Nonmotile Spore-Formers

Apicomplexa: The Sporozoans

All sporozoans are nonmotile, spor-forming parasites of animals. Their spores are small, infective bodies that are transmitted from host to host. These organisms are distinguished by a unique arrangement of fibrils, microtubules, vacuoles, and other cell organelles at one end of the cell. There are 3900 described species of this phylum; best known among them is the malarial parasite, Plasmodium.

Sporozoans have complex life cycles that involve both asexual and sexual phases. Sexual reproduction involves an alternation of haploid and diploid generations. Both haploid and diploid individuals can also divide rapidly by mitosis, thus producing a large number of small infective individuals. Sexual reproduction involves the fertilization of a large female gamete by a small, flagellated male gamete. The zygote that results soon becomes an oocyst. Within the oocyst, meiotic divisions produce infective haploid spores called sporozoites.

An alternation between different hosts often occurs in the life cycles of sporozoans. Sporozoans of the genus Plasmodium are spread from person to person by mosquitoes of the genus Anopheles (figure 35.23); at least 65 different species of this genus are involved. When an Anopheles mosquito penetrates human skin to obtain blood, it injects saliva mixed with an anticoagulant. If the mosquito is infected with Plasmodium, it will also inject the elongated sporozoites into the bloodstream of its victim. The parasite makes its way through the bloodstream to the liver, where it rapidly divides asexually. After this division phase, merozoites, the next stage of the life cycle, form, either reinwading other liver cells or entering the host’s bloodstream. In the bloodstream, they invade the red blood cells, dividing rapidly within them and causing them to become enlarged and ultimately to rupture. This event releases toxic substances throughout the body of the host, bringing about the well-known cycle of fever and chills that is characteristic of malaria. The cycle repeats itself regularly every 48 hours, 72 hours, or longer.

Plasmodium enters a sexual phase when some merozoites develop into gametocytes, cells capable of producing gametes. There are two types of gametocytes: male and female. Gametocytes are incapable of producing gametes within their human hosts and do so only when they are extracted from an infected human by a mosquito. Within the gut of the mosquito, the male and female gametocytes form sperm and eggs, respectively. Zygotes develop within the mosquito’s intestinal walls and ultimately differentiate into oocysts. Within the oocysts, repeated mitotic divisions take place, producing large numbers of sporozoites. These sporozoites migrate to the salivary glands of the mosquito, and from there they are injected by the mosquito into the bloodstream of a human, thus starting the life cycle of the parasite again.

Malaria. Malaria, caused by infections by the sporozoan Plasmodium, is one of the most serious diseases in the world. According to the World Health Organization, about 500 million people are affected by it at any one time, and approximately 2 million of them, mostly children, die each year. Malaria kills most children under five years old who contract it. In areas where malaria is prevalent, most survivors more than five or six years old do not become seriously ill again from malaria infections. The symptoms, familiar throughout the tropics, include severe chills, fever, and sweating, an enlarged and tender spleen, confusion, and great thirst. Ultimately, a victim of malaria may die of anemia, kidney failure, or brain damage. The disease may be brought under control by the person’s immune system or by drugs. As discussed in chapter 20, some individuals are genetically resistant to malaria. Other persons develop immunity to it.

Efforts to eradicate malaria have focused on (1) the elimination of the mosquito vectors; (2) the development of drugs to poison the parasites once they have entered the human body; and (3) the development of vaccines. The widescale applications of DDT from the 1940s to the 1960s led to the elimination of the mosquito vectors in the United States, Italy, Greece, and certain areas of Latin America. For a time, the worldwide elimination of malaria appeared possible, but this hope was soon crushed by the development of DDT-resistant strains of malaria-carrying mosquitoes in many regions; no fewer than 64 resistant strains were identified in a 1980 survey. Even though the worldwide use of DDT, long banned in the United States, nearly doubled from its 1974 level to more than 30,000 metric tons in 1984, its effectiveness in controlling mosquitoes is dropping. Further, there are serious environmental concerns about the use of this long-lasting chemical anywhere in the world. In addition to the problems with resistant strains of mosquitoes, strains of Plasmodium have appeared that are resistant to the drugs that have historically been used to kill them.

As a result of these problems, the number of new cases of malaria per year roughly doubled from the mid-1970s to
the mid-1980s, largely because of the spread of resistant strains of the mosquito and the parasite. In many tropical regions, malaria is blocking permanent settlement. Scientists have therefore redoubled their efforts to produce an effective vaccine. Antibodies to the parasites have been isolated and produced by genetic engineering techniques, and they are starting to produce promising results.

Vaccines against Malaria. The three different stages of the *Plasmodium* life cycle each produce different antigens, and they are sensitive to different antibodies. The gene encoding the sporozoite antigen was cloned in 1984, but it is not certain how effective a vaccine against sporozoites might be. When a mosquito inserts its proboscis into a human blood vessel, it injects about a thousand sporozoites. They travel to the liver within a few minutes, where they are no longer exposed to antibodies circulating in the blood. If even one sporozoite reaches the liver, it will multiply rapidly there and cause malaria. The number of malaria parasites increases roughly eightfold every 24 hours after they enter the host’s body. A compound vaccination against sporozoites, merozoites, and gametocytes would probably be the most effective preventive measure, but such a compound vaccine has proven difficult to develop.

However, research completed in 1997 brings a glimmer of hope. An experimental vaccine containing one of the surface proteins of the disease-causing parasite, *P. falciparum*, seems to induce the immune system to produce defenses that are able to destroy the parasite in future infections. In tests, six out of seven vaccinated people did not get malaria after being bitten by mosquitoes that carried *P. falciparum*. Although research is still underway, many are hopeful that this new vaccine may be able to fight malaria, especially in Africa, where it takes a devastating toll.

The best known of the sporozoans is the malarial parasite *Plasmodium*. Like other sporozoans, *Plasmodium* has a complex life cycle involving sexual and asexual phases and alternation between different hosts, in this case mosquitoes and humans. Malaria kills about 2 million people each year.