BLY 122
Chapter 48 Animal Reproduction

I. Asexual and Sexual Reproduction

A. The offspring of asexual reproduction are genetically identical to their parent; asexual reproduction occurs in a variety of ways.
   1. Budding is when offspring forms on or in a parent and eventually breaks free. (**Fig. 48.1a**)
   2. A new individual forms from a fragment of another in regeneration.
   3. Fission is the process by which two new individuals are formed when an animal splits apart. (**Fig. 48.1b**)
   4. Parthenogenesis is the production of offspring from unfertilized eggs. (**Fig. 48.1c**)
      a. Many species reproduce via parthogenesis.
      b. These include fish, rotifers, and insects.

B. *Daphnia* switch to sexual reproduction when environmental cues indicate that conditions are becoming adverse.
   1. *Daphnia* are crustaceans that live in freshwater habitats.
   2. They reproduce asexually, but produce only diploid females in the spring and summer via parthogenesis. (**Fig. 48.2a**)
   3. In late summer, diploid females produce males via parthogenesis.
   4. This is when sexual reproduction begins.
   5. Why does this switch occur?
      a. Researchers found a strong correlation between population density and the number of females reproducing sexually. (**Fig. 48.2b**)
      b. Further studies showed high population density, low food availability, and short day length were all needed for the switch to occur. (**Fig. 48.2c**)
      c. This likely happens because offspring produced by sexual reproduction have greater genetic diversity and more fitness to survive in a resource-limited environment.

C. Mechanisms of Sexual Reproduction: Gametogenesis
   1. Gametogenesis is the formation of gametes, better known as egg and sperm.
      a. Spermatogenesis takes place in the male gonads, the testes.
      b. Oogenesis takes place in the female gonads, the ovaries.
   2. Gametogenesis is very different in males and females. (**Fig. 48.3**)
      a. In males, a diploid spermatogonia divides via mitosis to generate primary spermatocytes.
         (1) One primary spermatocyte divides via meiosis to give rise to four spermatids.
         (2) Each spermatid matures into a sperm.
      b. In females, a diploid oogonium divides mitotically to generate a primary oocyte.
         (1) The primary oocyte undergoes meiosis, producing only one large egg.
         (2) The other three cell products of meiosis degenerate.
      c. Egg cells are much larger than sperm cells due to the unequal distribution of cytoplasm during meiotic divisions.

II. Fertilization and Egg Development

A. Fertilization can occur externally in the environment or internally in the female reproductive tract.
   1. Species that use external fertilization produce large numbers of gametes and require cues to synchronize the release of sperm and eggs.
   2. Internal fertilization involves the male directly depositing sperm into the female reproductive tract.
      a. This act, called copulation, is often enabled by the male organ, the penis.
      b. In some species the male packages sperm in a spermatophore package that is then placed in the female's reproductive tract by either individual.
      c. With internal fertilization, sperm competition may occur when females mate with multiple males.
         (1) Sperm from the last male to mate with the female are more likely to fertilize the egg(s)—*Drosophila* study on second-male advantage.
         (2) Sperm from second male may dislodge or poison sperm from previous male. (**Fig. 48.4**)
         (3) Females do play a role in sperm selection, in a process called female cryptic choice.
      d. Other interesting variations on internal fertilization exist. (**Box 48.1**)

B. Viviparity and oviparity describe whether embryonic development takes place in the environment or internally.

1. Oviparous species lay eggs that must contain all the nutrients required for the developmental period.
2. Viviparous species retain their embryos, which receive nourishment directly from the mother.
3. Viviparity may be an adaptation that improves the survival of offspring in cold climates.
    a. This hypothesis emerged from studies with lizards in the genus *Sceloporus*. (**Fig. 48.5a**)
    b. Some *Sceloporus* species are oviparous, and some are viviparous.
    c. Analysis of the *Sceloporus* phylogenetic tree suggests that viviparity seemed to have evolved from oviparity on several occasions. (**Fig. 48.5b**)

III. Reproductive Structures and Their Functions

A. The Male Reproductive System
1. Variations in the anatomy of the scrotum and penis may be important for sexual display or sperm competition in some species. (**Fig. 48.6**)
2. The human male reproductive system is designed for spermatogenesis, copulation, and hormone production. (**Fig. 48.7**)
    a. Spermatogenesis, the production of haploid sperm cells, occurs in the seminiferous tubules of the testes.
    b. Mature sperm are stored in the epididymis.
    c. Additional fluids are added to the sperm cells, forming semen, by the prostate gland, the bulbourethral glands, and the seminal vesicles.
    d. During intercourse, sperm are transported through the vas deferens and ejaculated by the urethra into the female reproductive tract.
3. In some species the penis has a bone called the baculum that helps stiffen the penis during copulation.

B. The Female Reproductive Tract
1. The human female reproductive system is designed for oogenesis, embryonic development, and hormone production. (**Fig. 48.8**)
    a. The external anatomy
        (1) The labia minora and labia majora are external folds of skin that cover the clitoris, urethral opening, and vaginal opening.
        (2) The clitoris is a sensitive organ that becomes erect during sexual stimulation.
        (3) Urine is expelled from the urethra, separate from reproductive structures.
        (4) The vagina is the birth canal and the chamber into which the penis is inserted to deposit sperm.
    b. The internal anatomy
        (1) The ovaries produce eggs during ovulation (oogenesis).
        (2) The developing egg (ovum) is expelled from the ovary into the oviduct (fallopian tube).
        (3) The ovum moves to the uterus where, if fertilized, it develops into an embryo.
        (4) During childbirth, the fetus will pass through the cervix to the vagina.

IV. The Role of Sex Hormones in Mammalian Reproduction.

A. Both male and female hormones are steroids that belong to the hormone class known as estrogens.
1. The male sex hormone is called testosterone and is made in the testes.
2. The female sex hormone is called estradiol and is made by cells (forming a structure called a follicle) surrounding the developing egg in the ovaries.
3. Both of these hormones bind to receptors inside the cell that move to the nucleus to change gene expression.

B. Puberty in males and females is triggered by surges of GnRH from hypothalamus.
1. GnRH stimulates the release of FSH and LH from the anterior pituitary. (**Fig. 48.9**)
2. FSH stimulates male spermatogenesis and female follicular development.
3. LH stimulates testosterone production in the testes and estradiol production in the ovaries.
    a. Testosterone initiates the development of secondary sex characteristics in males. (**Table 48.1**)
        (1) These include an increase in muscle mass, growth of pubic hair, voice changes, etc.
        (2) Athletes that use steroids to build muscle mass put themselves at risk for myriad health problems. (**Box 48.2**)
    b. Estradiol production in the ovaries initiates the menstrual cycle.

C. The female reproductive cycle, the menstrual cycle, consists of two distinct phases. (**Figs. 48.10, 48.11**)
1. The follicular phase starts with the onset of menses and ends with ovulation.

a. FSH levels stimulate follicular development during this phase.
b. Estradiol production by the follicle increases greatly.
c. Once estradiol levels reach a certain concentration, they trigger a positive feedback response on LH, causing both LH and estradiol levels to spike.
d. The LH spike triggers ovulation, and the mature secondary oocyte is released to the oviduct.

2. The luteal phase begins with ovulation and ends with the onset of menses (unless fertilization occurs). (**Fig. 48.12**)
   a. The remaining follicular cells develop into the corpus luteum, which secretes the pregnancy maintenance hormone, progesterone.
   b. Progesterone helps to prepare the uterine lining in case fertilization occurs.
   c. If fertilization does not occur, the corpus luteum regresses; a new cycle then begins with the shedding of the uterine lining.
   d. If fertilization does occur, the corpus luteum is retained and continues to produce estrogen and progesterone until the placenta takes over that role.

V. Human Pregnancy and Birth

A. Major Events during Pregnancy
1. Fertilization occurs in the oviduct where sperm meet a newly released ovum.
   a. Once fertilized, the ovum completes meiosis; egg and sperm nuclei join.
   b. The resulting zygote moves through the oviduct into the uterus.
2. Once in the uterus, the zygote undergoes implantation as it embeds itself in the nutritive uterine lining.
3. Once implanted the developing embryo begins to make human gonadotropin hormone (hCG).
   a. This prevents the corpus luteum from degenerating.
   b. The ovary continues to release progesterone, and the menstrual cycle is arrested.

B. Gestation, which is divided into three trimesters, is the period when fetal development occurs.
1. Formation of the placenta, during the first trimester, allows for the efficient transfer of nutrients, gases, water, and wastes between mother and fetus. (**Fig. 48.13a**)
   a. A membrane called the amnion completely surrounds the embryo, which fills with amniotic fluid to cushion the developing baby.
   b. The placenta forms on the uterine wall; the placenta is a mixture of mother and baby's tissues, and the main source of nutrients for the baby.
   c. Arteries transport blood from the fetus via the umbilical cord to the placenta to meet with maternal blood and exchange nutrients, wastes, and gases.
2. The second and third trimesters are characterized by a period of rapid growth. (**Fig. 48.13b, c**)

C. How does the mother nourish the fetus during gestation?
1. Adaptations that improve the transfer of oxygen from the maternal to the fetal circulation include maternal cardiovascular adjustments and fetal hemoglobin.
   a. Blood volume expansion, increased heart rate, and stroke volume all contribute to the ability to meet fetal demand by increasing flow to the placenta.
   b. Fetal hemoglobin has a higher affinity for oxygen than maternal hemoglobin, promoting the transfer of oxygen to fetal blood.
   c. Countercurrent exchange between maternal and fetal blood vessels maximizes the driving partial pressure gradient for O_2 uptake by the fetus. (**Fig. 48.14**)
2. Substances (ethanol, nicotine, and caffeine) can cross the placental barrier and affect fetal development. (**Fig. 48.15**)

D. Birth
1. Oxytocin stimulates uterine contractions during the birthing process.
2. As labor progresses, the cervix softens and becomes dilated. (**Fig. 48.16**)
3. Uterine contractions become forceful, longer, and more frequent, eventually functioning to expel the fetus from the womb.
4. After the baby is born and the umbilical cord cut, the placenta is expelled and the process is complete.
5. While the process seems straightforward, many complications are possible.
6. However, due to sterile technique, antibiotics and blood transfusion, the mortality rate of women during childbirth has decreased significantly over the last century. (**Fig. 48.17**)