1

BACTERIA, TOXINS, AND VIRUSES

A staggering variety of microbes and chemicals found in the environment pose serious health threats to humans, but some can be manipulated to be even more dangerous. Certain types of bacteria, toxins, and viruses have been identified as potential weapons of bioterrorism. While each agent has its own unique characteristics, it is worthwhile to consider some traits common to each group.

1.1 BACTERIA

Bacteria are too small to be seen without a microscope, yet they comprise more of the total biomass of Earth than all plants and animals combined. Different species are adapted to different conditions, and bacteria can be found in virtually every environment on the planet. Many species have established mutually beneficial, **symbiotic** relationships with humans; our bodies provide a home and nutrition for the bacteria, and the bacteria provide some type of benefit to our health. The human digestive system is particularly dependent on the multitude of bacteria occupying the intestines. In fact, the population of bacteria living in and on the human body outnumbers human body cells by 10 to 1. The presence of symbiotic bacteria also confers protection against other bacterial species that are actually **pathogenic** to humans, causing various symptoms of disease or, in many cases, death. Some of these pathogens, however, are undaunted by symbiotic bacteria and will cause disease in virtually everyone they encounter.

Biological Weapons: Recognizing, Understanding, and Responding to the Threat, First Edition.
Kristy Young Johnson and Paul Matthew Nolan.

Companion Website: http://www.wiley.com/go/Johnson/BiologicalWeapons

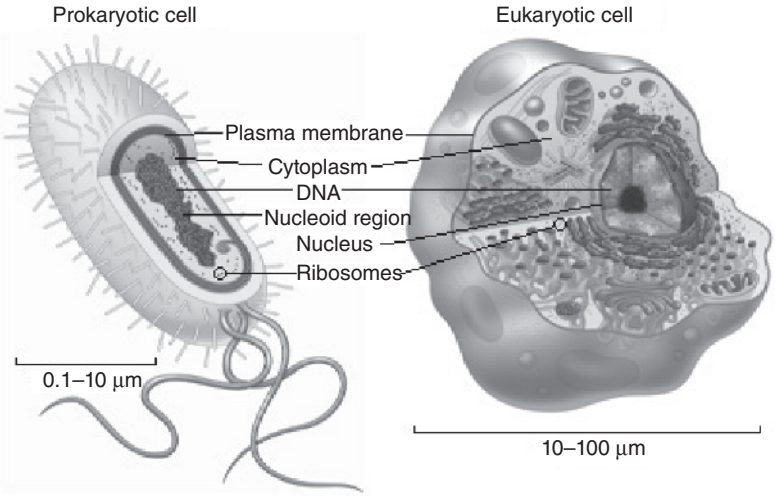

Figure 1.1 Prokaryotic and eukaryotic cells share many features, but eukaryotic cells are typically larger and have their DNA enclosed in a nucleus Source: Wikipedia, https://biology12-lum.wikispaces.com/Recombinant+DNA, Used under CC BY-SA 3.0, http://creativecommons.org/licenses/by-sa/3.0/

Organisms such as plants and animals consist of many cells and have numerous intracellular structures called **organelles** that perform specific cellular functions; some of these organelles are enclosed in membranes within the internal environment of the cell. Such organisms are considered **eukaryotic**. Bacteria, however, exist as individual cells that also have organelles, but none of their organelles are membrane-bound; these organisms are considered **prokaryotic** (Fig. 1.1).

The genetic material of bacteria is composed of **deoxyribonucleic acid** (DNA), the same molecule that carries hereditary information in all living cells. While eukaryotic DNA is organized into linear, thread-like **chromosomes** (imagine miniscule strands of spaghetti) encased in a membrane to form the nucleus (Fig. 1.2), bacterial chromosomes have a circular formation (as microscopic SpaghettiOs™) and are not bound by a membrane. Most bacterial cells have one large, circular chromosome, and many also have smaller, circular strands of DNA called **plasmids** (Fig. 1.3). Bacteria frequently exchange copies of plasmids, easily generating diversity within a bacterial population descended from the same bacterial cell.

Without microscopes, bacterial species can often be differentiated based on the appearance of their **colonies**, macroscopic clusters of cells growing on a solid surface. However, many species produce colonies with similar appearances and must be distinguished by other means. Often, extensive laboratory tests are required to identify bacterial species conclusively, but the first step in identification is to characterize the shape of the individual cells. Most bacterial cells can be categorized as rod-shaped (**bacillus**), spherical (**coccus**), corkscrew-shaped (**spirillum**), or comma-shaped (**vibrio**) (Fig. 1.4). Some bacterial species do not fit neatly into one of these cell-shape categories; for example, those that are more round than bacilli but more elongated than cocci are referred to as **coccobacilli**.

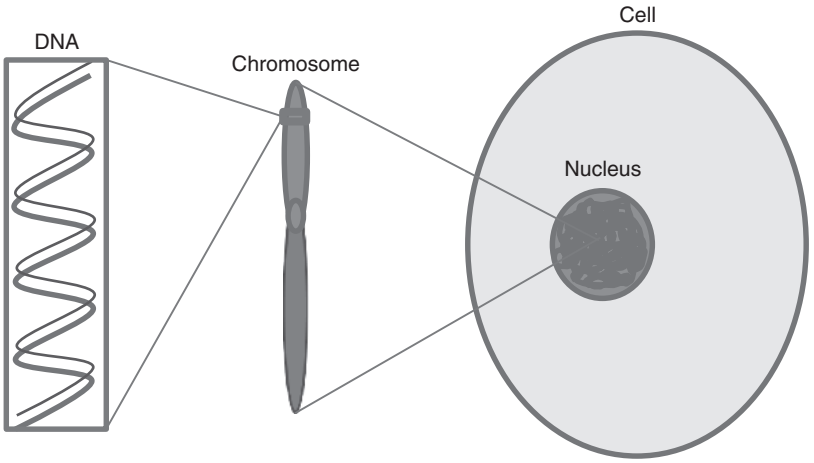

Figure 1.2 Long strands of DNA are folded into chromosomes and located in the nucleus of eukaryotic cells

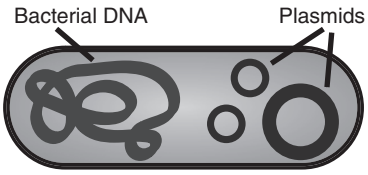

Figure 1.3 Prokaryotic DNA is not enclosed in a nucleus. Small molecules of DNA called plasmids are often present Source: Wikipedia, https://commons.wikimedia.org/wiki/File:Plasmid_(english).svg. Used under CC BY-SA 2.5, https://creativecommons.org/licenses/by-sa/2.5/deed.en

Another step in the initial identification of bacterial species is based on their appearance after certain staining procedures. While all living cells have a flexible **cell membrane** that envelops their internal components, bacteria have an additional **cell wall** composed of **peptidoglycan** (a complex of protein and sugar molecules) on the outer surface of their cell membrane (Fig. 1.5). A staining procedure known as the **Gram stain** distinguishes bacteria with thick cell walls (**Gram positive**) from those with thin cell walls (**Gram negative**). After staining, Gram positive bacteria appear purple (seen here as dark gray), while Gram negative bacteria appear pink (seen here as light gray) (Fig. 1.6). In many cases, the bacterial cell wall renders the bacteria impervious to medications, making some bacterial infections extremely difficult to treat.

Reality Check:

What are some tests scientists could use to identify biological agents rapidly in the field?

Some bacteria that are pathogenic to humans also infect other species. For instance, the bacterium that causes plague in humans also infects rodents and fleas.

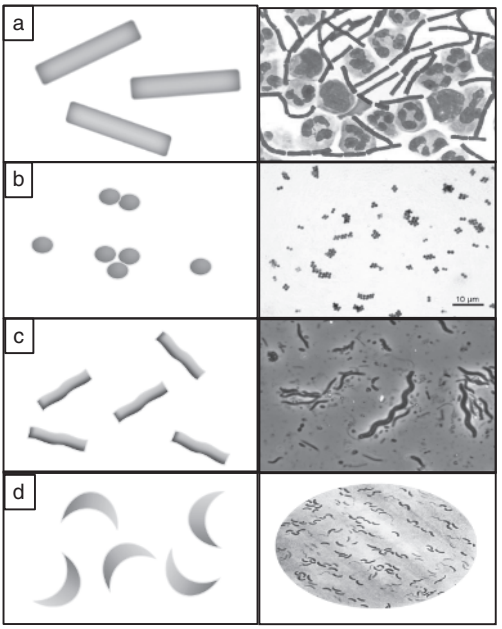

Figure 1.4 (a) Rod-shaped *Bacillus anthracis* cells among large, round neutrophils. (b) Spherical *Staphylococcus aureus* cells. (c) Spiral-shaped Spirillum volutans cells. (d) Comma-shaped Vibrio

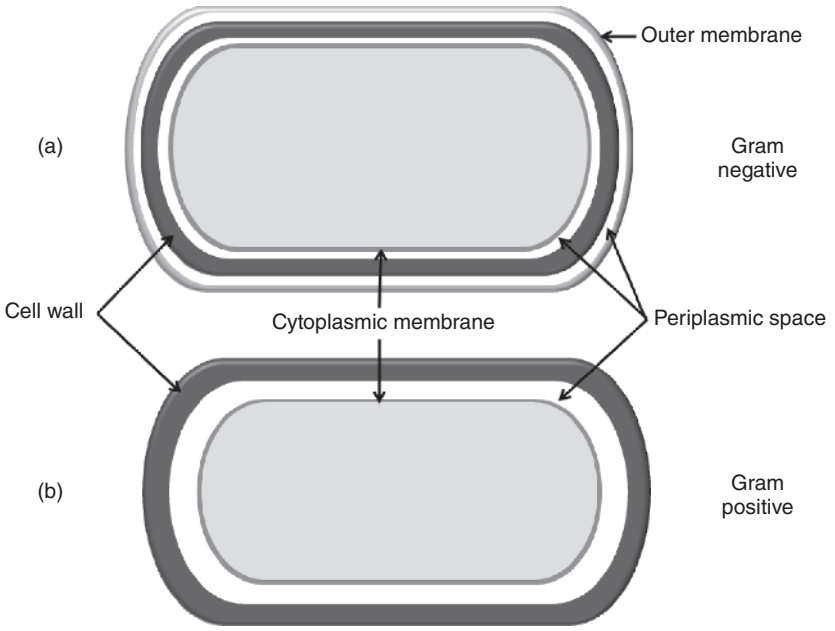

Figure 1.5 Some prokaryotic cells have a thin peptidoglycan layer (a), while others have a thick peptidoglycan layer (b) Source: http://www.intechopen.com/books/viscoelasticity-from-theory-to-biological-applications/viscoelasticity-in-biological-systems-a-special-focus-on-microbes, Used under CC BY 3.0, http://creativecommons.org/licenses/by/3.0/

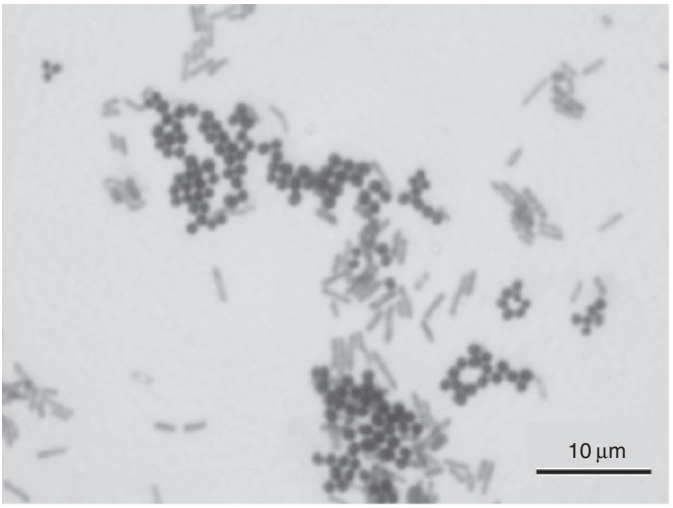

Figure 1.6 Gram positive cocci appear dark gray, while Gram negative bacilli appear light gray Source: Wikipedia, https://commons.wikimedia.org/wiki/File:Gram_stain_01.jpg, Used under CC BY-SA 3.0, https://creativecommons.org/licenses/by-sa/3.0/

A species that commonly carries but is not killed by a pathogen is known as a **reservoir host**. While infection with the bacterium that causes plague produces nonfatal sickness in rodents, the same bacteria do not cause those symptoms in fleas. Thus, fleas ingest the bacteria while feeding on an infected rodent. If the rodent dies, the fleas often turn to humans as a source of food, transmitting plague bacteria with every bite. Any species that is involved in transmitting a pathogen to humans is considered a **vector**. Vectors can be employed by bioterrorists as a means of spreading a biological weapon across borders, particularly if the vector is a flying insect such as a mosquito that could easily bypass security checkpoints.

Some bacteria can live and multiply only in the presence of oxygen; these are known as **aerobes**. Others grow best in the absence of oxygen; these bacteria are called **anaerobes**. Aerobes are most commonly found in open environments, while active anaerobes are found in closed environments such as sealed jars and cans. Because of their different environmental requirements, these categories of bacteria pose different threats. Aerobes can be dispersed in open-air environments, while anaerobes can be covertly distributed in canned food or other sealed containers.

While there are specific environmental conditions that are ideal for each species of bacteria, most are able to tolerate a range of conditions, if only for minutes or hours. This hardiness allows bacteria to be transmitted via **fomites**, inanimate objects that can become contaminated when touched by an infected individual. Some frequently encountered fomites include monetary currency (especially paper bills), elevator buttons, door handles, and even restaurant menus. Because infection often results from touching the mouth, nose, or eyes after making contact with a fomite, frequent hand-washing is one of the best defenses against everything from bacteria to viruses (Fig. 1.7). Similar to vectors, fomites can also be used to spread biological weapons, and an object as innocent as the contaminated surface of a

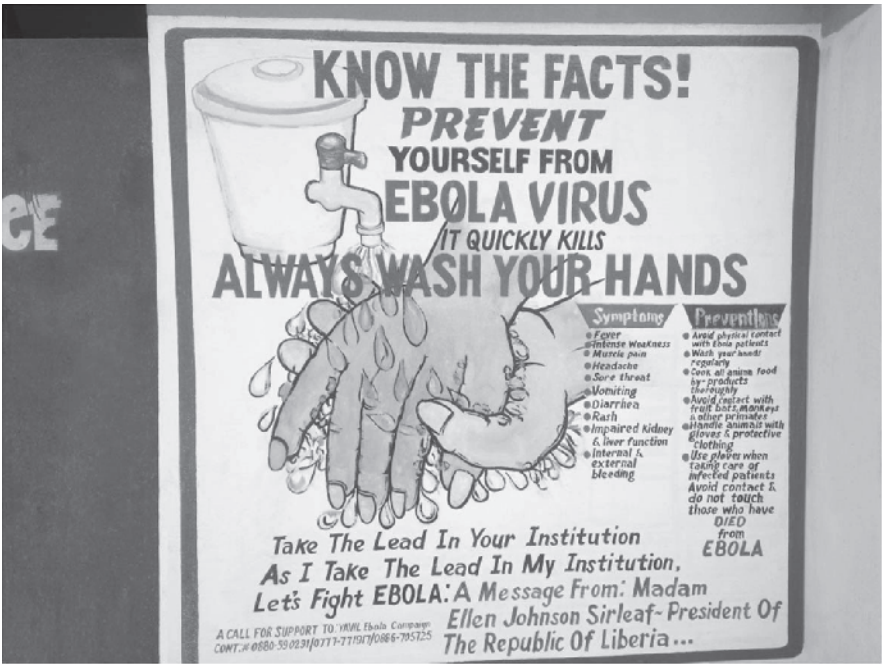

Figure 1.7 The CDC recommends frequent hand-washing to prevent Ebola

sticky ketchup bottle in a restaurant can instantly become a deadly weapon. In some cases, live aerobic bacteria can be **aerosolized**, traveling on air currents for great distances, possibly miles, before being inhaled by unsuspecting victims. Most living bacteria have a low tolerance to ultraviolet radiation and would be most effective if released at night, indoors, or in an underground structure such as a subway. Chapter 6 includes a discussion of the harrowing results of government-sponsored testing of the release of a bacterial agent in a New York City subway.

While they are generally considered simple organisms, bacteria possess some bizarre qualities not found in eukaryotic organisms. Some bacterial species possess the astounding ability to survive extended periods of harsh environmental conditions in a state of suspended animation by forming structures known as **endospores**. Each bacterial cell forms a single endospore that consists mainly of its genetic material encased in several protective layers of protein (Fig. 1.8). Endospores are most often generated in response to nutrient depletion and are able to "awaken" and become actively growing bacteria when nutrients are again present. Bacteria growing in a laboratory environment can be induced to form endospores simply by not replenishing their nutrient supply. Because endospore formation can be completed in a matter of hours, these bacteria can survive even rapidly changing environments. While this ability to survive a period of dormancy is impressive, it is even more amazing to consider the conditions tolerated by the endospores themselves. Endospores may be thoroughly desiccated, soaked in bleach, boiled for over an hour, exposed to extreme levels of ultraviolet radiation, or frozen for centuries, yet remain capable of reactivation as soon as they encounter a favorable environment. This freakish

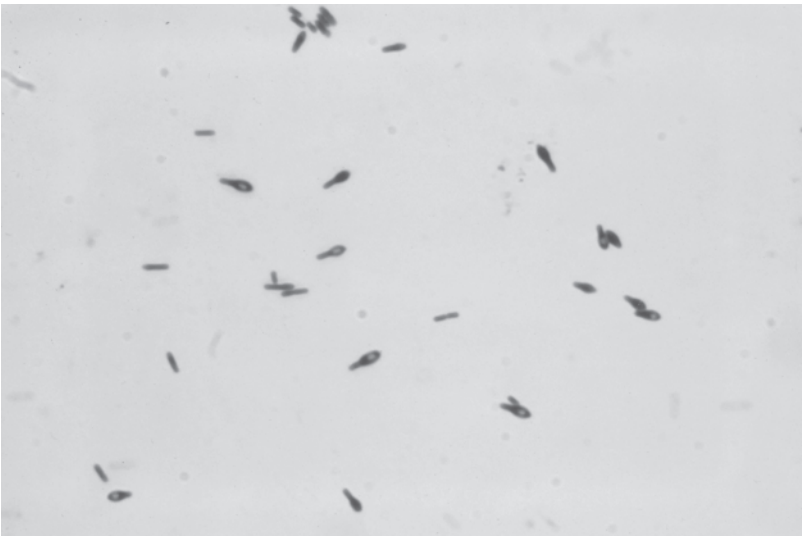

Figure 1.8 Endospores forming in *Clostridium botulinum* cells appear as clear areas

behavior makes these bacterial species particularly well-suited for weaponization because endospores are easier to concentrate, transport, and disseminate than living cells. A single gram of the notorious white powder sent through the US postal system in 2001 (discussed in Chapter 4) contained over 1 trillion anthrax endospores, each able to transform into a live anthrax bacterium once inside a human host. The powder could be stored in airtight containers for decades without losing potency and was so fine that it literally wafted into the air like smoke when the envelopes were opened. A weapon of this nature could be manufactured and then placed into long-term storage or transported around the world, remaining as deadly as the day it was made.

Reality Check:

Why would endospores be easier to transport than live bacteria?

Fortunately for modern society, most pathogenic bacteria can be killed with **antibiotics**. Early antibiotics were produced naturally by microbes and were essentially biological weapons employed in the war between microbes competing for resources. In 1928, a Scottish scientist named **Alexander Fleming** (Fig. 1.9) accidentally contaminated a bacterial culture in the laboratory with a fungus. Within days, he noticed that a substance produced by the fungus actually killed the bacteria; that substance is now known as penicillin. In the decades following Fleming's discovery, many other natural and synthetically modified antibiotics have been discovered, making possible the successful treatment of previously untreatable infections. Antibiotics work by various methods, but most target the synthesis of prokaryotic proteins and do not interfere with similar processes in eukaryotic cells. The most common deleterious effect of antibiotic treatment is the depletion of populations of symbiotic bacteria within the human digestive tract.

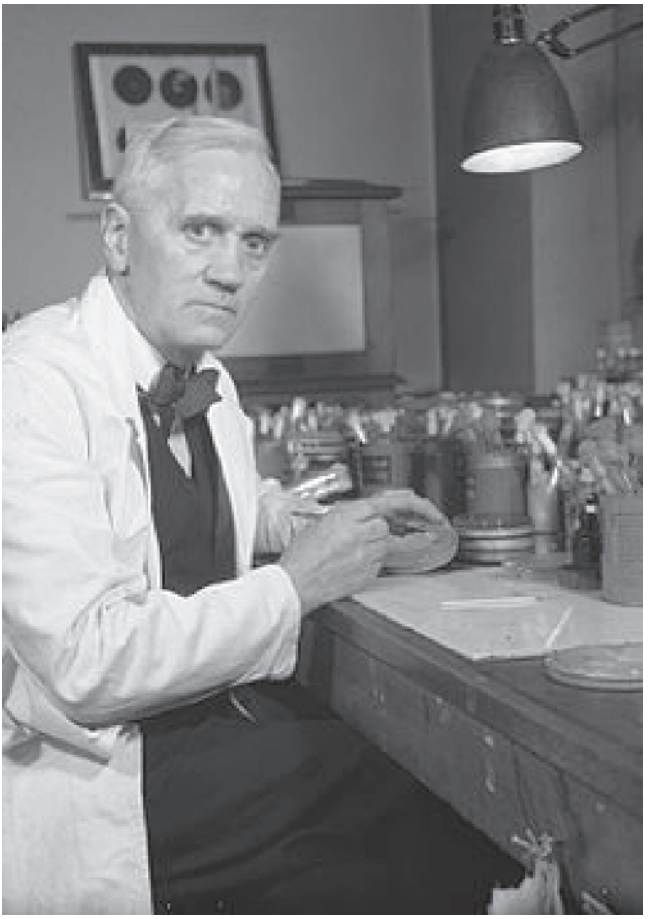

Figure 1.9 Sir Alexander Fleming was best known for his discovery of penicillin

Unfortunately, with extensive use of antibiotics has come the development of **antibiotic resistance**. Because bacterial cells of the same species may possess different plasmids, making some genetically different from others, individual cells may be resistant, or able to withstand longer exposure, to a particular antibiotic. If an entire course of antibiotic treatment is not completed, the resistant bacterial cells can survive and reproduce, causing a rebounding infection that is largely impervious to the original antibiotic. Widespread use of penicillin over many decades eventually generated such an abundance of penicillin-resistant bacteria that alternative versions of penicillin are now much more commonly prescribed. In effect, using antibiotics leads to the natural selection of antibiotic-resistant bacteria; thus, antibiotic treatment should be reserved for serious infections only (Fig. 1.10). Inevitably, a widely prescribed antibiotic will become less effective as more and more populations of resistant bacteria develop.

Bacteria considered potential biological weapons discussed in this book include *Bacillus anthracis* (anthrax), *Yersinia pestis* (plague), *Francisella tularensis* (tularemia), and *Vibrio cholerae* (cholera).

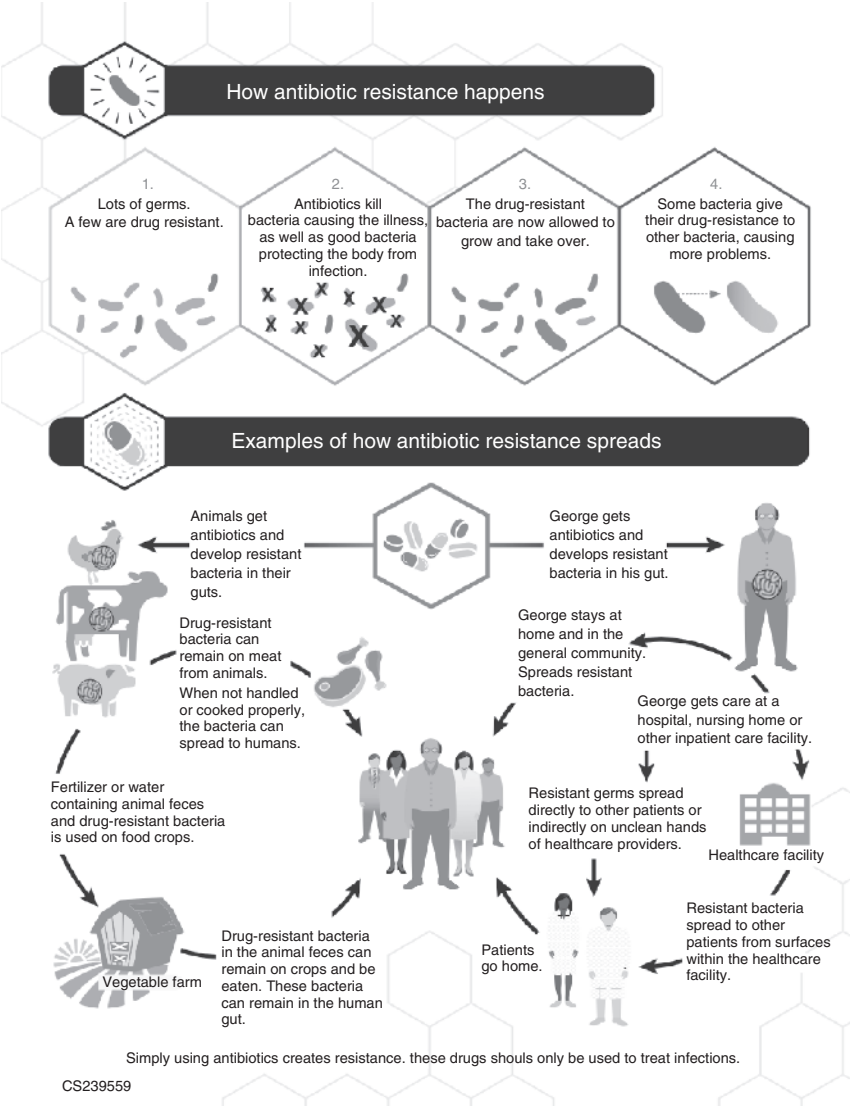

Figure 1.10 The CDC encourages cautious use of antibiotics to limit the development of antibiotic resistance

1.2 TOXINS

Toxins are substances produced in nature that are poisonous to humans. Some toxins cause only localized inflammation, but others are quite deadly; common toxins include those found in bee stings and snake venoms. While they are generated by living organisms, toxins themselves are inanimate and do not reproduce. A weaponized toxin can be used with surgical precision to assassinate specific individuals without fear of contagion. Unlike live bacteria, toxins can often withstand extreme conditions

without losing potency. Although standard cooking practices kill the bacteria that produce the toxin responsible for botulism, the toxin itself is unaltered, and cases of botulism can result from ingesting fully cooked food containing preformed toxin. Some toxins can be aerosolized under conditions that would easily destroy the bacteria that produced them. Because they are impervious to ultraviolet radiation, toxins aerosolized on a bright, sunny day are still highly effective.

The mechanisms of toxins are incredibly diverse. Some cause intense pain, while others cause partial to full paralysis. Some elicit the death of red blood cells, while others result in the **necrosis**, or death at the cellular level, of affected tissue. An animal that survives exposure to a particular toxin will develop molecules of **antitoxin** in its bloodstream that attach to and neutralize circulating molecules of the toxin, essentially "handcuffing" the molecules before they can damage host cells. Because of their size, horses can often be exposed to low doses of a toxin without experiencing any harmful effects, and their immune systems will naturally form effective antitoxin molecules. Scientists can then collect blood samples from the horses to isolate and stockpile the antitoxin (Fig. 1.11). Because they only block the effects of toxin molecules that have not yet bound to body cells, antitoxins typically need to be administered quickly after toxin exposure. Thus, antitoxins do not reverse the effects of a toxin but are often able to stop its progression. If diagnosis of toxin exposure is delayed in any way, antitoxin treatment may be rendered useless.

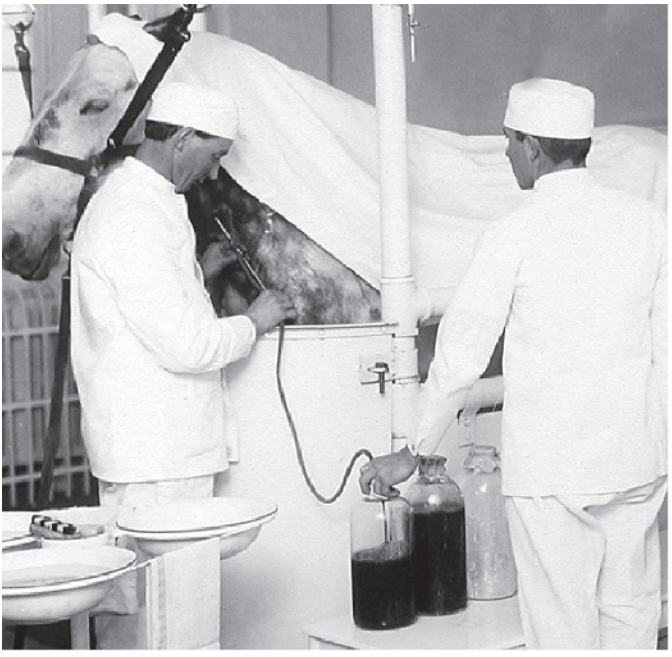

Figure 1.11 Antitoxin molecules can be isolated from the serum of horses exposed to low doses of the toxin

Reality Check:

How are antibiotics and antitoxins different?
How are they similar?

Toxins considered potential biological weapons that are discussed in this book include *Ricinus communis* toxin (ricin), *Clostridium botulinum* neurotoxin (botulism), and Staphylococcus enterotoxin B (SEB).

1.3 VIRUSES

Bacteria are living organisms, toxins are nonliving chemicals, and **viruses** fall somewhere in between. Every life form on the planet is susceptible to infection by some type of virus, and viruses, similar to bacteria, can be found in all ecosystems. Some viruses, called **bacteriophages** or simply **phages**, are even known to infect bacteria. Unlike bacteria, however, viruses are not composed of cells and are not typically considered living organisms. Biologists have long debated how to classify viruses because they do not fit into any standard biological classification system.

While virus structures vary widely, most are exponentially smaller than typical bacterial cells (Fig. 1.12); millions could easily fit on the period at the end of this sentence. A virus basically consists of genetic material encased in a protein shell. As is the case with living cells, the genetic material of many viruses is DNA, but **retroviruses** contain **ribonucleic acid** (RNA) instead, which becomes converted to DNA once inside a living cell.

In the same way that there are genetic variations within a population of bacteria, genetic variation also exists in viruses. This variation results from random mutations, and different variants of the same type of virus, called **strains**, can have vastly different effects on their hosts. Among strains of the Ebola virus, Ebola Zaire usually

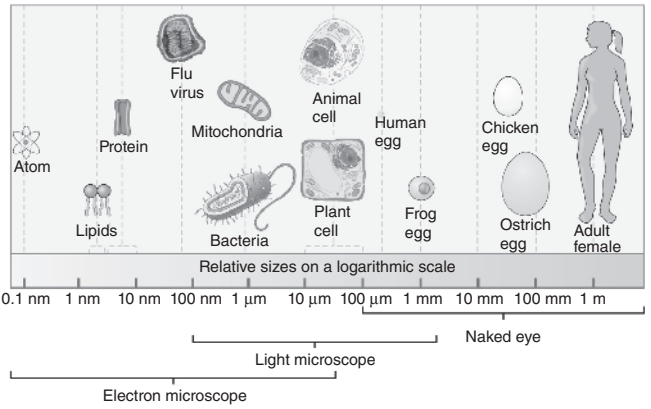

Figure 1.12 This figure shows the relative sizes of different kinds of cells and cellular components. An adult human is shown for comparison Source: http://cnx.org/contents/b3c1e1d2-839c-42b0-a314-e119a8aafbdd@8.49:11/Concepts_of_Biology, Creative Commons Attribution 4.0 License, http://cnx.org/tos

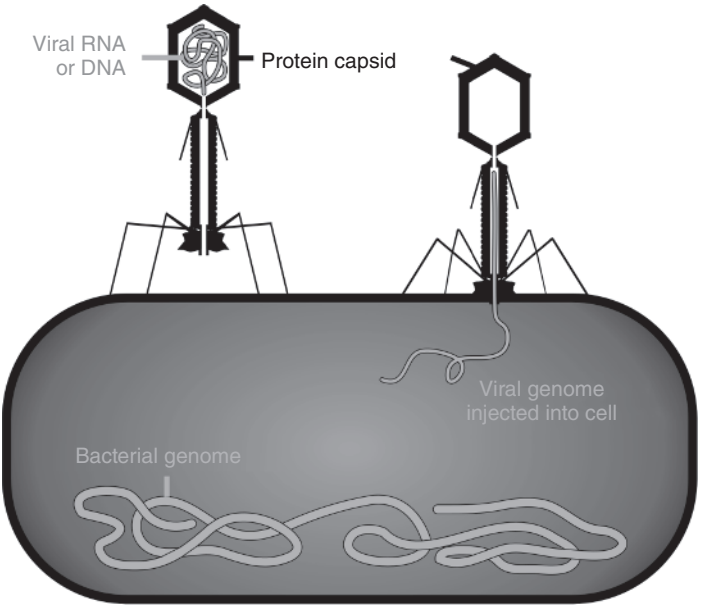

Figure 1.13 In this diagram, a virus attaches to a bacterial cell and injects its genetic material into the bacterium Source: Wikipedia, https://commons.wikimedia.org/wiki/File:Phage_injecting_its_genome_into_bacteria.svg. Used under CC-BY-SA-3.0, https://commons.wikimedia.org/wiki/Category:CC-BY-SA-3.0

kills one out of every two people infected, but Ebola Reston causes no symptoms whatsoever in humans (discussed further in Chapter 11). Viruses and their strains are often named based on the geographic area where they are first identified; Ebola was first seen near the Ebola River, and Ebola Reston was identified in Reston, Virginia.

Because a virus does not contain any of the internal organelles of living cells, it cannot reproduce on its own. Instead, a virus parasitically injects its genetic material into a living host cell (Fig. 1.13) and "hijacks" the cell's reproduction machinery to generate new virus particles, called **virions** (Fig. 1.14). The infected cell will usually cease all normal activity in the relentless "zombie-like" production of new virions. The virions collect in tight clusters inside the host cell and begin to ooze out through the cell membrane. Eventually, the host cell can become so packed with virions that it literally bursts, releasing multitudes of virus particles able to infect and kill more host cells. In this way, a few virus particles can invade a human body and, within days, multiply into a massive army that usurps the body's resources in an inexorable quest for reproduction.

The evolutionary origin of viruses is unclear. Because of their diminutive size, no virus fossils have been found, but some viruses probably existed alongside early life forms and may very well have acted as a population control mechanism for ancient species. Because a virus needs a host to replicate, it will thrive in a crowded population where it can easily pass to a new host if the original host dies. Ancient accounts indicate that viruses such as smallpox have long played a role in human history; the Egyptian pharaoh Ramses V is thought to have suffered from infection with the

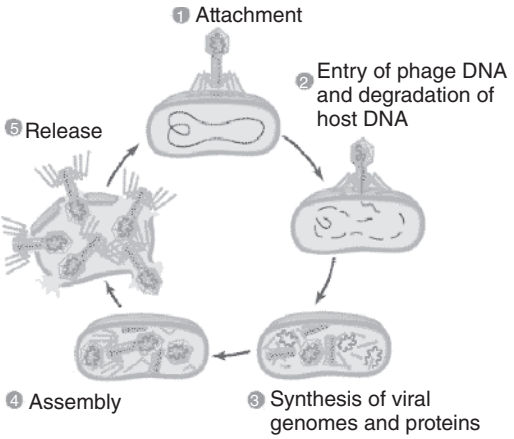

Figure 1.14 A virus injects its genetic material into a host cell, and the host cell builds new virions, eventually bursting with their release Source: http://smithlhhsb122.wikispaces.com/Kyle+R., Creative Commons Attribution Share-Alike 3.0 License, http://creativecommons.org/licenses/by-sa/3.0/

smallpox virus before his death in 1157 B.C. (Fig. 1.15), and Sanskrit texts from 1500 B.C. describe a disease with symptoms similar to those of smallpox. Millions of different viruses have been identified, and it is likely that an abundance of viruses exist in nature but have yet to be described.

While all life forms are subject to viral infection, each virus is only able to infect certain species. Viruses such as rabies can infect several species and are said to have a wide **host range**. Other viruses have a narrow host range; smallpox, for example, can only infect humans and poses no threat to any other living species. On occasion, a virus may develop random genetic mutations that enable it to infect a new host species. For example, some strains of the avian influenza virus have begun to infect humans in recent years. Because we have no historical exposure to and, thus, no natural immunity to this virus, the mortality rates for human infection are extremely high, and outbreaks must be monitored closely.

One of the most dangerous features of viruses is their **communicability**, the ability to pass from person to person. Some viruses spread only through contact with bodily fluids, threatening only those in immediate contact with infected individuals, but other viruses are capable of rapid, expansive spread through airborne transmission. These highly contagious airborne viruses can be spread by coughs, sneezes, or air circulation systems in confined spaces. Viruses vary in their ability to tolerate environmental conditions, but some remain viable for hours, possibly days, after being sneezed or sprayed into the air, especially in areas shaded from the ultraviolet radiation of sunlight. An individual infected with such a virus could sneeze in a taxicab just after sunset, coating much of the interior of the cab in virus particles, and infect everyone who enters the cab until sunrise. An airborne virus would make a highly effective weapon, but its spread would be unpredictable and essentially uncontrollable. Anyone releasing such a weapon would have to accept the chance of infecting more than just the target population.

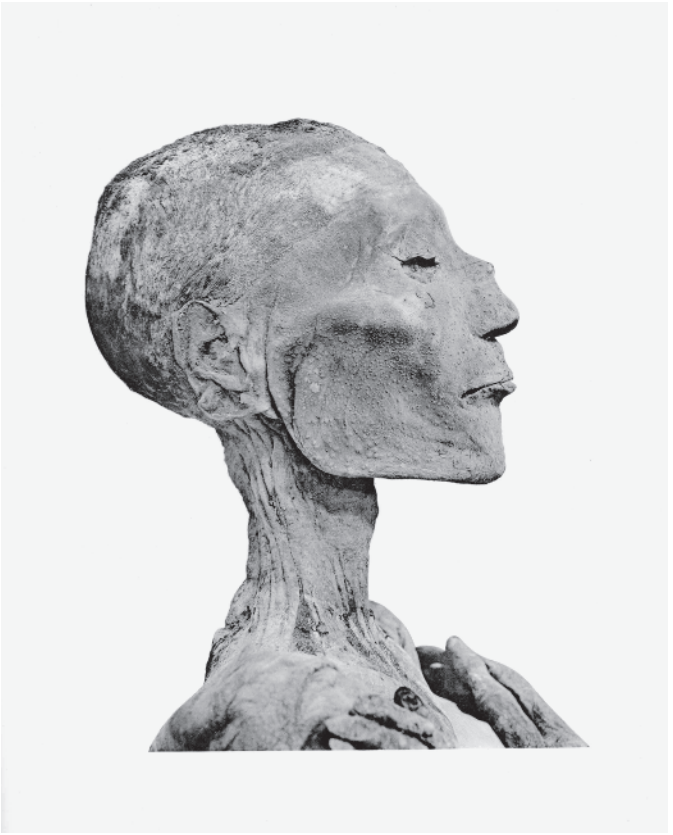

Figure 1.15 Pharaoh Ramses V of Egypt may have died from smallpox in 1145 B.C.

When a virus infects a human, the virus multiplies by means of the eukaryotic organelles of the human cells. Because antibiotics only affect prokaryotic cell activity, they are not effective against viruses. Treating a viral infection with antibiotics will have no effect on the virus; such erroneous treatment can, however, lead to the formation of antibiotic-resistant bacteria and must be curtailed. Scientists have discovered some **antivirals**, medications that inhibit some portion of the viral reproduction process without harming the infected host cell. Similar to antitoxins, antivirals do not reverse but rather halt the progression of an infection, so they must also be administered early in the course of viral infection to be effective. Because viruses frequently develop genetic mutations, they may also form resistance to antivirals.

Reality Check:

How are antivirals and antibiotics similar?
How are they different?

As the saying goes, "An ounce of prevention is worth a pound of cure." In the case of viruses, this sentiment is particularly appropriate. While there is no effective

treatment for many viruses, some infections can be prevented through **vaccination**. Vaccines work by injecting a person with either an **attenuated** (weakened) or a killed virus that generates mild or no symptoms but allows the immune system to develop an arsenal of weapons specifically designed to kill the virus. This arsenal may remain effective for months, years, or a lifetime. With some problematic viruses, vaccines with attenuated virus cause full-blown infections, and vaccines with killed virus may fail to elicit an adequate immune response. Rarely, as in the case of smallpox, another similar virus may be used as an effective vaccine (discussed in Chapter 13), but no effective vaccines have been found for many viruses. For such viruses, the only way to prevent infection is to avoid exposure to the virus.

Viruses considered potential biological weapons that are discussed in this book include Ebola, Variola major (smallpox), Hantavirus, viral encephalitis (EEEV, WEEV, VEEV), Nipah, Lassa, and Marburg (see Table 1.1).

1.4 GENETIC ENGINEERING

In all living organisms and DNA viruses, DNA molecules are built entirely from four basic building blocks called **nucleotides**. The same four nucleotides, adenine, guanine, cytosine, and thymine (Fig. 1.16), make up every molecule of DNA in every life form on the planet. Large molecules containing hundreds or thousands of nucleotides are called chromosomes. Along the chromosomes, small segments of DNA that control specific traits in the organism are called **genes** (Fig. 1.17). Since the recognition of DNA as the molecule of inherited traits in 1953, technology has advanced at an amazing rate. It is now possible to map the exact sequence of nucleotides (the **genetic sequence**) in every chromosome in a cell; in many cases, scientists can tell where genes start and stop and what trait each gene controls. Numerous published protocols enable scientists to "cut and paste" pieces of DNA from one organism to another, so it is now possible to create a "Frankenstein-type" biological weapon that produces symptoms of multiple agents simultaneously.

TABLE 1.1 The Biological Warfare Agents Described in This Book Include Bacteria, Toxins, and Viruses.

Bacteria	Toxins	Viruses
Bacillus anthracis (Anthrax)	*Ricinus communis* toxin (Ricin)	Ebola
Yersinia pestis (Plague)	*Clostridium botulinum* neurotoxin (Botulism)	Variola major (Smallpox)
Francisella tularensis (Tularemia)	Staphylococcal enterotoxin B	Hantavirus
Vibrio cholera (Cholera)		Viral encephalitis (EEEV, WEEV, VEEV)
		Nipah
		Lassa (Lassa fever)
		Marburg

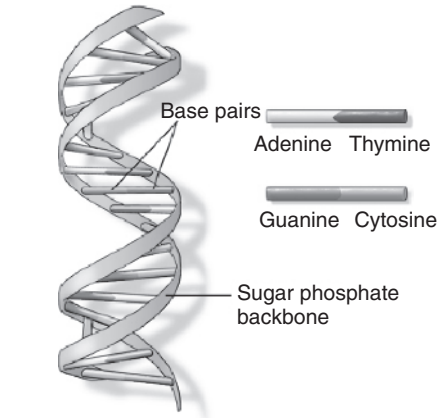

Figure 1.16 DNA is composed of four paired bases (adenine, thymine, guanine, and cytosine) linked by sugar and phosphate molecules into a double helix

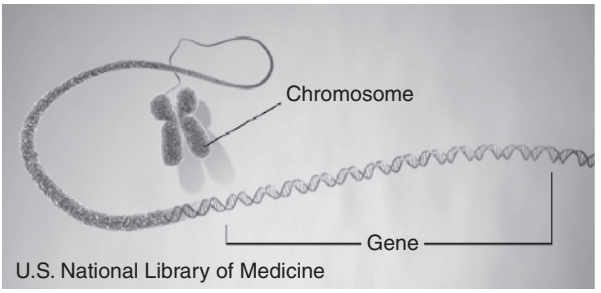

Figure 1.17 A gene is a section of DNA in a chromosome. A single chromosome can contain hundreds of genes

Reality Check:

What features from different viruses would a terrorist want to include in a genetically engineered bioweapon?

Some pathogenic bacteria are treatable with only a few known antibiotics. If another type of bacteria possesses genes that confer resistance to those antibiotics, the genes can often be "cut" from the resistant bacteria and "pasted" into the pathogenic bacteria, generating a genetically modified, antibiotic-resistant pathogen. While antibiotic resistance is not a factor for viruses, similar protocols can be used to combine genes from multiple viruses, in effect allowing a bioterrorist to design a new virus with hand-picked symptoms and communicability. Other assays can be employed to generate "designer" toxins by transferring genes between toxin-producing species, resulting in the production of a hybrid toxin with characteristics of both original toxins.

While the recipe for an atomic bomb includes some outrageously expensive and rare elements, the materials necessary for the genetic engineering of microbes are

much more affordable. Most undergraduate microbiology laboratory courses utilize the same equipment, and the protocols are as easy to follow as any cookbook. There is considerable evidence that genetic engineering has already been employed by government programs to combine some of the deadliest natural biological weapons into novel forms that could reduce the human population by more than 90%. Even more disturbing, a single individual with the proper background could conceivably create a genetically engineered weapon in his garage for a few thousand dollars. The next chapter of this book focuses on the systems already in place to prevent or respond to the development or deployment of biological weapons.

CHAPTER 1 SUMMARY

Vocabulary:

bacteria
symbiotic
pathogenic
prokaryotic
organelle
eukaryotic
deoxyribonucleic acid
plasmid
colonies
coccus
bacillus
spirillum
vibrio
coccobacilli
cell membrane
cell wall
peptidoglycan
Gram stain
Gram positive
Gram negative
reservoir host
vector
aerobes
anaerobes
fomite
aerosolized
endospore
antibiotic
antibiotic resistance
toxin
necrosis
antitoxin
virus
bacteriophage
phage
retrovirus
ribonucleic acid
virion
host range
communicability
antiviral
vaccination
attenuated
nucleotide
gene
genetic sequence

1.1 BACTERIA

- Some bacteria are symbiotic with humans; others are pathogenic.
- Bacterial DNA may be in the form of a circular chromosome or a plasmid.

- Common bacterial shapes include coccus, bacillus, spirillum, and vibrio.
- Gram-stained bacteria appear purple (G+) if they have a thick peptidoglycan layer and pink (G−) if they have a think peptidoglycan layer.
- Reservoir hosts are not killed by the infection they carry.
- Vectors and fomites can spread infection.
- Aerobic bacteria grow best in the presence of oxygen; anaerobic bacteria grow best in the absence of oxygen.
- Some bacteria form endospores that are virtually indestructible under natural conditions.
- Antibiotics only affect prokaryotes.
- Improper use of antibiotics can lead to the development of antibiotic-resistant bacteria.

1.2 TOXINS

- Toxins are nonliving poisons produced naturally by living organisms.
- Antitoxins only affect toxin molecules before the toxin binds to a cell.

1.3 VIRUSES

- Viruses are not composed of cells. They are basically genetic material coated in protein.
- Viruses hijack host cells to make new virus particles.
- Some viruses can infect several species; some can only infect one species.
- Viruses tend to be highly contagious and spread rapidly.
- Vaccination can prevent infection with some viruses. Some viral infections can be treated with antivirals.

1.4 GENETIC ENGINEERING

- All life forms on Earth have DNA made from the same four nucleotides.
- We know the genetic sequence for many organisms.
- Well-established protocols enable us to “cut” genes from one agent and “paste” them into another agent.

CHAPTER 1: REVIEW QUESTIONS

Fill in the blank.

1. If mice are commonly infected with a virus but are not killed by the virus, they are considered _____ hosts.

2. Some bacteria can form _____ that can exist in a dormant state for many years and are not damaged by boiling, freezing, or being soaked in bleach.
3. DNA is composed of building blocks called _____.
4. Rod-shaped bacteria are called _____.
5. The first antibiotic was discovered by a scientist named _____.

Choose the best answer.

1. The Gram stain procedure works based on the thickness of the (*peptidoglycan/plasma membrane*) in the cell wall.
2. Based on the name *Vibrio cholerae*, you would expect these bacteria to be (*spherical/rod-shaped/spiral/comma-shaped*).
3. A sticky menu in a restaurant contaminated with smallpox would be considered a (*vector/fomite/reservoir host*).
4. Antibiotics that target prokaryotic cell structures only affect (*bacteria/toxins/viruses*).
5. Genetic engineering involves transferring (*DNA/protein/lipids*) from one organism to another.
6. Bacteria are considered (*prokaryotic/eukaryotic*) organisms.
7. Vaccines that use a weakened version of the live virus are referred to as (*endosporic/attenuated*) vaccines.
8. The only biological agents that are definitely living organisms are the (*bacteria/toxins/viruses*).

Short answer.

1. You are diagnosed with a bacterial infection and given a prescription for antibiotics for 10 days. You start to feel much better after taking the antibiotics for 5 days. Should you save the rest of the antibiotics in case you have a relapse? Why or why not?
2. Your roommate has been sick for 5 days with a respiratory virus and is coughing and sneezing. Is it safe to borrow the jacket that he wore yesterday since it has been hanging in the closet overnight?
3. What might be the advantages and disadvantages of using an attenuated virus in a vaccine?