Lytic Cycle When the bacteriophage lambda collides with an *E. coli* cell, it binds to the surface and injects its DNA. Once inside, the viral DNA brings about disintegration of host DNA and takes over the operation of the cell. Viral DNA replication, utilizing the nucleotides within the host cell, produces many copies of viral DNA. Transcription occurs, and mRNA molecules utilize host ribosomes to bring about the production of multiple copies of coat proteins. Viral DNA and capsids are *assembled* to produce about 100 viral particles. In the meantime, viral DNA has directed the synthesis of lysozyme, an enzyme that digests the cell wall. The host cell bursts and the viral particles are released.

Lysogenic Cycle During the lysogenic cycle, viral DNA is integrated into the bacterial DNA. In this stage the viral DNA is called a *prophage*. The prophage is replicated along with the host DNA, and all subsequent cells, called *lysogenic cells*, carry a copy of the prophage. Certain environmental factors, such as ultraviolet radiation, can induce the lytic cycle. The prophage leaves the bacterial chromosome; replication of viral DNA, production of capsids, assembly, and cell lysis follow.

During the lytic cycle of a bacteriophage, the bacterial cell dies when the viral particles burst from the cell. During the lysogenic cycle, viral DNA is integrated into bacterial DNA for an indefinite period of time.

Animal Viruses

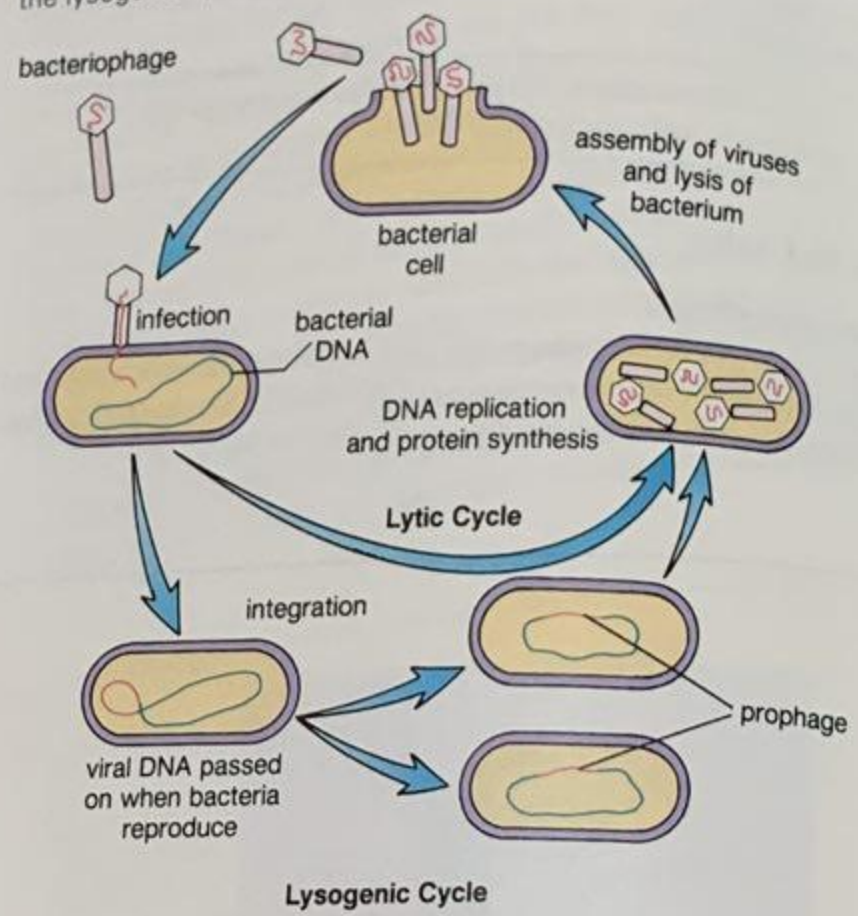
Animal viruses sometimes have a membranous outer envelope. Such viruses enter a cell by endocytosis, and *uncoating* releases viral nucleic acid from the capsid. These viruses leave a cell by exocytosis, or *budding*, and in this way, they acquire the membranous envelope (fig. 23.4*a*). The envelope often contains glycoproteins that interact with the next host cell plasma membrane, permitting entry of the virus into this cell.

DNA Animal Viruses After a DNA virus with an envelope has gained entry to the cell and uncoating has occurred, transcription, translation, and assembly occur as we have just described for bacteriophages. Then, as each virus buds from the cell, it acquires its envelope. The DNA codes for coat protein and also envelope glycoprotein (fig. 23.4*a*).

RNA Animal Viruses Some animal viruses have RNA genomes; that is, only RNA is enclosed within the capsid. In most of these viruses, the single strand of RNA serves as a template for the production of double-stranded RNA. This unique molecule then serves as a template for multiple replicas of the genetic material and for the transcription of mRNA molecules. Special enzymes, termed *RNA replicase* and *transcriptase*, perform these tasks.

Other RNA viruses called **retroviruses** (fig. 23.4*b*) have the enzyme called *reverse transcriptase*, which carries out RNA → DNA transcription. Following replication, the resulting double-stranded DNA (called *cDNA* because it is complementary to viral RNA) is integrated into the host chromosome for an indefinite period of time before reproduction of the virus and budding from the host cell occurs. Because integration occurred, RNA viruses sometimes carry host genes into a new host cell.

Figure 23.3
Lytic versus lysogenic life cycle. In the lytic cycle, a bacteriophage reproduces within the host bacterial cell and then the cell is lysed (broken open), allowing the viral particles to escape. In the lysogenic cycle, the DNA of a bacteriophage is integrated into the host DNA and becomes a prophage. Thereafter, the prophage is replicated along with the bacterial chromosome and is passed to all the daughter cells. When and if the viral DNA leaves the chromosomes, the lysogenic cycle can be followed by the lytic cycle.



Retroviruses are of extreme interest because these are the viruses that bring cancer-causing oncogenes into a host cell. Also, the AIDS viruses are retroviruses.

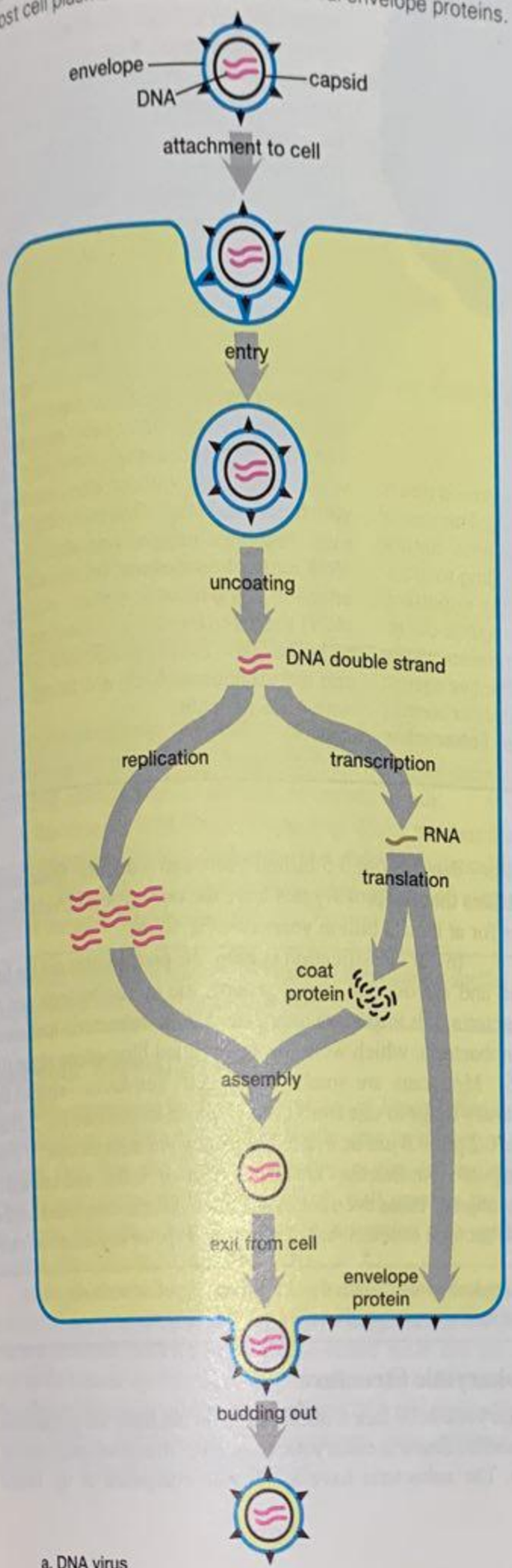
Animal viruses sometimes have a membranous envelope that they acquire by budding from the host cell. Retroviruses are RNA viruses that carry out RNA → DNA transcription and integrate this cDNA into the host cell.

Viroids

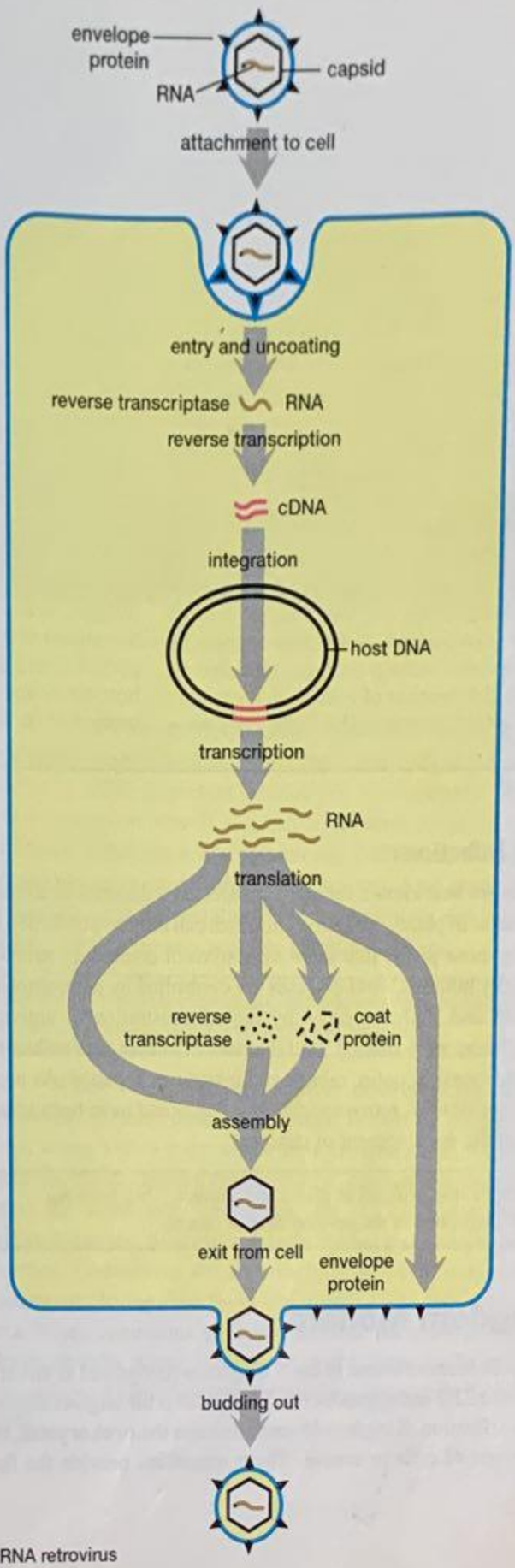
Viroids are very unusual infectious particles that can be compared to viruses. **Viroids** differ from viruses in that they consist only of a short chain of naked RNA. The number of nucleotides present is not sufficient to code for a capsid and there is no evidence that the viroid RNA is ever translated into a protein. We know of their presence only because they cause disease in plants; the first viroid to be recognized is the cause of potato spindle tuber disease. Viroids also have attacked coconut trees in the Philippines and chrysanthemums in the United States. The manner in which they cause disease is not known, but it is hypothesized that they are reproduced by the host cell and that they interfere with gene regulation in these cells.

Figure 23.4
Life cycles of animal viruses. **a.** DNA virus. After entering the host cell by endocytosis, the virus is uncoated. The DNA then codes for proteins, some of which are capsid (coat) proteins and some of which are envelope proteins. Assembly follows replication of the DNA. When the virus exits by budding, it is enclosed by an envelope made up of host cell plasma membrane lipids and viral envelope proteins.

b. RNA retrovirus. The life cycle includes steps not seen in (**a**). The RNA genes are transcribed to cDNA (complementary DNA), which is integrated into the host DNA. Transcription produces many copies of the RNA genes, which also serve to direct the synthesis of 3 types of proteins: the enzyme reverse transcriptase, capsid (coat) protein, and envelope protein. Again, the virus buds from the host cell.



a. DNA virus



b. RNA retrovirus

Antibiotics and Antiviral Drugs

An antibiotic is a chemical that selectively kills bacteria when it is taken into the body as a medicine. Since the introduction of the first antibiotics in the 1940s, there has been a dramatic decline in deaths due to pneumonia, tuberculosis, and other infectious diseases.

Most antibiotics are produced naturally by soil microorganisms. Penicillin is made by the fungus *Penicillium;* streptomycin, tetracycline, and erythromycin are all produced by the bacterium *Streptomyces.* Sulfa, a chemotherapeutic agent rather than an antibiotic, is an analogue of a bacterial growth factor and can be produced in the laboratory.

A few antibiotics are metabolic inhibitors specific for bacterial enzymes. This means that they poison bacterial enzymes without harming host enzymes. Penicillin blocks the synthesis of the bacterial cell wall; streptomycin, tetracycline, and erythromycin block protein synthesis; and sulfa prevents the production of a coenzyme.

There are problems associated with antibiotic therapy. Some patients are allergic to antibiotics, and their reaction to them may even be fatal. Antibiotics not only kill off disease-causing bacteria, they also reduce the number of beneficial bacteria in the intestinal tract. The latter may have held in check a pathogen that now is free to multiply and invade the body. The use of antibiotics sometimes prevents natural immunity from occurring, leading to recurring antibiotic therapy. Most important, perhaps, is the growing resistance of certain strains of bacteria to antibiotics. While penicillin used to be 100% effective against hospital strains of *Staphylococcus aureus,* today it is far less effective. Tetracycline and penicillin, long used to cure gonorrhea, now have a failure rate of more than 20% against certain strains of gonococcus. Most physicians believe that antibiotics should only be administered when absolutely necessary. Some believe that if antibiotic use is not strictly limited, then resistant strains of bacteria will completely replace present strains and antibiotic therapy will no longer be effective at all. They are very much opposed to the current practice of adding antibiotics to livestock feed in order to make animals grow fatter because resistant bacteria are easily transferred from animals to humans.

Figure 23.A
Penicillium chrysogenum, from which the antibiotic penicillin is prepared.

The development of antiviral drugs has lagged far behind the development of antibiotics. Viruses lack most enzymes and instead utilize the metabolic machinery of the host cell. Rarely has it been possible to find a drug that successfully interferes with viral reproduction without also interfering with host metabolism. One such drug, however, called vidarabine, was approved in 1978 for treatment of viral encephalitis, an infection of the nervous system. Acyclovir (ACV) seems to be helpful in treating genital herpes, and the drugs zidovudine (AZT) and dideoxyinosine (DDI) are being used with AIDS patients.

Viral Infections

Viruses are best known for causing infectious diseases in animals and plants. In plants, infectious diseases can only be controlled by burning those plants that show symptoms of disease. In animals, especially humans, viral diseases are controlled by administering vaccines and, only recently, by the administration of antiviral drugs. Some well-studied viral diseases in humans are influenza, mumps, measles, polio, rabies, and infectious hepatitis. As mentioned previously, retroviruses cause AIDS and have been implicated in the development of cancer.

Viruses cause diseases in plants and animals. They have also been implicated in the development of cancer.

Kingdom Monera

Kingdom Monera is one of the 5 kingdoms recognized in this text (see table 22.2 and appendix A). A kingdom is the largest category of classification. Kingdom Monera contains the **prokaryotes,** the first types of cells to evolve. These organisms provide the first fossils—dated about 3.5 billion years ago—and the fossil record indicates that the prokaryotes were the only type of living organisms for at least 2 billion years (see fig. 22.5).

In our classification system, the prokaryotes are the **bacteria** and are divided into 2 groups, the archaebacteria and the eubacteria. It is important to realize that the eubacteria include the cyanobacteria, which were formerly called blue-green algae (fig. 23.5). Monerans are small, single cells (*moneres*—single) that generally range in size from 1 μm-10 μm in length (see fig. 5.2) and from 0.2 μm-0.3 μm in width. Since they are microscopic, it is not always obvious that they are abundant in air, water, and soil and on most objects. It has even been suggested that the combined number of all bacteria exceeds that of any other type of organism on earth.

Kingdom Monera includes the various types of bacteria, which are microscopic, single-celled prokaryotes.

Prokaryotic Structure

Prokaryotic cells lack a nucleus and do not have the cytoplasmic organelles found in eukaryotic cells, other than ribosomes (see fig. 5.3). The eubacteria have a cell wall composed of the unique