fertilisation is an adaptation to terrestrial life that enables sperm to reach an egg in a dry environment. Internal fertilisation requires sophisticated reproductive systems, including copulatory organs that deliver sperm and receptacles for their storage and transport to ripe eggs. Mating animals may use **pheromones,** chemical signals released by one organism that influence the behaviour or physiology of other individuals of the same species. Pheromones are small, volatile, or water-soluble molecules that disperse into the environment. Like hormones, pheromones are active in minute amounts. Many pheromones act as male attractants. All species produce more offspring than can survive to reproduce. Internal fertilisation usually involves the production of fewer zygotes than does external fertilisation. However, the survival rate is higher for internal fertilisation. Major types of protection include tough eggshells, development of the embryo within the reproductive tract of the mother, and parental care of the eggs and offspring. Marsupial mammals retain their embryos for only a short period in the uterus. The embryos crawl out and complete fetal development attached to a mammary gland in the mother's pouch. The embryos of eutherian mammals develop entirely within the uterus, nourished through the placenta. Parental care of offspring can occur regardless of whether fertilisation is external or internal.

Gamete production and delivery

The least complex reproductive systems lack **gonads,** the organs that produce gametes in most animals. Polychaete worms lack gonads. Eggs and sperm develop from undifferentiated cells lining the coelom. As the gametes mature, they are released from the body wall and fill the coelom. In some species, the body splits open to release the gametes, killing the parent. Some reproductive systems, such as those of parasitic flatworms, are very complex. Most insects have separate sexes with complex reproductive systems. In many species, the female reproductive system includes a **spermatheca,** a sac in which sperm may be stored for a year or more. The basic plan of all vertebrate reproductive systems is very similar. However, there are variations. In many non-mammalian vertebrates, the digestive, excretory, and reproductive systems

share a common opening to the outside, the **cloaca.** Mammals have separate openings for the digestive and reproductive systems. Female mammals also have separate openings for the excretory and reproductive systems. The uterus of most vertebrates is partly or completely divided into two chambers. Male reproductive systems differ mainly in copulatory organs. Many mammalian vertebrates do not have a well-developed penis and simply turn the cloaca inside out to ejaculate.

8.5 Reproductive organs

Recommended reading: pages 1061–1066 of chapter 45 in Campbell et al. (2015)

Human reproduction involves intricate anatomy and complex behaviour

The reproductive anatomy of the human female includes external and internal reproductive structures. External reproductive structures consist of two sets of labia surrounding the clitoris and vaginal opening. Internal reproductive organs consist of a pair of gonads and a system of ducts and chambers. The role of the ducts and chambers is to conduct the gametes and house the embryo and fetus. The **ovaries**, the female gonads, lie in the abdominal cavity, attached to the uterus by a mesentery. Each ovary is enclosed in a tough protective capsule and contains many follicles. Each **follicle** consists of one egg cell surrounded by one or more layers of follicle cells. A woman is born with about 400 000 follicles. Only several hundred of these will release eggs during a female's reproductive years. Follicles produce the primary female sex hormones, estrogens. Usually one follicle matures and releases its egg during each menstrual cycle in the process of **ovulation**. After ovulation, the remaining follicular tissue develops into the corpus luteum. The corpus luteum secretes additional estrogens and progesterone; hormones that help maintain the uterine lining during pregnancy. If pregnancy does not occur, the corpus luteum disintegrates and a new follicle matures during the next cycle. At ovulation, the egg is released into the abdominal cavity near the opening of the oviduct. The cilia-lined funnel-like opening of the oviduct draws in the egg. Cilia convey the egg through the oviduct to the **uterus**. The highly vascularized inner lining of the uterus is called the **endometrium**.

The neck of the uterus, the **cervix**, opens into the **vagina**. The vagina is a thin-walled chamber that forms the birth canal and is the repository for sperm during copulation. It opens to the outside at the **vulva**, the collective term for the external female genitalia. The vaginal opening is partially covered by a thin sheet of tissue called the **hymen**. The vaginal and urethral openings are located within a recess called the **vestibule**. The vestibule is surrounded by a pair of slender folds called the **labia minora**. The labia majora enclose and protect the labia minora and vestibule. The **clitoris** is found at the front edge of the vestibule. During sexual arousal, the clitoris, vagina, and labia engorge with blood and enlarge. During sexual arousal, **Bartholin's glands** secrete mucus into the vestibule, providing lubrication and facilitating intercourse. **Mammary glands** are present in both males and females but normally function only in females. They are not a component of the human reproductive system but are important to mammalian reproduction. Within the glands, small sacs of epithelial tissue secrete milk, which drains into a series of ducts opening at the nipple.

The male's external reproductive organs consist of the **scrotum** and **penis**. The internal reproductive organs consist of gonads that produce sperm and hormones, accessory glands that secrete products essential to sperm movement, and ducts to carry the sperm and glandular secretions. The male gonads, or **testes**, consist of highly coiled tubes surrounded by layers of connective tissue. The tubes are **seminiferous tubules**, where sperm are produced. **Leydig cells** scattered between the seminiferous tubules produce testosterone and other androgens. The **scrotum**, a fold in the body wall, holds the testes outside the body cavity at a temperature about 2°C below that of the abdomen. This keeps testicular temperature cooler than that in the body cavity. The testes develop in the body cavity and descend into the scrotum just before birth. From the seminiferous tubules of the testes, the sperm pass through the coiled tubules of the **epididymis**. As they pass through this duct, sperm become motile and gain the ability to Fertilise an egg. **Ejaculation** propels sperm from the epididymis to the **vas deferens**. The vas deferens runs from the scrotum and behind the urinary bladder. Each vas deferens joins with a duct from the seminal vesicle to form an **ejaculatory duct**. The ejaculatory ducts open into the urethra. The urethra drains both the excretory and reproductive systems.

Accessory sex glands add secretions to **semen**. A pair of seminal vesicles contributes about 60% of total semen volume. Seminal fluid is thick, yellowish, and alkaline. It contains mucus, fructose, a coagulating enzyme, ascorbic acid, and prostaglandins. The **prostate gland** secretes directly into the urethra. Prostatic fluid is thin and milky. This fluid contains anticoagulant enzymes and citrate. Prostate problems are common in males older than 40 years. Benign prostate enlargement occurs in virtually all males older than 70 years. Prostate cancer is one of the most common cancers in men.

The **bulbourethral glands** are a pair of small glands along the urethra below the prostate. Prior to ejaculation, they secrete clear mucus that neutralizes any acidic urine remaining in the urethra. Bulbourethral fluid also carries some sperm released before ejaculation. This is one of the reasons the withdrawal method of birth control has a high failure rate. A male usually ejaculates about 2–5 mL of semen, with each milliliter containing about 50–130 million sperm. Once in the female reproductive tract, prostaglandins in semen thin the mucus at the opening of the uterus and stimulate uterine contractions that help move the semen. When ejaculated, semen coagulates, making it easier for uterine contractions to move it along. Anticoagulants then liquefy the semen, and the sperm begin swimming. The alkalinity of semen helps neutralize the acidic environment of the vagina, protecting the sperm and increasing their motility.

The human penis is composed of three layers of spongy erectile tissue. During sexual arousal, the erectile tissue fills with blood from arteries. The resultant increased pressure seals off the veins that drain the penis, causing it to engorge with blood. The engorgement of the penis with blood causes an erection, which is essential for the insertion of the penis into the vagina. The penis of some mammals possesses a **baculum**, a bone that helps stiffen the penis. Temporary impotence can result from the consumption of alcohol or other drugs, and from emotional problems. Irreversible impotence due to nervous

system or circulatory problems can be treated with drugs and penile implant devices. The oral drug Viagra acts by promoting the action of nitric oxide, enhancing relaxation of smooth muscles in the blood vessels of the penis. This allows blood to enter the erectile tissue and sustain an erection. The main shaft of the penis is covered by relatively thick skin. The sensitive head, or glans penis, is covered by thinner skin. The glans is covered by the foreskin, or prepuce, which may be removed by circumcision.

In females, plateau includes vasocongestion of the outer third of the vagina, expansion of the inner two-thirds of the vagina, and elevation of the uterus to form a depression that receives sperm at the back of the vagina. Orgasm is the shortest phase of the sexual response cycle. It is characterised by rhythmic, involuntary contractions of the reproductive structures in both sexes. In male orgasm, emission is the contraction of the glands and ducts of the reproductive tract, which forces semen into the urethra. Ejaculation occurs with the contraction of the urethra and expulsion of semen. In female orgasm, the uterus and outer vagina contract. Resolution completes the cycle and reverses the responses of earlier stages. Vasocongested organs return to their normal sizes and colours; muscles relax.

8.6 The interplay of tropic and sex hormones

Recommended reading: pages 1066–1070 of chapter 45 in Campbell et al. (2015)

Spermatogenesis and oogenesis both involve meiosis but differ in three significant ways

Gametogenesis is based on meiosis. **Spermatogenesis** is the production of mature sperm cells from spermatogonia. Spermatogenesis is a continuous and prolific process in the adult male. Each ejaculation contains 100–650 million sperm. Spermatogenesis occurs in seminiferous tubules.

Primordial germ cells of the embryonic testes differentiate into spermatogonia, the stem cells that give rise to sperm. As spermatogonia differentiate into spermatocytes and then into spermatids, meiosis reduces the chromosome number from diploid to haploid. As spermatogenesis progresses, the developing sperm cells move from the wall to the lumen of a seminiferous tubule and then to the epididymis, where they become motile. A head containing the haploid nucleus is tipped with an acrosome, which contains enzymes that help the sperm penetrate to the egg. Behind the head are a large number of mitochondria (or a single large one) that provide ATP to power the flagellum.

Oogenesis is the production of ova from **oogonia**. Oogenesis differs from spermatogenesis in three major ways. At birth an ovary may contain all of the primary oocytes it will ever have. Sperm are produced from spermatogonia throughout a man's life.

Unequal cytokinesis during meiosis results in the formation of a single large secondary oocyte and three small polar bodies. The secondary oocyte becomes the ovum, while the polar bodies degenerate. In spermatogenesis, all four products of meiosis become mature sperm.

Oogenesis has long "resting" periods. Spermatogenesis produces mature sperm from spermatogonia in an uninterrupted sequence. Oogenesis begins in the female embryo with differentiation of primordial germ cells into oogonia, ovary-specific stem cells. An oogonium multiplies by mitosis and begins meiosis, but the process stops at prophase I. The primary oocytes remain quiescent within small follicles until puberty. Beginning at puberty, follicle-stimulating hormone (FSH) stimulates a follicle to grow and induces its primary oocyte to complete meiosis I and start meiosis II. It is arrested at metaphase II as a secondary oocyte. The secondary oocyte is released when the follicle breaks open at ovulation. Meiosis is completed when a sperm penetrates the oocyte. Oogenesis is completed, producing an ovum.

In females, the secretion of hormones and the reproductive events they regulate are cyclic. Hormonal control of the female cycle is complex. Humans and many other primates have menstrual cycles. If pregnancy does not occur, the endometrium is shed through the cervix and vagina in menstruation. Other mammals have estrous cycles. If pregnancy does not occur, the uterus reabsorbs the endometrium. Estrous cycles are associated with more pronounced behavioural cycles than are menstrual cycles. The period of sexual activity, estrus, is the only time the condition of the vagina permits mating.

Human females may be sexually receptive throughout their menstrual cycle. The term menstrual cycle refers specifically to the changes that occur in the uterus, and is also called the uterine cycle. It is caused by cyclic events that occur in the ovaries, the ovarian cycle. The cycle begins with the release from the hypothalamus of **GnRH** or **gonadotropin-releasing hormone**, which stimulates the pituitary to secrete small amounts of **FSH (follicle stimulates hormone)** and **LH (luteinizing hormone)**. Follicle stimulates hormone, aided by LH, and the cells of the growing follicles start to make estrogen.

The high concentration of estrogen stimulates the secretion of gonadotropins by acting on the hypothalamus to increase its output of GnRH. This stimulates the secretion of FSH and LH. LH secretion is especially high; because the high concentration of estrogen increases the sensitivity of LH-releasing cells in the pituitary to GnRH. LH induces the final maturation of the follicle and ovulation.

Menopause, the cessation of ovarian and menstrual cycles, usually occurs between ages 46 and 54. During these years, the ovaries lose their responsiveness to FSH and LH, and menopause results from a decline in estrogen production by the ovary. Menopause is an unusual phenomenon. In most species, females and males retain their reproductive capacity throughout life. There might be an evolutionary explanation for menopause. One hypothesis proposes that cessation of reproduction allowed a woman to provide better care for her children and grandchildren, increasing the survival of individuals bearing her genes and increasing her fitness.

The principle sex hormones in the male are the **androgens**. The male sex hormones, androgens, are steroid hormones produced mainly by the Leydig cells of the testes, interstitial cells near the seminiferous tubules. Testosterone, the most important male androgen, and other androgens are responsible for the primary and secondary male sex characteristics. Primary sex characteristics are associated with the development of the vas deferens and other ducts, development of the external reproductive structures, and sperm production. Secondary sex characteristics are features not directly related to the reproductive system, including deepening of the voice, distribution of facial and pubic hair, and muscle growth. Androgens also affect behaviour. In addition to specific sexual behaviour and sex drive, androgens increase general aggressiveness. They are responsible for vocal behaviour, like singing in birds and calling by frogs. Hormones from the anterior pituitary and hypothalamus control androgen secretion and sperm production by the testes.

8.7 Placental mammals

Recommended reading: pages 1070–1076 of chapter 45 in Campbell et al. (2015)

In placental mammals, pregnancy or gestation is the condition of carrying one or more embryos. A human pregnancy averages 266 days. Many rodents have gestation periods of 21 days. Cows have a gestation of 279 to 289 days, and elephant gestation lasts 600 days.

Fertilisation or conception occurs in the oviduct. Twenty-four hours later, cleavage begins. Three to four days after Fertilisation, the embryo reaches the uterus as a ball of cells. By one week past Fertilisation, the blastocyst forms as a sphere of cells containing a cavity.

After a few more days, the blastocyst implants in the endometrium. The embryo secretes hormones to signal its presence and control the mother's reproductive system. Human chorionic gonadotropin (HCG) acts like pituitary LH to maintain secretion of progesterone and estrogens by the corpus luteum for the first few weeks of pregnancy. Some HCG is excreted in the urine, where it is detected by pregnancy tests. Human gestation is divided into three trimesters of three months each. For the first 2–4 weeks of development, the embryo obtains nutrients from the endometrium. The outer layer of the blastocyst, called the trophoblast invades the endometrium, eventually helping to form the placenta.

The placenta allows diffusion of material between maternal and embryonic circulations, providing nutrients, exchanging respiratory gases, and disposing of metabolic wastes for the embryo. Blood from the embryo travels to the placenta and returns via the umbilical vein. Organogenesis occurs during the first trimester. By the end of week four, the heart is beating. By the end of week eight, all the major structures of the adult are present in rudimentary form. The rapidity of development makes this a time when the embryo is especially sensitive to environmental insults such as radiation or drugs.

High levels of progesterone initiate changes in the maternal reproductive system. These include increased mucus in the cervix to form a protective plug, growth of the maternal part of the placenta, enlargement of the uterus, and cessation of ovarian and menstrual cycling.

Contraception can be achieved in several ways

Some methods prevent the release of mature secondary oocytes and sperm from gonads, others prevent fertilisation by keeping sperm and egg apart, and still others prevent implantation of an embryo.

Fertilisation can be prevented **by abstinence from sexual intercourse** or by any of several barriers that keep sperm and egg apart.

Temporary abstinence is called the **rhythm method** of birth control. This means of natural family planning depends on refraining from intercourse when conception is most likely. Ovulation can be detected by noting changes in cervical mucus and body temperature during the menstrual cycle.

Natural family planning brings a pregnancy rate of 10–20%

As a method of preventing fertilisation, coitus interruptus, or withdrawal (removal of the penis from the vagina before ejaculation), is unreliable. Sperm may be present in secretions that precede ejaculation. The several barrier methods of contraception that block sperm from meeting the egg have pregnancy rates of less than 10%.

The **condom** used by the male is a thin latex or natural membrane sheath that fits over the penis to collect the semen. The diaphragm is a dome-shaped rubber cap that fits into the upper portion of the vagina before intercourse. Both methods are more effective when used in conjunction with a spermicide.

Birth control pills are chemical contraceptives with a pregnancy rate of less than 1%. The most commonly used birth control pills are a combination of a synthetic estrogen and progestin (progesterone-like hormone). This combination acts by negative feedback to stop the release of GnRH by the hypothalamus and, thus, of FSH and LH by the pituitary. The prevention of LH release prevents ovulation. As a backup mechanism, the inhibition of FSH secretion by the low dose of estrogen in the pills prevents follicles from developing.

A second type of birth control pill, the **minipill**, contains only progestin.

Sterilisation is the permanent prevention of gamete release. Tubal ligation in women involves cauterization or ligation of a section of the oviducts to prevent the eggs from traveling into the uterus. Vasectomy in men is the cutting of each vas

deferens to prevent sperm from entering the urethra.

Abortion is the termination of a pregnancy

Spontaneous abortion or miscarriage occurs in as many of one-third of all pregnancies. In addition, 1.5 million American women choose abortions performed by physicians each year. A drug called mifepristone, or RU-486, enables a woman to terminate pregnancy non-surgically within the first seven weeks. An analogue of progesterone, RU-486 blocks progesterone reception in the uterus, preventing progesterone from maintaining pregnancy. It is taken with a small amount of prostaglandin to induce uterine contractions.

Modern technology offers solutions for some reproductive problems

It is now possible to diagnose many genetic and congenital abnormalities while the fetus is in the uterus. Amniocentesis and chorionic villus sampling are invasive techniques in which amniotic fluid or fetal cells are obtained for genetic analysis. Commonly used noninvasive techniques use ultrasound imaging to detect fetal conditions. A newer noninvasive method uses the fact that maternal blood contains fetal blood cells that can be tested. A maternal blood sample yields fetal cells that can be identified by specific antibodies and tested for genetic disorders. Reproductive technology can help with infertility treatments. Hormone therapy can increase sperm and egg production.

8.8 Activity 8.2

Do this activity and add it to your portfolio.

Refer to your textbook and answer the following questions:

b. What organs are parts of the male genital system?
d. Concerning reproduction, what is the function of the testicles?
f. What is the function of the secretions of the prostate, seminal vesicle and bulbourethral glands in reproduction?
h. What organs are parts of the female reproductive system?
j. During which period of life does the formation of gametes begin in women?
l. What endocrine glands are involved in the menstrual cycle? What hormones are in involved?
n. In what part of the female reproductive system does fertilisation occur?
p. How do contraceptive pills generally work?

8.9 Feedback on activity 8.2

b. The organs that comprise the male genital system are the testicles, the epididymis, the vas deferens, the seminal vesicles, the ejaculatory duct, the prostate, the bulbourethral glands, the urethra and the penis.
d. The testicles are the male gonads; that is, the organs where the production of gametes takes place. In human beings, gametes are produced by meiosis that occurs in the testicles.
f. These secretions, along with sperm cells from the testicles, form semen. These secretions have the function of nourishing the sperm cells and serving as a fluid means of propagation for them. The alkaline pH of seminal fluid also neutralises the acidic secretions of the vagina, allowing the survival of sperm cells in the vaginal environment after copulation.
h. The organs that make up the female reproductive system are the ovaries, the Fallopian tubes (or uterine tubes), the uterus, the vagina and the vulva.
j. The meiosis that forms female gametes begins in the cells of ovarian follicles before birth. After the beginning of puberty, under hormonal stimuli, during each menstrual cycle, one of the cells is released on the surface of the ovary and meiosis resumes. However, the meiotic process is only concluded if fertilisation occurs.
l. The endocrine glands that secrete hormones involved in the menstrual cycle are the hypophysis (the pituitary gland) and the ovaries. The hormones from the adenohypophysis are FSH (follicle-stimulating hormone) and LH (luteinizing hormone) and the hormones from the ovaries are estrogen and progesterone.
n. Fertilisation generally occurs in the Fallopian tubes, but it can also take place in the uterus. There are cases when fertilisation may occur even before the ovum enters the uterine tube, which may lead to a severe medical condition known as abdominal pregnancy.
p. Contraceptive pills generally contain the hormones estrogen and progesterone. If taken daily from the 4th day after menses, the abnormal elevation of these hormones acts upon the hypophysis-hypothalamus endocrine axis, inhibiting FSH and LH secretions. Since these hormones do not reach their normal high levels during the menstrual cycle, ovulation does not occur.

8.10 Summary

Asexual reproduction is the production of offspring without gamete fusion. Mechanisms of asexual reproduction include budding, fission, and fragmentation with regeneration. Whereas, sexual reproduction requires the fusion of gametes to form a zygote. Variation modes of reproduction achieved through parthenogenesis, hermaphroditism, and sex reversal.

Fertilisation occurs external when sperm and eggs are both released outside the body, or internally, when sperm is

deposited by the male fertilise an egg in the female reproduction system. In some case, fertilisation requires coordinated timing, which may be mediated by environmental cues, pheromones, or courtship behaviour.

In human males, sperm are always produced in testes, which are suspended outside the body in the scrotum. Ducts connect the testes to internal accessory glands and the penis. Whereas, the reproduction system of the human female consists principally of the labia and the glans of the clitoris externally. Eggs are produced in the ovaries and upon fertilisation develop in the uterus.

In mammals, GnRH from the hypothalamus regulates the release of two hormones, FSH and LH, from the anterior pituitary. In males, FSH and LH control the secretion of androgens (chiefly testosterone) and sperm production. While, in females, cyclic secretion of FSH and LH orchestrates the ovarian and uterine cycles via estrogens (primarily estradiol) and progesterone. The developing follicle and the corpus luteum also secrete hormones, which help coordinate the uterine and ovarian cycles through positive and negative feedback.

After fertilisation and the completion of meiosis in the oviduct, the zygote undergoes a series of cell divisions and develops into a blastocyst before implantation in the endometrium. All major organs start developing by 8 weeks. Contraception may prevent release of mature gametes from the gonads, fertilisation, or embryo implantation.