27.6 The human sexual response occurs in four phases

Most female mammals are receptive to males only on certain days—in many species, for only a brief period once or a few times a year. A female deer or bear, for example, will mate only during a few weeks in the autumn. During specific mating times, a female is said to be in estrus, meaning she is at her peak of sexual readiness. This is the only time she ovulates and the only time her uterus is primed for implantation.

Humans and several other primates are unusual in having no distinct mating periods; females are potentially receptive to males throughout the year. The arousal of sexual interest in humans involves a variety of psychological as well as physical factors. Nevertheless, human sexual response is characterized by a common physiological pattern.

The physical events of the human sexual response occur in a sequence of four phases. The **excitement phase** prepares the sexual organs for coitus (sexual intercourse): Sexual passion builds, the penis and clitoris become erect, the testes, labia, and nipples may swell, the vagina secretes lubricating fluid, and muscles tighten in the arms and legs. These responses continue during the **plateau phase**, which is marked by increases in breathing and heart rate. **Orgasm** follows, characterized by rhythmic involuntary contractions of the reproductive structures, extreme pleasure for both partners, and ejaculation by the male. The **resolution phase** completes the cycle and reverses the previous responses: Organs return to normal size, muscles relax, and passion subsides.

? How does the timing of mating in humans contrast with that of most other mammals?

Human females are potentially receptive to mating throughout the year, in contrast to the seasonal mating of most other mammals.

CONNECTION

27.7 Sexual activity can transmit disease

TABLE 27.7 STDS COMMON IN THE UNITED STATES

Disease	Microbial Agent	Major Symptom and Effects	Treatment
Bacterial			
Chlamydial infections	*Chlamydia trachomatis*	Genital discharge, itching, and/or painful urination; often no symptoms in women; pelvic inflammatory disease (PID)	Antibiotics
Gonorrhea	*Neisseria gonorrhoeae*	Genital discharge; painful urination; sometimes no symptoms in women; PID	Antibiotics
Syphilis	*Treponema pallidum*	Ulcer (chancre) on genitalia in early stages; spreads throughout body and can be fatal if not treated	Antibiotics can cure in early stages
Viral			
Genital herpes (see Chapter 10 introduction and Module 10.18)	Herpes simplex virus type 2, occasionally type 1	Recurring symptoms: small blisters on genitalia, painful urination, skin inflammation; linked to cervical cancer, miscarriage, birth defects	Valacyclovir can prevent recurrences
Genital warts	Papilloma-viruses	Painless growths on genitalia; some of the viruses linked to cancer	Removal by freezing
AIDS and HIV infection	HIV	See Module 24.12	Combination of drugs
Protozoan			
Trichomoniasis	*Trichomonas vaginalis*	Vaginal irritation, itching, and discharge; usually no symptoms in men	Antiprotozoal drugs
Fungal			
Candidiasis (yeast infections)	*Candida albicans*	Similar to symptoms of trichomoniasis; frequently acquired nonsexually	Antifungal drugs

Sexually transmitted diseases (STDs) are contagious diseases spread by sexual contact. AIDS is caused by HIV (see Modules 10.21 and 24.12); genital herpes and genital warts are also caused by viruses. Viral STDs are not curable. They can be controlled by medications, but symptoms and the ability to infect others remain a possibility through a person's lifetime. Other STDs are usually curable with drugs, especially if diagnosed early.

Many STDs can cause long-term problems or even death if left untreated. Anyone who is sexually active should have regular medical exams, be tested for STDs, and seek immediate help if any suspicious symptoms appear—even if they are mild (Table 27.7).

STDs are most prevalent among teenagers and young adults; nearly two-thirds of infections occur among people under 25. The best way to avoid the spread of STDs is, of course, abstinence. Alternatively, latex condoms provide the best protection for "safe sex."

? Besides abstinence from sexual contact, what can prevent the spread of STDs?

Latex condoms

27.8 Contraception can prevent unwanted pregnancy

Contraception is the deliberate prevention of pregnancy. Table 27.8 lists common methods of contraception, with their failure rates when used correctly and when used typically. Note that these two rates are often quite different, emphasizing the importance of learning to use contraception correctly. It is also important to note that the "safe sex" provided by condoms can prevent both unwanted pregnancy and sexually transmitted diseases; this is not true of other contraceptive methods.

Complete abstinence (avoiding intercourse) is the only totally effective method of birth control, but other methods are effective to varying degrees. Sterilization, surgery that prevents sperm from reaching an ovum, is very reliable. A woman may have a **tubal ligation**, in which a doctor removes a short section from each oviduct (and may tie, or ligate, the remaining ends). A man may undergo a **vasectomy**, in which a doctor cuts a section out of each vas deferens to prevent sperm from reaching the urethra. Both forms of sterilization are relatively safe and free from side effects but are permanent.

The effectiveness of other methods of contraception depends on how they are used. Temporary abstinence, also called the **rhythm method** or **natural family planning**, depends on refraining from intercourse during the days around ovulation, when fertilization is most likely. It is difficult, however, to predict ovulation accurately. Thus, while the rhythm method is reliable in theory, in practice it is among the least reliable methods of contraception. **Withdrawal** of the penis from the vagina before ejaculation is also ineffective because some sperm may be released before climax.

If used correctly, **barrier methods** can be quite effective at physically preventing the union of sperm and egg. Condoms are sheaths, usually made of latex, that fit over the penis or within the vagina (Figure 27.8). A diaphragm is a dome-shaped rubber cap that covers the cervix; a cervical cap is similar but thimble-shaped and smaller. Both require a doctor's visit for proper fitting. Barrier devices (including condoms) are more effective when used in combination with **spermicides**, sperm-killing foam or jelly; spermicides used alone are not particularly reliable.

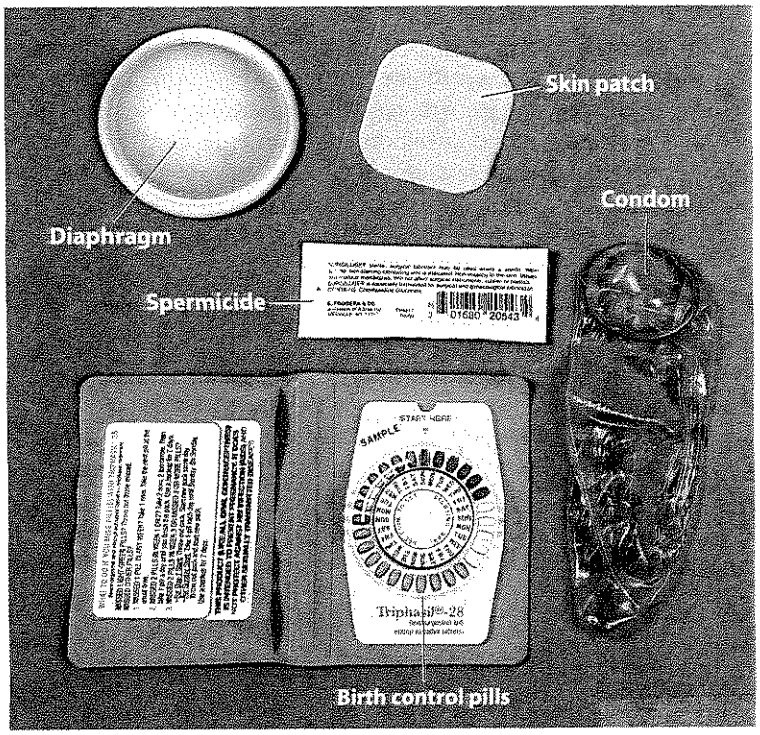

Figure 27.8 Some contraceptive devices

Some of the most effective methods of contraception prevent the release of gametes. **Oral contraceptives**, or **birth control pills**, come in several different forms that vary in their combinations of hormones. The most widely used pills contain a combination of synthetic estrogen and a synthetic progesterone-like hormone called progestin. "The pill" prevents ovulation and keeps follicles from developing. Combined hormone contraceptives are also available as an injection, a ring inserted into the vagina, or a skin patch. The hormone progestin by itself is available as tablets (the "minipill") or as injections that last for three months (Depo-Provera).

Certain drugs can prevent fertilization or implantation even after intercourse has occurred. Combination birth control pills can be prescribed in high doses for emergency contraception; they function as **morning after pills** (MAPs). If taken within three days after unprotected intercourse, MAPs are about 75% effective. Such treatments should only be used in emergencies because they have significant side effects. If pregnancy has already occurred, the drug mifepristone can induce an abortion during the first seven weeks of pregnancy. Mifepristone requires a doctor's prescription and several visits to a medical facility.

TABLE 27.8 CONTRACEPTIVE METHODS

Method	Pregnancies/100 Women/Year*	
	Used Perfectly	Typically
Birth control pill (combination)	0.1	5
Vasectomy	0.1	0.15
Tubal ligation	0.2	0.5
Progestin minipill	0.5	5
Rhythm	1–9	20
Withdrawal	4	19
Condom (male)	3	14
Diaphragm and spermicide	6	20
Spermicide alone	6	26

*Without contraception, about 85 pregnancies would occur.

? _____ is to males as tubal ligation is to _____.

Vasectomy . . . females

27.9 Fertilization results in a zygote and triggers embryonic development

The last seven modules have focused on the anatomy and physiology of the human reproductive system. In the next seven modules, we will examine the results of reproduction: the formation and development of an embryo. The concepts presented in this section apply to most vertebrates. We will return to the human story in the final section of this chapter.

Embryonic development begins with **fertilization**, the union of a sperm and an egg to form a diploid zygote. Fertilization combines haploid sets of chromosomes from two individuals and also activates the egg by triggering metabolic changes that start embryonic development.

The Properties of Sperm Cells Figure 27.9A is a micrograph of an unfertilized human egg almost covered by sperm. Of all these sperm, only one will enter and fertilize the egg. All the other sperm—the ones shown here and millions more that were ejaculated with them—will die. The one sperm that penetrates the egg adds its unique set of genes to those of the egg and contributes to the next generation.

Figure 27.9B illustrates the structure of a mature human sperm. Here is another case of form fitting function. The sperm's streamlined shape is an adaptation for swimming through fluids in the vagina, uterus, and oviduct of the female. The sperm cell's thick head contains a haploid nucleus and is tipped with a vesicle, the **acrosome**, which lies just inside the plasma membrane. The acrosome contains enzymes that help the sperm penetrate the egg. The neck and middle piece of the sperm contain a long, spiral mitochondrion. The sperm absorbs high-energy nutrients, especially the sugar fructose, from the semen. Thus fueled, its mitochondrion provides ATP for movement of the tail, which is actually a flagellum. By the time a sperm has reached the egg, it has consumed much of the energy available to it. But a successful sperm will have enough energy left to penetrate the egg and deposit its nucleus in the egg's cytoplasm.

The Process of Fertilization Figure 27.9C on the facing page illustrates the sequence of events in fertilization. This diagram is based on fertilization in sea urchins (phylum Echinodermata—see Module 18.13), on which a great deal of research has been done. Similar processes occur in other animals, including humans. The diagram traces one sperm through the successive activities of fertilization. Notice that to reach the egg nucleus, the sperm nucleus must pass through three barriers: the egg's jelly coat (yellow), a middle region of glycoproteins called the vitelline layer (pink), and the egg cell's plasma membrane.

Let's follow the steps shown in the figure. As a sperm ❶ approaches and then ❷ contacts the jelly coat of the egg, the acrosome in the sperm head releases a cloud of enzyme molecules that digest a cavity into the jelly. When the sperm head reaches the vitelline layer, ❸ species-specific protein molecules on its surface bind with specific receptor proteins on the vitelline layer. The binding between these proteins ensures that sperm of other species cannot fertilize the egg. This specificity is especially important when fertilization is

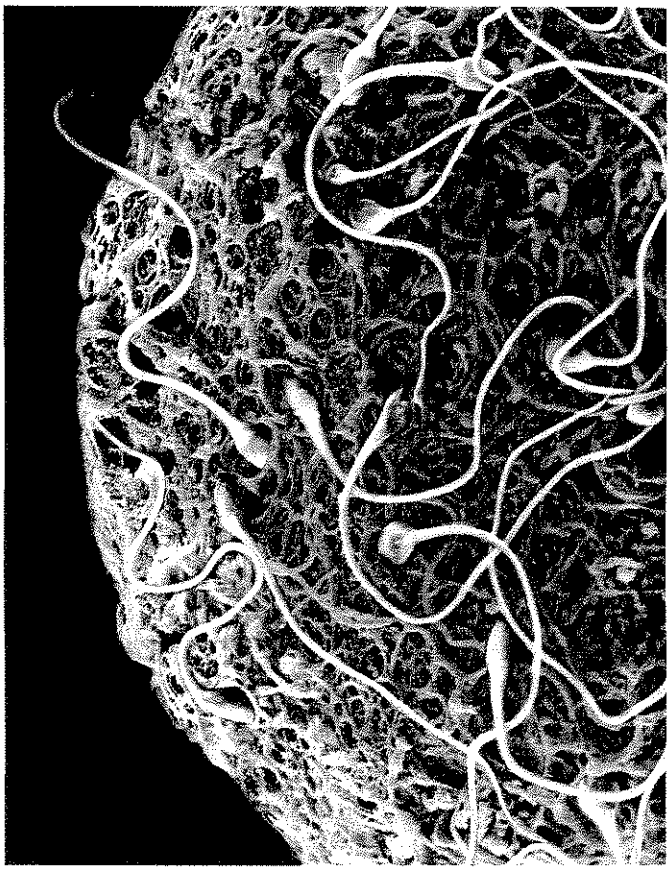

Figure 27.9A A human egg cell surrounded by sperm

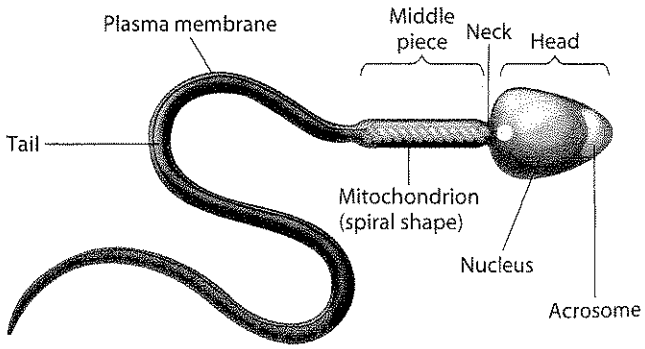

Figure 27.9B The structure of a human sperm cell