

Reproductive System

Introduction

Reproduction is the process by which living organisms produce young ones of their own species. It is one of the most important characteristics of living organisms. It maintains the continuity of the race. Reproduction is mainly of two types viz asexual and sexual. In asexual reproduction organism is formed without production of gamete *e.g.* Amoeba, Paramecium, Bacteria while in sexual reproduction the organism is formed by the union of 2 gametes with haploid nuclei. *e.g.* Some invertebrate and all vertebrate

8.1 Parthenogenesis

Parthenogenesis is a modified form of sexual reproduction in which a female gamete develops into a new individual without being fertilized by a male gamete. Development of egg without fertilization is called parthenogenesis. Natural parthenogenesis occurs in honeybee. The queens and workers are developed from fertilized ova. Drones (males) are produced parthenogenetically. Natural parthenogenesis can be classified into arrhenotoky (haplo-diploidy) and thelytoky (diploidy). In arrhenotoky as in honeybee, the male develops from unfertilized egg and the female from fertilized egg. In thelytoky, the diploid unfertilized egg parthenogenetically develop into females.

8.2 Mammalian reproductive system

Like other mammals, sexes are separate in human beings; males and females. Sexual characteristics in human beings can be classified as follows :

Sex	Primary sex organ	Secondary sex organ	Accessory or external sex character
Male	Testis	Prostate gland Seminal vesicle Vas deferens Epididymis Penis	Low-pitch voice Beard Broad shoulder Narrow hips
Female	Ovary	Fallopian tubes Uterus Vagina Mammary glands	High-pitch voice Smooth face Narrow shoulder Broad hips

(i) Male reproductive system consists of following parts :

(a) **Testes** : Testes are the primary male sex organs. Testis produces spermatozoa and secretes the male sex hormone **testosterone**. In mammals, the testes are located in the extra-abdominal scrotal sacs. Scrotum communicates with abdominal cavity through inguinal canal. The temperature in scrotum is 2 to 4°C below the temperature of abdominal cavity. Testes in mammals are present outside the abdominal cavity because maturation of sperm needs low temperature.

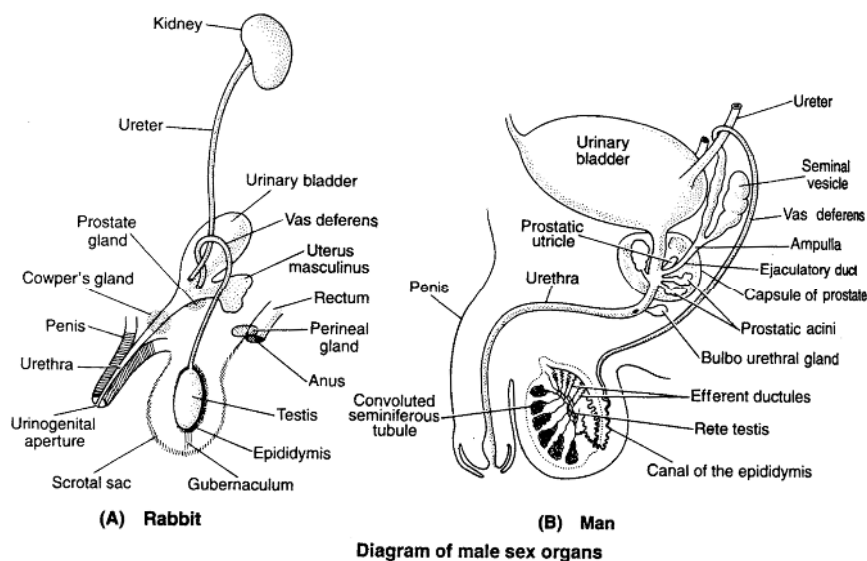


Diagram of male sex organs

Cryptorchidism is nondescent of testes in scrotum. Person becomes sterile. Orchiectomy is the surgical removal of testes. It is also known as castration. Gubernaculum is the ligamentous connective cord (elastic cord) which connects testes to scrotal sacs posteriorly. Gubernaculum represents mesorchium. The capsule enclosing testes of mammal is called tunica albuginea. **Cells of Leydig** are found in interstitial connective tissue of testes. They secrete male hormone testosterone. A few larger, tall, columnar supporting cells are called **Sertoli cells** or **sustentacular cells**. Sertoli cells are located in seminiferous tubules which nourish spermatozoa. All the seminiferous tubules in each testis open into a network called rete testis leading to fine ductules called vasa efferentia.

(b) **Epididymis** : Several tubes called vasa efferentia arise from rete testis and conduct sperms into epididymis. Epididymis is an irregular, narrow and highly convoluted tubule found on the inner surface of testis. Wolffian duct of embryo gives rise to epididymis in adult. Epididymis has three parts – anterior caput epididymis, middle corpus epididymis and posterior cauda epididymis. Vasa efferentia enter into caput epididymis. Testis is attached with abdominal wall through spermatic cord.

(c) **Vas deferens** : Vas deferens or sperm duct arises from cauda epididymis, ascends to abdomen, passes over the urinary bladder and receive the duct from seminal vesicle behind the urinary bladder forming ejaculatory duct. Ejaculatory duct passes through the prostate gland to open into urethra shortly after its origin from urinary bladder. The urethra receives the ducts of **prostate** and **Cowper's gland**, passes through penis and opens to outside.

(d) **Seminal vesicles** : Seminal vesicles (uterus masculinus) are situated behind the bladder. They are narrow, long pouches with muscular tissue on their wall. Uterus masculinus is situated at the junction of vas deferens and prostate gland. About 60% of the semen is seminal fluid produced by seminal vesicles. Seminal fluid has a *pH* of about 7.4 and contains fructose, citrate, ascorbic acid, prostaglandins and various enzymes. The fructose is a source of energy for the spermatozoa.

(e) **Prostate gland** : Prostate is situated around the first part of the urethra. It contains prostatic utricle and acini and covered by a capsule. Enlargement of prostate results in prostatitis, urination is difficult or

impossible. Prostatic secretion contains substances important for sperm mobility notably albumin and proteolytic enzymes fibrinolysin and fibrinogenase.

(f) **Cowper's glands** : These are also known as **bulbourethral glands**, situated beneath bladder and behind the urethra. Cowper's glands are present in male mammals. Cowper's glands open into urethra before entering into penis. Cowper's glands are yellow in colour. Their secretion is slightly alkaline and is produced during sexual stimulation. Cowper's gland secretion acts as a lubricant for the glans penis. It also neutralizes any urine in urethra.

(g) **Urethra** : Urethra is a thick-walled muscular duct and it is a common passage for both urine and semen and called urinogenital duct. Urethra traverse and opens at the tip of the penis as the male urinogenital aperture.

(h) **Penis** : Penis is the copulatory organ. It is vascular, spongy and erectile structure. It has glans penis at tip covered with a fold of skin called prepuce. Penis contains three longitudinal columns of spongy erectile tissue which becomes filled with blood during sexual excitement. Surrounding the urinogenital duct is **corpus spongiosum** and above it lie two **corpora cavernosa**. Penis serves to transmit sperms into the vagina of the female during sexual intercourse.

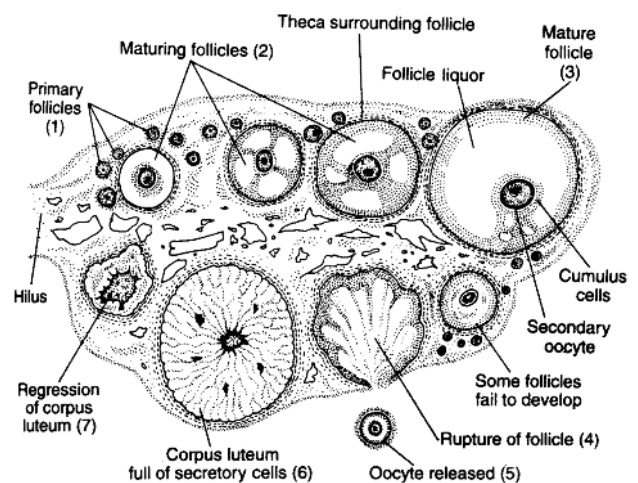
(i) **Perineal glands and rectal glands** : These are found in rabbit not in human beings. Perineum refers to the space between the anus and urinogenital opening. Perineal glands are a pair of dark elongated scent glands lying behind the Cowper's glands. They open into the hairless perineal depression on either side of anus. Their odorous secretion gives the rabbit its characteristic smell (its smell serves as sex attractant for the female). Ejaculation or seminal emission is the forceful expulsion of semen during sexual intercourse. At an average ejaculation, 3 ml of semen containing about 300 million spermatozoa is emitted in man.

(ii) **Female reproductive system** : Female reproductive system consists of the ovaries, oviducts (fallopian tubes), uterus, cervix, vagina, accessory genital glands, mammary glands, etc.

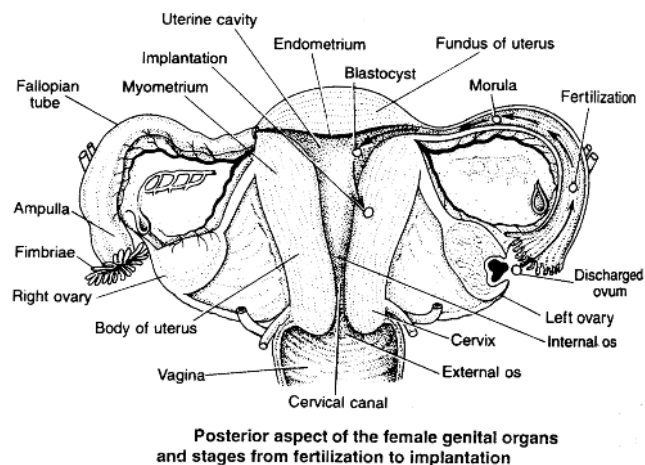
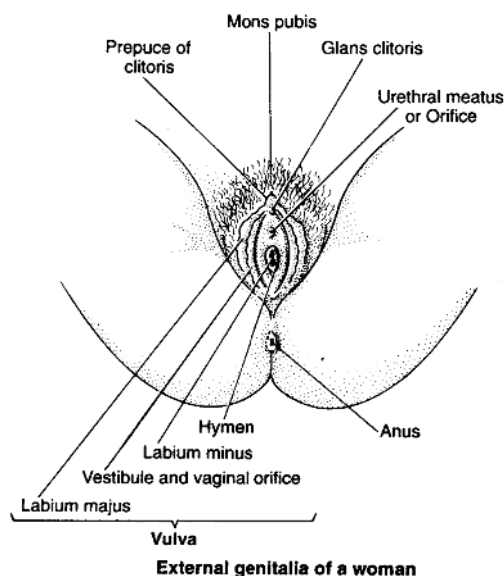
(a) **Ovary** : The ovary is the primary female sex organ. The ovary remains attached to the abdominal wall by a ligament called **mesovarium**. The ovary is solid, the blood vessels and nerve enter ovary at hilus. Ovary produces ova and secretes female sex hormones, viz., estrogens and progesterone. Ovary is covered by a cubical epithelium called the germinal epithelium. Ovary contains connective tissue, stroma composed of an outer dense layer called cortex and an inner loose layer known as medulla.

Cortex contains many small and large, spherical or oval ovarian follicles. A fully matured follicle is called **Graafian follicle**. It is the characteristic of mammalian ovary. Each graafian follicle contains an oocyte. Graafian follicle contains a large central follicular cavity or antrum with a fluid called liquor folliculi. The hillock or mass of cells which surrounds and attaches the primary oocyte to the follicle wall is called **discus proligerous**.

Discharge of a mature ovum from Graafian follicle is known as **ovulation**. After ovulation, a ruptured follicle turns into a yellowish solid mass of cells called corpus luteum. Corpus luteum secretes the female hormone, progesterone. Macula lutea or yellow spot is present in eye retina. Corpus luteum disappears leaving a whitish scar tissue called **corpus albicans**.



Structure of human ovary



(b) **Fallopian tube** : Fallopian tube is lined by ciliated epithelium whose cilia beat towards uterus. Fertilization in mammals occurs in fallopian tube. The embryo develops upto blastocyst stage in fallopian tube.

(c) **Uterus** : Uterus is situated above and behind the urinary bladder and remains attached to the bodywall by ligaments. The wall of uterus is composed of smooth muscles fibres called **myometrium**.

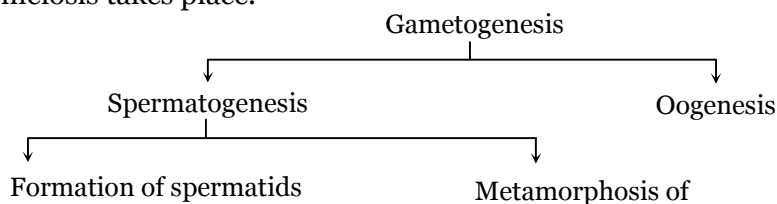
Lumen of uterus is lined by endometrium

(d) **Vagina** : *pH* of vagina is 4.9 to 3.5 by presence of lactobacillus acid philus bacteria. Bartholin's gland of female corresponds to bulbourethral gland (Cowper's glands) of the male. The hymen is a thin mucous membrane that stretches across the opening of the vagina.

(e) **Clitoris** : Clitoris is a small organ consisting of erectile tissue and is homologous to the penis of the male.

8.3 Gametogenesis

The process of the formation of haploid gametes from the undifferentiated, diploid germ cells in the gonads for sexual reproduction is called **gametogenesis**. During gametogenesis (spermatogenesis and oogenesis both), mitotic and meiotic both divisions take place. At multiplication phase, the mitosis and at the maturation phase, meiosis takes place.



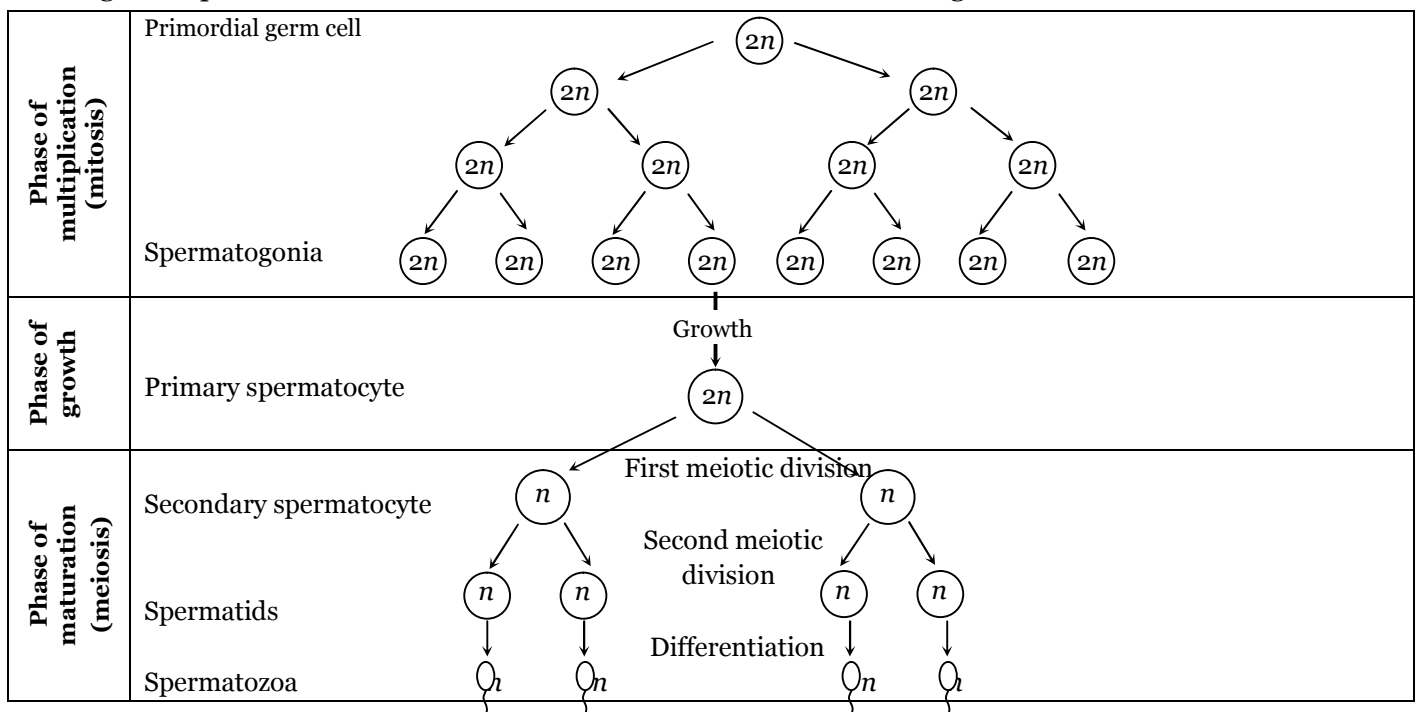
(i) **Spermatogenesis** : Mitochondria from different parts of spermatid get arranged in the middle piece around axial filament. Spermatogenesis includes two stages formation of spermatids and metamorphosis of spermatids. Spermatids are formed by three phases namely;

(a) **Phase of multiplication (mitosis)** : During phase of multiplication, the primordial germ cells divide repeatedly by mitosis to form diploid **spermatogonia**. Each spermatogonium divides mitotically to form two primary spermatocytes.

(b) **Phase of growth** : During phase of growth, the primary spermatocyte enlarges in size and prepares to undergo maturation division.

(c) **Phase of maturation (meiosis)** : During phase of maturation, the primary spermatocyte undergoes meiosis I giving rise to two haploid (n) secondary spermatocytes. The secondary spermatocytes undergo meiosis II resulting in the formation of four spermatids. Metamorphosis of spermatid to sperms is termed **spermiogenesis**. A spermatid is non-motile and heavy. It has organelles like mitochondria, Golgi bodies, centrioles, nucleus etc. During spermiogenesis, the weight of gamete is reduced along with development of locomotory structures.

Nucleus becomes compact forming the major part of head of spermatozoa after spermiogenesis. Just beneath the head (contain nucleus) mitochondria arrange in zig-zag manner at neck piece. It provides energy for movement of sperm. Golgi complex of spermatid give rise to acrosome. Acrosome forms a cap in front of nucleus containing lytic agent which dissolves egg membrane during fertilization. Acrosome of mammalian sperm produces sperm lysins called 'hyaluronidase'. If acrosome is removed from a sperm, it will fail to penetrate into ovum. The two centrioles of the spermatids become arranged one after the other behind the nucleus. The anterior one is known as the proximal centriole. The proximal centriole is usually located on the neck of spermatozoa. During fertilization, it is introduced in to egg. The proximal centriole is required for the first cleavage. The posterior centriole is known as the distal centriole. It changes into basal bodies.



Stages of spermatogenesis

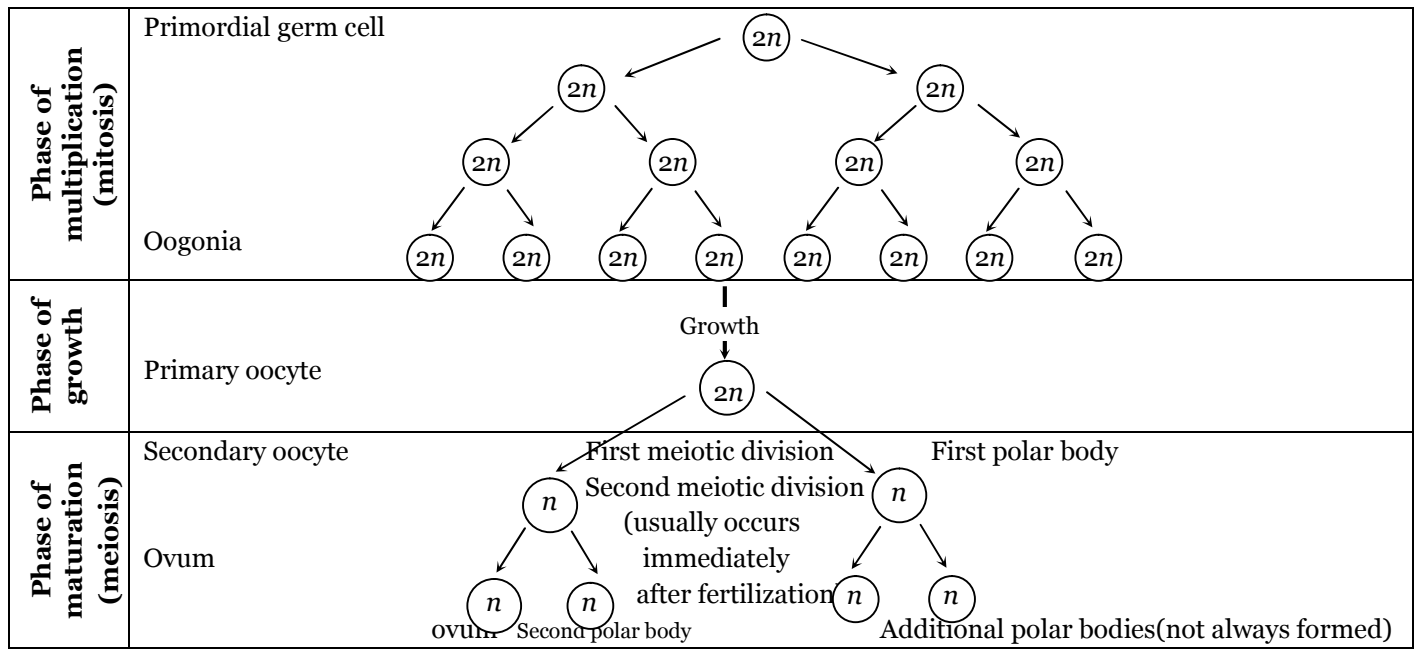
(ii) **Oogenesis** : Oogenesis is the process of maturation of reproductive cells in ovary. Oogenesis is basically similar to spermatogenesis. It includes three phases

(a) **Phase of multiplication** : During the phase of multiplication the primordial cells in the ovary divide mitotically to form **oogonia** (egg mother cells). Each oogonium divides mitotically to form two primary oocytes. Primary oocytes undergo growth, the growth phase during oogenesis is comparatively longer. The size of oocytes increases very much. In the primary oocyte of frog, the growth will be about 20 to 40 times.

(b) **Phase of growth** : During growth phase a large amount of fats and proteins become accumulated in the form of yolk.

(c) **Phase of maturation** : During maturation phase, the primary oocyte ($2n$) undergoes meiosis I producing two haploid cells (n), the larger one is secondary oocyte and the smaller one is first polar body.

Meiosis II of secondary oocyte results in the formation of functional egg or ovum and a second polar body. In oogenesis, only one of the four products of meiosis becomes a functional egg. The rest three are non-functional polar bodies which finally degenerate. **Vitellogenesis** is the formation and deposition of yolk in the egg. Major chemical components of yolk are phospholipids and proteins.

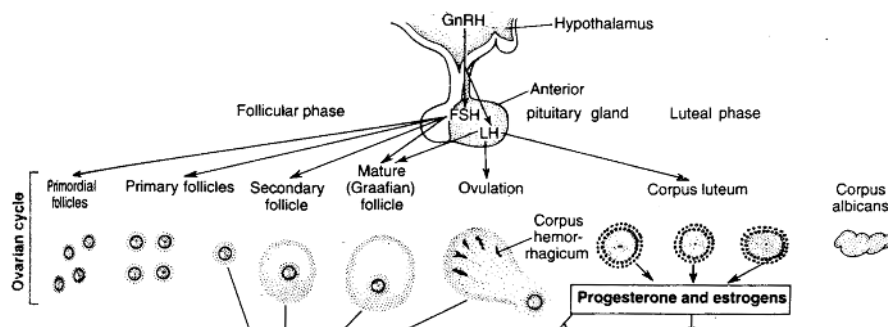


Stages of oogenesis

8.4 Menstrual cycle

Menstrual cycle is the cyclic change in the reproductive tract of primate females. Menstruation is the periodic shedding of the endometrium of the uterus with bleeding. In healthy women, menstruation occurs at intervals of about 28 days. Menarche is the starting of menstruation in girls at about 13 years. Menstrual cycle consists of menstrual phase, proliferative phase (follicular phase) and secretory phase (luteal phase). Proliferative phase (5th to 14th day) consists of growth of endometrium of uterus, fallopian tube and vagina. In ovary, a Graafian follicle grows, matures and secretes estrogen during this phase. Estrogen is the hormone active during proliferative phase.

The ovum is ejected from the follicle near the end of proliferative phase, *i.e.*, 14th day or midway during menstrual cycle. Ovulation occurs under the influence of LH from pituitary. The subsequent 14 days in which corpus luteum is active is referred to as the secretory phase. Progesterone secreted by corpus luteum is active during secretory phase. The uterine endometrium and glands grow further during secretory phase. At the end of secretory phase, corpus luteum degenerates in the ovary, progesterone secretion falls, the overgrown uterine endometrium breaks down and menstruation takes place. Menstrual cycle is controlled by FSH, LH, estrogen and progesterone. The menstrual cycle and menstruation remain suspended during pregnancy and lactation. Menopause (climacteric) is the period of life when menstruation naturally stops. Menopause occurs in females at the age of 45-50 years.



8.5 Estrous cycle

- (a) The animals that have only a single estrous during the breeding season are called **monoestrous**, *e.g.*, Dog, fox, deer, bat, etc.
- (b) The animals that have a recurrence of estrous during breeding season are called **polyestrous**, *e.g.*, Mouse, squirrel, cow, sheep, pig, horse, etc.
- (c) The estrogen level in blood increases resulting strong sex urge in the female. This is called “**period of heat**”.
- (d) The estrous cycles run only during the breeding season.
- (e) The estrous cycle consists of cyclic changes in the female reproductive system of non-primate mammals. There is no menstruation at the end of estrous cycle.