

ELEVENTH EDITION  
CAMPBELL  
**BIOLOGY**  
URRY • CAIN • WASSERMAN  
MINORSKY • REECE

**Chapter 46**

**Animal  
Reproduction**

Lecture Presentations by  
Nicole Tunbridge and  
Kathleen Fitzpatrick

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### **Concept 46.1: Both asexual and sexual reproduction occur in the animal kingdom**

- **Sexual reproduction** is the creation of an offspring by fusion of haploid gametes, male **sperm** and female **eggs**, to form a diploid **zygote**
- **Asexual reproduction** is creation of offspring without the fusion of egg and sperm

## Mechanisms of Asexual Reproduction

- Budding is a simple form of asexual reproduction found only among invertebrates
- New individuals arise from outgrowths of existing ones
- Many invertebrates reproduce asexually by **fission**, separation of a parent into two or more individuals of about the same size
- **Parthenogenesis** is the development of a new individual from an unfertilized egg
- Parthenogenesis is mainly observed in invertebrates, but is observed rarely in some vertebrates

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## Variation in Patterns of Sexual Reproduction

- For many sexually reproducing animals, finding a partner for reproduction can be challenging
- In **hermaphroditism**, each individual has both male and female reproductive systems
- Any two individuals can mate under this system, and in some species, hermaphrodites can also self-fertilize
- Several organisms can change their sex under certain circumstances

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## Reproductive Cycles

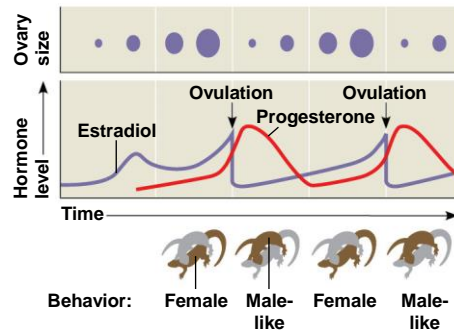
- Most animals exhibit reproductive cycles related to changing seasons
- Reproductive cycles are controlled by hormones and environmental cues
- **Ovulation** is the release of mature eggs at the midpoint of a female cycle
- Because seasonal temperature is often an important cue in reproduction, climate change can decrease reproductive success

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- Some organisms can reproduce sexually or asexually, depending on conditions
- Several genera of fishes, amphibians, and lizards reproduce by a form of **parthenogenesis** that involves the doubling of chromosomes after meiosis
- Asexual whiptail lizards are descended from a sexual species, and females still exhibit mating behaviors

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Figure 46.3

(a) *A. uniparens* females(b) The changes in sexual behavior of *A. uniparens* individuals are correlated with the cycles of ovulation

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- Sexual reproduction may enhance reproductive success of parents when environmental factors change relatively rapidly
- This is due to their production of genetically varied offspring
- *Asexual reproduction is expected to be most advantageous in stable, favorable environments*

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## Concept 46.2: Fertilization depends on mechanisms that bring together sperm and eggs of the same species

- **Fertilization**, the union of egg and sperm, can be *external* or *internal*
- In external fertilization, eggs shed by the female are fertilized by sperm in the external environment
- A moist habitat is always required for external fertilization to allow sperm to swim to the egg and to prevent the gametes from drying out

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Figure 46.5



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- Internal fertilization is an adaptation that enables sperm to reach an egg despite a dry external environment
- Internal fertilization requires behavioral interactions and *compatible copulatory organs*
- Mating animals may make use of **pheromones**, chemicals released by one organism that influence the physiology and behavior of individuals of the same species

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## Ensuring the Survival of Offspring

- Internal fertilization is typically associated with production of *fewer gametes* but *the survival of a higher fraction of zygotes*
- Internal fertilization is also often associated with mechanisms to provide *protection of embryos and parental care of young*

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Figure 46.6



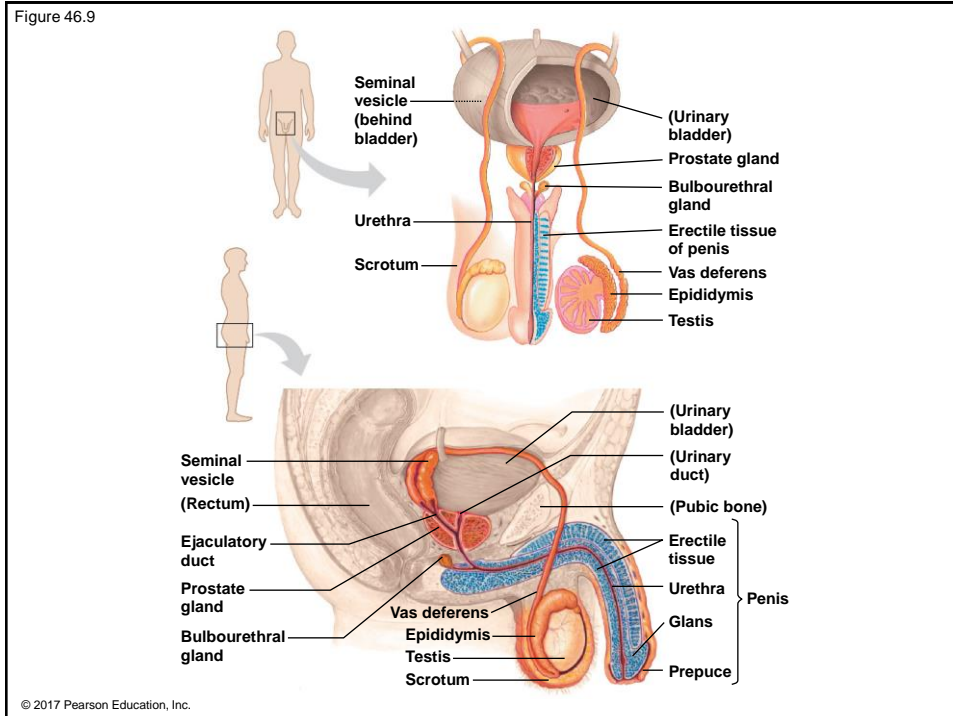
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## Human Male Reproductive Anatomy

- The male's external reproductive organs are the **scrotum** and **penis**
- Internal organs are:
  - the **gonads**, which produce sperm and hormones
  - **accessory glands** that secrete products needed for sperm movement
  - **ducts** that carry sperm and glandular secretions

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Figure 46.9



## Testes

- The male gonads, or **testes**, consist of highly coiled tubes surrounded by connective tissue
- Sperm form in these **seminiferous tubules**
- Production of normal sperm cannot occur at the body temperatures of most mammals
- The testes of many mammals are held outside the abdominal cavity in the **scrotum**, where the temperature is lower than in the abdominal cavity



## ***Ducts***

- From the seminiferous tubules of a testis, sperm pass into the coiled duct of the **epididymis**
- In humans, it takes 3 weeks for the sperm to travel the length of this duct
- During **ejaculation**, sperm are propelled through the muscular **vas deferens** and the ejaculatory duct, and then exit the penis through the **urethra**

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## ***Accessory Glands***

- **Semen** is composed of sperm plus secretions from three sets of accessory glands
- The two **seminal vesicles** contribute about 60% of the total volume of semen
- The **prostate gland** secretes its products directly into the urethra through several small ducts
- The **bulbourethral glands** secrete a clear mucus before ejaculation that neutralizes acidic urine remaining in the urethra

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## ***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
- The head of the penis, or **glans**, has a thinner skin covering than the shaft and is more sensitive to stimulation

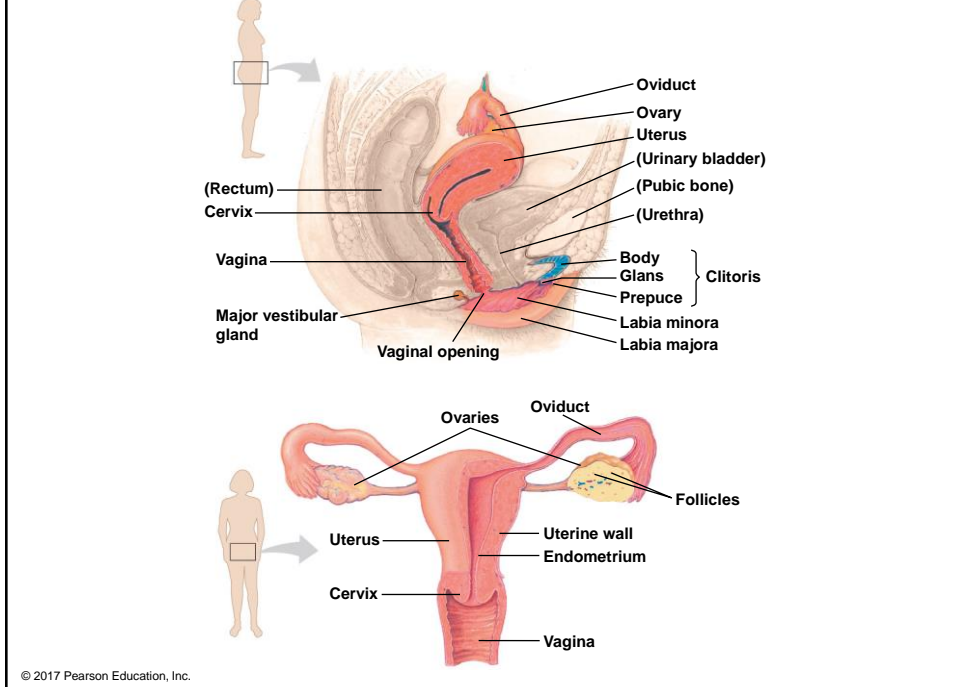
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## **Human Female Reproductive Anatomy**

- The female external reproductive structures include the **clitoris** and 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

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Figure 46.10



## Ovaries

- The female gonads, the **ovaries**, flank the uterus in the abdominal cavity
- Each ovary contains many **follicles**, which consist of a partially developed egg, called an **oocyte**, surrounded by support cells

## ***Oviducts and Uterus***

- The egg cell travels from the ovary to the uterus via an **oviduct**, or **fallopian tube**
- Cilia in the oviduct convey the egg to the **uterus**, also called the womb
- The uterus lining, the **endometrium**, has many blood vessels
- The uterus narrows at the **cervix**, then opens into the **vagina**

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## ***Vagina and Vulva***

- The **vagina** is a muscular but elastic chamber that is the repository for sperm during copulation and serves as the birth canal
- The vagina opens to the outside at the **vulva**, which consists of the **labia majora**, **labia minora**, **hymen**, and **clitoris**
- The clitoris has a head called a glans covered by the prepuce, a small hood of skin
- The vagina, labia minora, and clitoris are rich with blood vessels; the clitoris also has many nerve endings

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## ***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

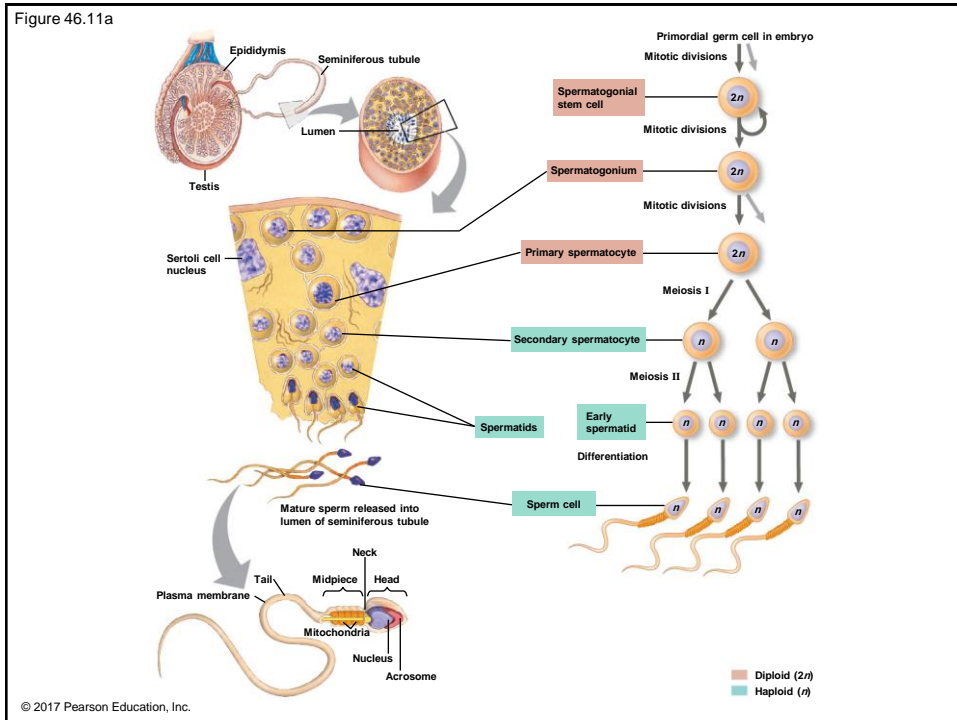
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## **Gametogenesis**

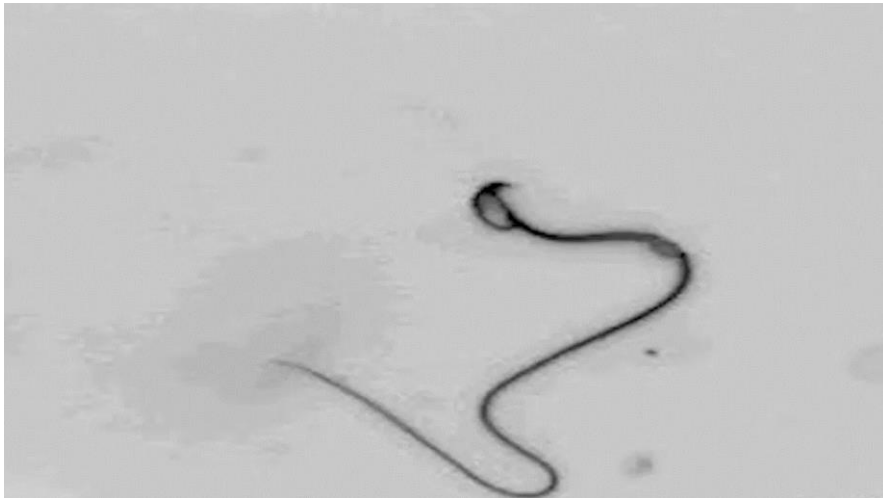
- **Gametogenesis** is the production of gametes
- **Spermatogenesis**, the formation of sperm, is continuous and prolific
  - Hundreds of millions of sperm are produced per day; each sperm takes about 7 weeks to develop
- **Oogenesis**, the development of a mature egg, is a prolonged process
  - Immature eggs form in the female embryo but do not complete their development until years or decades later

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Figure 46.11a

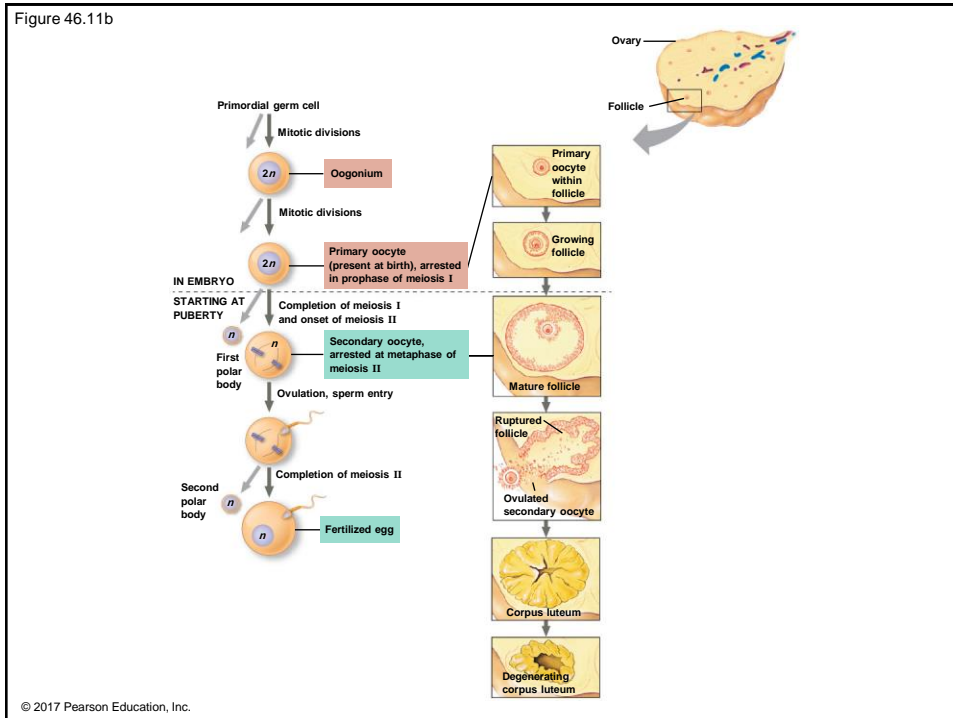


## Video: Motion of Isolated Flagellum



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Figure 46.11b



- Spermatogenesis differs from oogenesis in three ways:
  - All four products of meiosis develop into sperm, while only one of the four becomes an egg
  - Spermatogenesis occurs throughout adolescence and adulthood
  - Sperm are produced continuously without the prolonged interruptions in oogenesis

### **Concept 46.4: The interplay of tropic and sex hormones regulates reproduction in mammals**

- Mammalian reproduction is coordinated by hormones
- **FSH (follicle-stimulating hormone)** and **LH (luteinizing hormone)** stimulate sex hormone production by the gonads
- The main sex hormones are steroid hormones
- **Testosterone** is the main androgen
- Estrogens consist of mainly **estradiol** and **progesterone**
- Sex hormones function in gamete production, sexual behavior, and the development of primary and secondary sex characteristics

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### **Hormonal Control of the Male Reproductive System**

- FSH stimulates Sertoli cells to nourish developing sperm
- LH causes Leydig cells to produce testosterone and other androgens, which in turn promote spermatogenesis

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## Hormonal Control of Female Reproductive Cycles

- Hormones closely link the two cycles of female reproduction
- Changes in the ovaries define the **ovarian cycle**
- Changes in the uterus define the **menstrual cycle** (also called the **uterine cycle**)

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- In each **menstrual cycle**, the endometrium thickens with blood vessels in preparation for embryo implantation
- If an embryo does not implant in the endometrium, the endometrium is shed in a process called **menstruation**

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## ***The Ovarian Cycle***

- The ovarian cycle begins when the hypothalamus releases GnRH
- The GnRH stimulates the anterior pituitary to secrete small amounts of FSH and LH
- FSH stimulates follicle growth, aided by LH
- The follicles start to make estradiol

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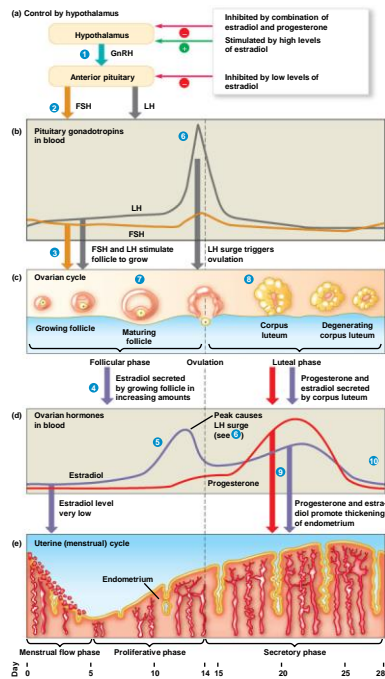
- When estradiol secretion by the follicle begins to rise steeply, FSH and LH levels increase markedly
- The maturing follicle enlarges to form a bulge at the surface of the ovary
- The follicular phase ends at ovulation, and the secondary oocyte is released
- The luteal phase follows ovulation

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- LH stimulates the remaining follicular tissue to form the **corpus luteum**
- The corpus luteum secretes progesterone and estradiol
- These exert negative feedback on the hypothalamus and pituitary to greatly reduce LH and FSH secretion, preventing maturation of another egg

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Figure 46.14



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## ***The Uterine (Menstrual) Cycle***

- Hormones coordinate the uterine cycle with the ovarian cycle
  - Thickening of the endometrium during the proliferative phase coordinates with the follicular phase
  - Secretion of nutrients during the secretory phase coordinates with the luteal phase
  - Shedding of the endometrium during the menstrual flow phase coordinates with the growth of new ovarian follicles
  - A new cycle begins if no embryo implants in the endometrium

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## ***Menopause***

- After about 500 cycles, human females undergo **menopause**, the cessation of ovulation and menstruation
- Menopause is very unusual among animals
- *Menopause might have evolved to allow a mother to provide better care for her children and grandchildren*

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## Human Sexual Response

- Two reactions predominate in both sexes:
  - **Vasocongestion**, the filling of tissue with blood
  - **Myotonia**, increased muscle tension
- The sexual response cycle has four phases: **excitement, plateau, orgasm, and resolution**
- Excitement prepares the penis and vagina for **coitus** (sexual intercourse)

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- Direct stimulation of genitalia maintains the plateau phase and prepares the vagina for receipt of sperm
- Orgasm is characterized by rhythmic contractions of reproductive structures
  - In males, semen is first released into the urethra and then ejaculated from the urethra
  - In females, the uterus and outer vagina contract
- During the resolution phase, organs return to their normal state and muscles relax

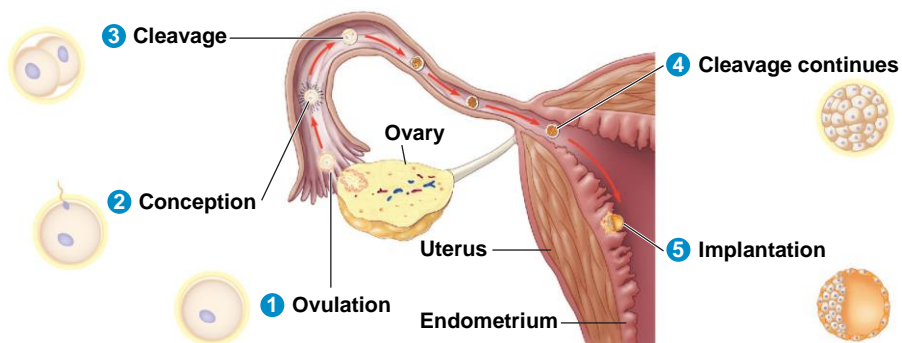
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### Concept 46.5: In placental mammals, an embryo develops fully within the mother's uterus

- **Conception**, fertilization of an egg by a sperm, occurs in the oviduct
- The resulting zygote begins to divide by mitosis in a process called cleavage
- Division of cells gives rise to a **blastocyst**, a ball of cells with a central cavity

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Figure 46.15



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- After blastocyst formation, the embryo implants into the endometrium
- **Pregnancy**, or **gestation**, is the condition of carrying one or more embryos in the uterus
- Duration of pregnancy in other species correlates with body size and maturity of the young at birth
- The roughly nine months of human gestation are divided into three trimesters of equal length

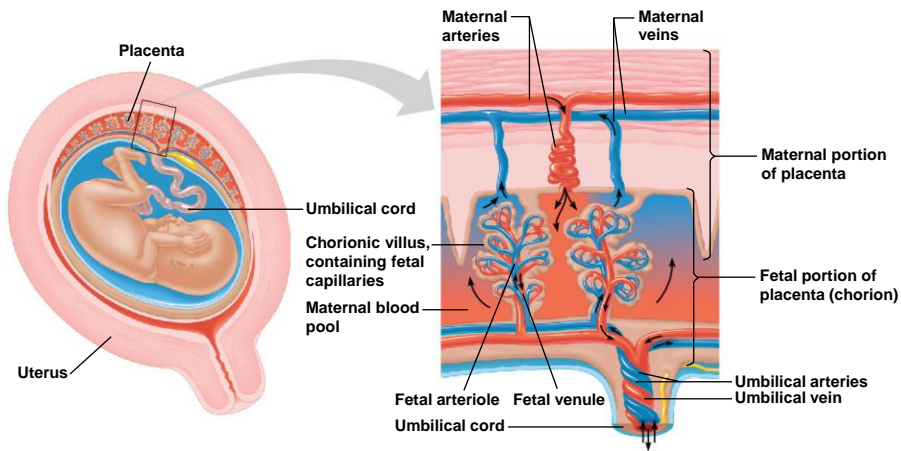
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### ***First Trimester***

- The implanted embryo secretes hormones that signal its presence and regulate the mother's reproductive system
- One such hormone, human chorionic gonadotropin (hCG), maintains secretion of progesterone and estrogens during early pregnancy
- Not all embryos are capable of completing development
- Many spontaneously stop developing due to chromosomal or other developmental abnormalities
- Rarely, a fertilized egg lodges in a fallopian tube, resulting in an **ectopic pregnancy**

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Figure 46.16



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- Splitting of the embryo during the first month of development results in genetically identical (monozygotic) twins
- Release and fertilization of two eggs result in fraternal and genetically distinct (dizygotic) twins
- The first trimester is the main period of **organogenesis**, development of the body organs
- All the major structures are present by 8 weeks, and the embryo is called a **fetus**

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Figure 46.17

**(a) 5 weeks****(b) 14 weeks**

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## ***Second and Third Trimesters***

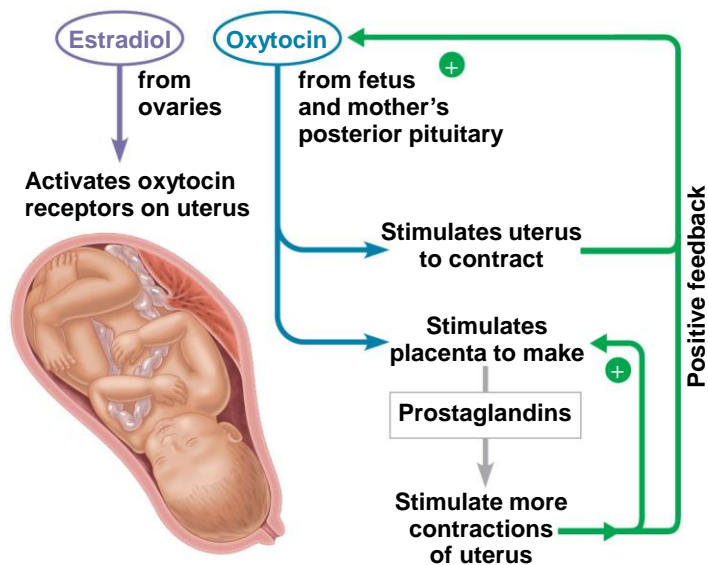
- During the second trimester
  - The fetus grows and is very active
  - The mother may feel fetal movements
  - Hormone levels stabilize
  - The placenta takes over the production of progesterone, the hormone that maintains the pregnancy

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- During the third trimester, the fetus grows and fills the space within the embryonic membranes
- Childbirth begins with labor, a series of strong, rhythmic uterine contractions that push the fetus and placenta out of the body
- Labor is regulated by prostaglandins and hormones such as estradiol and oxytocin

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Figure 46.18

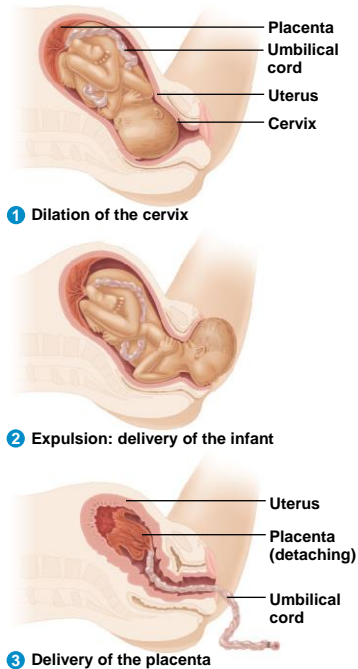


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- Labor typically has three stages:
  - Thinning and opening of the cervix, or dilation
  - Expulsion, or delivery, of the baby
  - Delivery of the placenta
- Postnatal care in mammals includes lactation, the production of mother's milk

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Figure 46.19



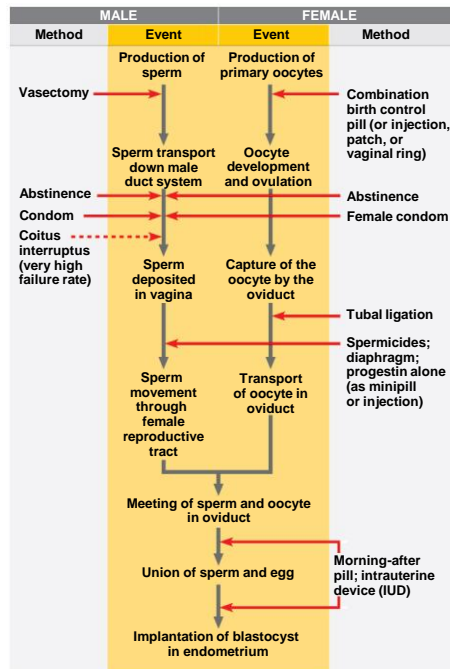
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## Contraception and Abortion

- **Contraception**, the deliberate prevention of pregnancy, can be achieved in a number of ways
- Contraceptive methods fall into three categories:
  - Preventing release of eggs and sperm
  - Keeping sperm and egg apart
  - Preventing implantation of an embryo

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Figure 46.20



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- The rhythm method, or natural family planning, is to refrain from intercourse when conception is most likely; it has a pregnancy rate of 10–20%
- Coitus interruptus, the withdrawal of the penis before ejaculation, is unreliable
- Barrier methods block fertilization with a pregnancy rate of less than 10%
  - A condom fits over the penis
  - A diaphragm is inserted into the vagina before intercourse

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- Intrauterine devices (IUDs) are inserted into the uterus and interfere with fertilization and implantation; the pregnancy rate is less than 1%
- Female **birth control pills** are hormonal contraceptives with a pregnancy rate of less than 1%
- Latex condoms are the only contraceptives that are effective in preventing the spread of sexually transmitted diseases

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- Sterilization is permanent and prevents the release of gametes
  - **Tubal ligation** ties off the oviducts
  - **Vasectomy** ties off the vas deferens
- **Abortion** is the termination of a pregnancy
- Spontaneous abortion, or miscarriage, occurs in up to one-third of all pregnancies
- The drug RU486 terminates a pregnancy nonsurgically within the first 7 weeks

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### ***Infertility and In Vitro Fertilization***

- Causes of infertility are quite varied, with men and women equally affected
- Among preventable causes of infertility, STDs are most significant
- ***In vitro* fertilization (IVF)** mixes eggs with sperm in culture dishes and returns the embryo to the uterus at the eight-cell stage
- Sperm or sperm nuclei can also be injected directly into an oocyte

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Figure 46.21



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