33

Viruses

Concept Outline

33.1 Viruses are strands of nucleic acid encased within a protein coat.

The Discovery of Viruses. The first virus to be isolated proved to consist of two chemicals, one a protein and the other a nucleic acid.

The Nature of Viruses. Viruses occur in all organisms. Able to reproduce only within living cells, viruses are not themselves alive.

33.2 Bacterial viruses exhibit two sorts of reproductive cycles.

Bacteriophages. Some bacterial viruses, called bacteriophages, rupture the cells they infect, while others integrate themselves into the bacterial chromosome to become a stable part of the bacterial genome.

Cell Transformation and Phage Conversion. Integrated bacteriophages sometimes modify the host bacterium they infect.

33.3 HIV is a complex animal virus.

AIDS. The animal virus HIV infects certain key cells of the immune system, destroying the ability of the body to defend itself from cancer and disease. The HIV infection cycle is typically a lytic cycle, in which the HIV RNA first directs the production of a corresponding DNA, and this DNA then directs the production of progeny virus particles.

The Future of HIV Treatment. Combination therapies and chemokines offer promising avenues of AIDS therapy.

33.4 Nonliving infectious agents are responsible for many human diseases.

Disease Viruses. Some of the most serious viral diseases have only recently infected human populations, the result of transfer from other hosts.

Prions and Viroids. In some instances, proteins and "naked" RNA molecules can also transmit diseases.

FIGURE 33.1
Influenza viruses. A virus has been referred to as "a piece of bad news wrapped up in a protein." How can something as "simple" as a virus have such a profound effect on living organisms? (30,000×)

We start our exploration of the diversity of life with viruses. Viruses are genetic elements enclosed in protein and are not considered to be organisms, as they cannot reproduce independently. Because of their disease-producing potential, viruses are important biological entities. The virus particles you see in figure 33.1 produce the important disease influenza. Other viruses cause AIDS, polio, flu, and some can lead to cancer. Many scientists have attempted to unravel the nature of viral genes and how they work. For more than four decades, viral studies have been thoroughly intertwined with those of genetics and molecular biology. In the future, it is expected that viruses will be one of the principal tools used to experimentally carry genes from one organism to another. Already, viruses are being employed in the treatment of human genetic diseases.

It is no accident that new strains of flu usually originate in the far east. The most common hosts of influenza virus are ducks, chickens, and pigs, which in Asia often live in close proximity to each other and to humans. Pigs are subject to infection by both bird and human strains of the virus, and individual animals are often simultaneously infected with multiple strains. This creates conditions favoring genetic recombination between strains, producing new combinations of H and N subtypes. The Hong Kong flu, for example, arose from recombination between A(H3N8) [from ducks] and A(H2N2) [from humans]. The new strain of influenza, in this case A(H3N2), then passed back to humans, creating an epidemic because the human population has never experienced that H N combination before.

A potentially deadly new strain of flu virus emerged in Hong Kong in 1997, A(H5N1). Unlike all previous instances of new flu strains, A(H5N1) passed to humans directly from birds, in this case chickens. A(H5N1) was first identified in chickens in 1961, and in the spring of 1997 devastated flocks of chickens in Hong Kong. Fortunately, this strain of flu virus does not appear to spread easily from person to person, and the number of human infections by A(H5N1) remains small. Public health officials remain concerned that the genes of A(H5N1) could yet mix with those of a human strain to create a new strain that could spread widely in the human population, and to prevent this ordered the killing of all 1.2 million chickens in Hong Kong in 1997.

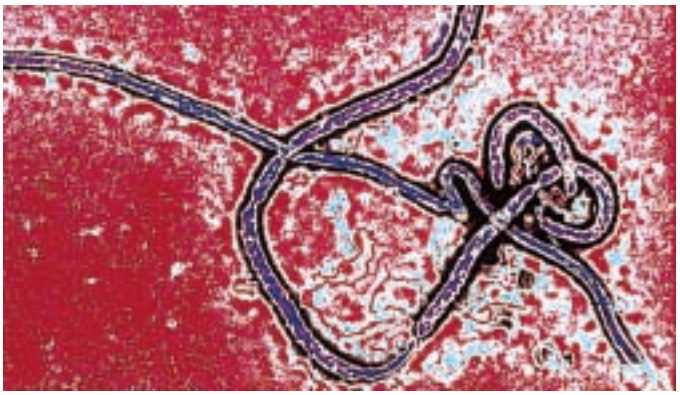

FIGURE 33.10
The Ebola virus. This virus, with a fatality rate that can exceed 90%, appears sporadically in West Africa. Health professionals are scrambling to identify the natural host of the virus, which is unknown, so they can devise strategies to combat transmission of the disease.

Emerging Viruses

Sometimes viruses that originate in one organism pass to another, thus expanding their host range. Often, this expansion is deadly to the new host. HIV, for example, arose in chimpanzees and relatively recently passed to humans. Influenza is fundamentally a bird virus. Viruses that originate in one organism and then pass to another and cause disease are called **emerging viruses** and represent a considerable threat in an age when airplane travel potentially allows infected individuals to move about the world quickly, spreading an infection.

Among the most lethal of emerging viruses are a collection of filamentous viruses arising in central Africa that cause severe hemorrhagic fever. With lethality rates in excess of 50%, these so-called filoviruses are among the most lethal infectious diseases known. One, Ebola virus (figure 33.10), has exhibited lethality rates in excess of 90% in isolated outbreaks in central Africa. The outbreak of Ebola virus in the summer of 1995 in Zaire killed 245 people out of 316 infected—a mortality rate of 78%. The latest outbreak occurred in Gabon, West Africa, in February 1996. The natural host of Ebola is unknown.

Another type of emerging virus caused a sudden outbreak of a hemorrhagic-type infection in the southwestern United States in 1993. This highly fatal disease was soon attributed to the hantavirus, a single-stranded RNA virus associated with rodents. The hantavirus is transmitted to humans through rodent fecal contamination in areas of human habitation. Although hantavirus has been known for some period of time, this particular outbreak was attributed to the presence of an unusually large rodent population in the area following a higher than normal amount of rainfall the previous winter.

Viruses and Cancer

Through epidemiological studies and research, scientists have established a link between some viral infections and the subsequent development of cancer. Examples include the association between chronic hepatitis B infections and the development of liver cancer and the development of cervical carcinoma following infections with certain strains of papillomaviruses. It has been suggested that viruses contribute to about 15% of all human cancer cases worldwide. Viruses are capable of altering the growth properties of human cells they infect by triggering the expression of oncogenes (cancer-causing genes). Certain viruses can either activate host proto-oncogenes (see chapter 18) or bring in viral oncogenes that become incorporated into the host genome. Virus-induced cancer is not simply a matter of infection. The disease involves complex interactions with cellular genes and requires a series of events in order to develop.

Viruses are responsible for some of the most lethal diseases of humans. Some of the most serious examples are viruses that have transferred to humans from some other host. Influenza, a bird virus, has been responsible for the most devastating epidemics in human history. Newly emerging viruses such as Ebola have received considerable public attention.