Chapter 46
Animal Reproduction

Overview: Doubling Up for Sexual Reproduction
- The two earthworms in this picture are mating
- Each worm produces both sperm and eggs, which will fertilize
  - And in a few weeks, new worms will hatch

A population transcends finite life spans
- Only by reproduction

Concept 46.1: Both asexual and sexual reproduction occur in the animal kingdom
- Asexual reproduction is the creation of new individuals
  - Whose genes all come from one parent

Sexual reproduction is the creation of offspring
- By the fusion of male and female gametes to form a zygote
- The female gamete is the egg
- The male gamete is the sperm

Mechanisms of Asexual Reproduction
- Many invertebrates reproduce asexually by fission
  - The separation of a parent into two or more individuals of approximately the same size
• Also common in invertebrates is budding
  – In which two new individuals arise from outgrowths of existing ones
• Another type of asexual reproduction is fragmentation, which
  – Is the breaking of the body into several pieces, some or all of which develop into complete adults
  – Must be accompanied by regeneration, the regrowth of lost body parts

Reproductive Cycles and Patterns
• Most animals exhibit cycles in reproductive activity
  – Often related to changing seasons
• Reproductive cycles
  – Are controlled by hormones and environmental cues

• Animals may reproduce exclusively asexually or sexually
  – Or they may alternate between the two
• Some animals reproduce by parthenogenesis
  – A process in which an egg develops without being fertilized

• Among vertebrates, several genera of fishes, amphibians, and lizards, including whiptail lizards
  – Reproduce exclusively by a complex form of parthenogenesis

• Sexual reproduction presents a special problem for certain organisms
  – That seldom encounter a mate
• One solution to this problem is hermaphroditism
  – In which each individual has both male and female reproductive systems

• Another remarkable reproductive pattern is sequential hermaphroditism
  – In which an individual reverses its sex during its lifetime
• Concept 46.2: Fertilization depends on mechanisms that help sperm meet eggs of the same species
• The mechanisms of fertilization, the union of egg and sperm
  – Play an important part in sexual reproduction

• Some species have external fertilization, in which
  – Eggs shed by the female are fertilized by sperm in the external environment

• Other species have internal fertilization, in which
  – Sperm are deposited in or near the female reproductive tract, and fertilization occurs within the tract

• In either situation, fertilization requires critical timing
  – Often mediated by environmental cues, pheromones, and/or courtship behavior
• Internal fertilization
  – Requires important behavioral interactions between male and female animals
  – Requires compatible copulatory organs

Ensuring the Survival of Offspring
• All species produce more offspring than the environment can handle
  – But the proportion that survives is quite small

• The embryos of many terrestrial animals
  – Develop in eggs that can withstand harsh environments
• Instead of secreting a shell around the embryo
  – Many animals retain the embryo, which develops inside the female
Many different types of animals

- Exhibit parental care to ensure survival of offspring

Gamete Production and Delivery

- To reproduce sexually
  - Animals must have systems that produce gametes

The least complex systems

- Do not even contain distinct gonads, the organs that produce gametes in most animals

The most complex reproductive systems

- Contain many sets of accessory tubes and glands that carry, nourish, and protect the gametes and the developing embryos

Many animals with relatively simple body plans

- Possess highly complex reproductive systems

Most insects

- Have separate sexes with complex reproductive systems
• Concept 46.3: Reproductive organs produce and transport gametes: focus on humans

Female Reproductive Anatomy

• The female external reproductive structures include
  – The clitoris
  – Two sets of labia

• The internal organs are a pair of gonads
  – And a system of ducts and chambers that carry gametes and house the embryo and fetus

Reproductive anatomy of the human female

Ovaries

• The female gonads, the ovaries
  – Lie in the abdominal cavity
• Each ovary
  – Is enclosed in a tough protective capsule and contains many follicles
• A follicle
  – Consists of one egg cell surrounded by one or more layers of follicle cells

• The process of ovulation
  – Expels an egg cell from the follicle
• The remaining follicular tissue then grows within the ovary
  – To form a solid mass called the corpus luteum, which secretes hormones, depending on whether or not pregnancy occurs

Oviducts and Uterus
• The egg cell is released into the abdominal cavity
  – Near the opening of the oviduct, or fallopian tube
• Cilia in the tube
  – Convey the egg to the uterus

Vagina and Vulva
• The vagina is a thin-walled chamber
  – That is the repository for sperm during copulation
  – That serves as the birth canal through which a baby is born

Mammary Glands
• The mammary glands are not part of the reproductive system
  – But are important to mammalian reproduction
• Within the glands
  – Small sacs of epithelial tissue secrete milk

• The vagina opens to the outside at the vulva
  – Which includes the hymen, vestibule, labia minora, labia majora, and clitoris
Male Reproductive Anatomy

- In most mammalian species
  - The male’s external reproductive organs are the scrotum and penis
- The internal organs
  - Consist of the gonads, which produce sperm and hormones, and accessory glands

Testes

- The male gonads, or testes
  - Consist of many highly coiled tubes surrounded by several layers of connective tissue
- The tubes are seminiferous tubules
  - Where sperm form

Ducts

- From the seminiferous tubules of a testis
  - The sperm pass into the coiled tubules of the epididymis
- During ejaculation
  - Sperm are propelled through the muscular vas deferens, the ejaculatory duct, and exit the penis through the urethra
Glands

- Three sets of accessory glands
  - Add secretions to the semen, the fluid that is ejaculated
- A pair of seminal vesicles
  - Contributes about 60% of the total volume of semen
- The prostate gland
  - Secretes its products directly into the urethra through several small ducts
- The bulbourethral gland
  - Secretes a clear mucus before ejaculation that neutralizes acidic urine remaining in the urethra

Semen in the Female Reproductive Tract

- Once in the female reproductive tract
  - A number of processes, including contractions of the uterus, help move the sperm up the uterus

Penis

- The human penis
  - Is composed of three cylinders of spongy erectile tissue
- During sexual arousal
  - The erectile tissue fills with blood from the arteries, causing an erection

Human Sexual Response

- Two types of physiological reactions predominate in both sexes
  - Vasocongestion, the filling of tissue with blood
  - Myotonia, increased muscle tension
- The sexual response cycle can be divided into four phases
  - Excitement, plateau, orgasm, and resolution
• Concept 46.4: In humans and other mammals, a complex interplay of hormones regulates gametogenesis.

• The process of gametogenesis
  – Is based on meiosis, but differs in females and males.

• Spermatogenesis is the production of mature sperm

• Oogenesis is the development of mature ova

• Oogenesis differs from spermatogenesis
  – In three major ways

• First, during the meiotic divisions of oogenesis
  – Cytokinesis is unequal, with almost all the cytoplasm monopolized by a single daughter cell, the secondary oocyte.

• Second, sperm are produced continuously throughout a male’s life
  – Which is not the case in oogenesis.

• Third, oogenesis has long “resting” periods
  – While spermatogenesis produces sperm in uninterrupted sequence.
The Reproductive Cycles of Females

• In females
  – The secretion of hormones and the reproductive events they regulate are cyclic

Menstrual Versus Estrous Cycles

• Two different types of cycles occur in females

Humans and other primates have menstrual cycles
  – While other mammals have estrous cycles

In both cases ovulation occurs at a time in the cycle
  – After the endometrium has started to thicken in preparation for implantation

In menstrual cycles
  – The endometrium is shed from the uterus in a bleeding called menstruation
  – Sexual receptivity is not limited to a specific timeframe

In estrous cycles
  – The endometrium is reabsorbed by the uterus
  – Sexual receptivity is limited to a “heat” period

The Human Female Reproductive Cycle: A Closer Look

• The female reproductive cycle
  – Is one integrated cycle involving two organs, the uterus and ovaries

• Cyclic secretion of GnRH from the hypothalamus
  – And of FSH and LH from the anterior pituitary orchestrates the female reproductive cycle

• Five kinds of hormones
  – Participate in an elaborate scheme involving both positive and negative feedback
The reproductive cycle of the human female

**Control by hypothalamus**
- Inhibited by combination of estrogen and progesterone
- Stimulated by high levels of estrogen
- Inhibited by low levels of estrogen

**Hypothalamus**
- Anterior pituitary
- GnRH
- FSH
- LH

**Pituitary gonadotropins in blood**
- LH
- FSH

**FSH and LH stimulate follicle to grow**
**LH surge triggers ovulation**

**Ovarian cycle**
- Growing follicle
- Mature follicle
- Corpus luteum
- Degenerating corpus luteum

**Estrogen secreted by growing follicle in increasing amounts**
**Progesterone and estrogen secreted by corpus luteum**

**Ovarian hormones in blood**
- Peak causes LH surge

**Menstrual cycle**
- Estrogen
- Progesterone

**Estrogen level very low**
**Progesterone and estrogen promote thickening of endometrium**

**Uterine (menstrual) cycle**
- Endometrium
- Menstrual flow phase
- Proliferative phase
- Secretory phase

**Days**
- 0
- 5
- 10
- 14
- 15
- 20
- 25
- 28

**The Ovarian Cycle**
- In the ovarian cycle
  - Hormones stimulate follicle growth, which results in ovulation
- Following ovulation
  - The follicular tissue left behind transforms into the corpus luteum

**The Uterine (Menstrual) Cycle**
- Cycle after cycle
  - The maturation and release of egg cells from the ovary are integrated with changes in the uterus
  - If an embryo has not implanted in the endometrium by the end of the secretory phase
    - A new menstrual flow commences

**Menopause**
- After about 450 cycles, human females undergo menopause
  - The cessation of ovulation and menstruation

**Hormonal Control of the Male Reproductive System**
- Testosterone and other androgens
  - Are directly responsible for the primary and secondary sex characteristics of the male

**Androgen secretion and sperm production**
- Are both controlled by hypothalamic and pituitary hormones
Concept 46.5: In humans and other placental mammals, an embryo grows into a newborn in the mother’s uterus

Conception, Embryonic Development, and Birth

- In humans and most other placental mammals
  - Pregnancy, or gestation, is the condition of carrying one or more embryos in the uterus

Fertilization of an egg by a sperm, conception

- Occurs in the oviduct
  - Ovulation releases a secondary oocyte, which enters the oviduct.
  - Fertilization occurs; a sperm enters the oocyte, forming the zygote.
  - Cleavage begins in the oviduct as the embryo is moved toward the uterus by peristalsis and the movements of cilia.
  - Cleavage continues; the embryo enters the uterus, nourished by endometrial secretions.
  - Cleavage continues, by the time the embryo reaches the uterus, it becomes a blastocyst.
  - Implantation of blastocyst in the endometrium about 7 days after conception.

After fertilization

- The zygote undergoes cleavage and develops into a blastocyst before implantation in the endometrium.

First Trimester

- Human gestation
  - Can be divided into three trimesters of about three months each
  - The first trimester
    - Is the time of most radical change for both the mother and the embryo

During its first 2 to 4 weeks of development

- The embryo obtains nutrients directly from the endometrium

Meanwhile, the outer layer of the blastocyst

- Mingles with the endometrium and eventually forms the placenta
• Blood from the embryo
  - Travels to the placenta through arteries of the umbilical cord and returns via the umbilical vein

• The first trimester is the main period of organogenesis
  - The development of the body organs

  (a) 5 weeks. Limb buds, eyes, the heart, the liver, and rudiments of all other organs have started to develop in the embryo, which is only about 1 cm long.
  (b) 14 weeks. Growth and development of the offspring, now called a fetus, continue during the second trimester. This fetus is about 6 cm long.
  (c) 20 weeks. By the end of the second trimester (at 24 weeks), the fetus grows to about 30 cm in length.

Second Trimester
• During the second trimester
  - The fetus grows and is very active
  - The mother may feel fetal movements
  - The uterus grows enough for the pregnancy to become obvious

Third Trimester
• During the third trimester
  - The fetus continues to grow and fills the available space within the embryonic membranes

• A complex interplay of local regulators and hormones
  - Induces and regulates labor, the process by which childbirth occurs

• Birth, or parturition
  - Is brought about by a series of strong, rhythmic uterine contractions
• The process of labor has three stages

Figure 46.19 Delivery of the placenta

The Mother’s Immune Tolerance of the Embryo and Fetus

• A woman’s acceptance of her “foreign” offspring
  – Is not fully understood
  – May be due to the suppression of the immune response in her uterus

Contraception and Abortion

• Contraception, the deliberate prevention of pregnancy
  – Can be achieved in a number of ways

• Some contraceptive methods
  – Prevent the release of mature eggs and sperm from gonads
  – Prevent fertilization by keeping sperm and egg apart
  – Prevent implantation of an embryo

Modern Reproductive Technology

• Recent scientific and technological advances
  – Have made it possible to deal with many reproductive problems
• Amniocentesis and chorionic villus sampling
  – Are invasive techniques in which amniotic fluid or fetal cells are obtained for genetic analysis

• Noninvasive procedures
  – Usually use ultrasound imaging to detect fetal condition

• Modern technology
  – Can help infertile couples by in vitro fertilization