Protozoa vs bacteria vs virus size

Learning Objectives List the different types of microorganisms and describe their defining properties Give examples of different types of cellular and viral microorganisms and infectious agents Describe the similarities and differences between archaea and bacteria Give an overview of the field of microbiology Most microbes are single-celled and small enough that they require artificial magnification to be seen. However, there are some single-celled microbes that are visible to the naked eye, and some multicellular organisms that are microscopic. An object must measure about 100 microns (μm) to be seen without a microscope, but most microorganisms are many times smaller than that. For some perspectives, consider that a typical animal cell measures about 10 μm above but is still microscopic. Bacterial cells are typically about 1 μm, and viruses can be 10 times smaller than bacteria (Figure 1). See Table 1 for units of length used in microbiology. Figure 1. The relative sizes of different microscopic and nonmicroscopic objects. Note that a typical virus measures about 100 nm, 10 times less than a typical bacterium (~1 μm), which is at least 10 times smaller than a typical plant or animal cell (~10-100 μm). An object must measure about 100 μm to be visible without a microscope. Table 1. Units of Length Commonly Used in Microbiology Metric Unit Meaning of Prefix Metric Equivalent meter (m) — 1 m = 100 m decimeter (dm) 1/10 1 dm = 0.1 m = 10−1 m cm (cm) 1/100 1 cm = 0.01 m = 10−2 m millimeters (mm) 1/1000 1 mm = 0.001 m = 10−10−2 m millimeters (mm) 1/1000 1 mm = 0.001 m = 10−2 m millimeters (mm) 1/1000 1 mm = 0.001 m = 10−10 3 m micrometer (μm) 1/1,000,000 1 μm = 0.0000001 m = 10−6 m nanometer (nm) 1/1,000,000,000 1 nm = 0.000000001 m = 10−9 m Microorganisms differ from each other not in size, also but in structure, habitat, metabolism, and many other characteristics. While we usually think of microorganisms as single-celled, there are also many multicellular organisms that are too small to be seen without a microscope. Some microbes, such as viruses, are even acellular (not made up of cells). Microorganisms are found in each of the three areas of life: Archaea, Bacteria, and Eukarya. Microbes within the Domains Bacteria and Archaea are all prokaryotes (their cells lack a nucleus), while microbes in the Eukarya domain are eukaryotes (their cells have a nucleus). Some microorganisms, such as viruses, do not fall within any of life's three domains. In this section we will briefly introduce each of the broad groups of microbes. Later chapters will go into more depth about the different species within each group. Prokaryotic microorganisms Bacteria are found in almost every habitat on earth, including within and on humans. Most bacteria are harmless or helpful, but some are pathogens, causing disease in humans and other animals. Bacteria are prokaryotic because their genetic material (DNA) is not housed in a true nucleus. Most bacteria have cell walls that contain peptidoglykan. Bacteria are often described in of their general form. Common shapes include spherical (coccus), rod-shaped (bacillus), or curved (spirillum, spirochete, or vibrio). Figure 2 shows examples of these shapes. Figure 2. Common bacterial forms. Note how coccobacillus is a combination of spherical (coccus) and rod-shaped (bacillus). (credit Coccus: Amendment of Work by Janice Haney Carr, Centers for Disease Control and Prevention; credit Coccobacillus: Amendment of Work by Janice Carr, Centers for Disease Control and Prevention; credit Spirochete: Centers for Disease Control and Prevention) They have a wide range of metabolic capacity and can grow in a variety of environments, using different combinations of nutrients. Some bacteria are photosynthetic, such as oxygen oxide cyanobacteria and anoxygena green sulfur and green nonsulfur bacteria; these bacteria use energy derived from sunlight, and fix carbon dioxide for growth. Other types of bacteria are nonphotosynthetic, getting their energy from organic or inorganic compounds in their environment. Arkaea are also single-celled prokaryotic organisms. Archaea and bacteria have different evolutionary histories, as well as significant differences in genetics, metabolic pathways, and the composition of their cell walls and membranes. Unlike most bacteria, archaeal cell walls do not contain peptidoglycan, but their cell walls are often composed of a similar substance called pseudopeptidoglycan. Like bacteria, archaea is found in almost every habitat on Earth, even extreme environments that are very cold, very hot, very basic, or very acidic (Figure 3). Some archaea live in the human body, but none have been shown to be human pathogens. Figure 3. Some archaea live in extreme environments, such as the Morning Glory pool, a hot spring in Yellowstone National Park. The color differences in the pool are the result of the different communities of microbes that can thrive at different water temperatures. Think about it What are the two main types of prokaryotic organisms? Name some of the defining properties for each type. The Eukarya domain contains all eukaryotes, including uni- or multicellular eukaryotes such as protists, fungi, plants, and animals. The great defining characteristic of eukaryotes is that their cells contain a nucleus. Protists Protists are single-celled eukaryotes that are not plants, animals, or fungi. Algae and protozoa are examples of protists. Figure 4. Various diatoms, a type of algae, live in annual sea ice in McMurdo Sound, Antarctica. Diatomes range in size from 2 μm to 200 μm and are visualized here using light microscopy. (credit: change of work by the National Oceanic and Atmospheric Administration) Algae (singular: alga) are plant-like protists that can be either single-celled or multicellular (Figure 4). Their cells are surrounded by cell walls made of cellulose, a type of carbohydrate. Algae are photosynthetic organisms that extract energy from the sun and release oxygen and carbohydrates their environment. Since other organisms can use their waste products for energy, algae are important parts of many ecosystems. Many consumer products contain ingredients derived from algae, such as carrageenan or alginic acid, which are found in certain brands of ice cream, salad dressing, drinks, lipstick and toothpaste. A derivative of algae also plays a prominent role in the microbiology laboratory. Agar, a gel derived from algae, can be mixed with various nutrients and used to grow microorganisms in a petri dish. Algae are also being developed as a possible source of biofuels. Protozoans (singular: protozoa) are protists that form the backbone of many food webs by providing nutrients for other organisms. Protozoa is very diverse. Some protozoans move using hair-like structures called cilia or whip-like structures called flagella. Others expand part of their cell membrane and cytoplasm to push themselves forward. These cytoplasmic extensions are called pseudopods (fake feet). Some protozoa are photosynthetic; others feed on organic matter. Some are free-living, while others are parasitic, only able to survive by extracting nutrients from a host organism. Most protozoa are harmless, but some are pathogens that can cause disease in animals or humans (Figure 5). Figure 5. Giardia lamblia, an intestinal protozoic parasite that infects humans and other mammals, causing severe diarrhea. (credit: change of work by the Centers for Disease Control and Prevention) Fungi Mushrooms (singular: mushrooms) are also eukaryotes. Some multicellular fungi, such as mushrooms, are similar to plants, but they are actually completely different. Fungi are not photosynthetic, and their cell walls are usually made of chitin rather than cellulose. Figure 6. Candida albicans is a single-celled fungus, or yeast. It is the causative agent of vaginal yeast infections as well as oral thrush, a yeast infection in the mouth that usually affects infants. C. albicans have a morphology similar to that of coccus bacteria; However, yeast is a eukaryotic organism (note the nuclei) and is much larger. (credit: change of work by the Centers for Disease Control and Prevention) Single cellular fungi—yeast—are included in the study of microbiology. There are more than 1000 known species. Yeast is found in many different environments, from the deep sea to the human navel. Some yeasts have beneficial uses, such as causing bread to rise and drinks to ferment; but yeast can also cause food to spoil. Some even cause diseases, such as vaginal yeast infections and oral thrush (Figure 6). Other fungi of interest to microbiologists are multicellular organisms called molds. Molds consist of long filaments that form visible colonies (Figure 7). Molds are available in many different environments, from soil to rotting food to dank bathroom corners. Molds play a crucial role in the degradation of dead plants and animals. Some molds can cause allergies, and others metabolites called mycotoxins. Molds have been used to make drugs, including penicillin, which is one of the most commonly prescribed antibiotics, and cyclosporine, used to prevent organ rejection after a transplant. Figure 7. Large colonies of microscopic fungi can often be observed with the naked eye, as seen on the surface of these moldy oranges. Think of it Name two types of protists and two types of fungi. Name some of the defining properties for each type. Multicellular parasitic worms called helminths are not technically microorganisms, since most are large enough to see without a microscope. However, these worms fall into the field of microbiology because diseases caused by helminths involve microscopic eggs and larvae. An example of a helminth is the guinea worm, or Dracunculus medinensis, which causes dizziness, vomiting, diarrhea, and painful wounds on the legs and feet when the mask works its way out of the skin (Figure 8). Infection usually occurs after a person drinks water containing water fleas infected by guinea-worm larvae. In the mid-1980s, there were an estimated 3.5 million cases of guinea-worm disease, but the disease has largely been eradicated. In 2014, only 126 cases were reported, thanks to coordinated efforts by the World Health Organisation and other groups committed to improving the sanitation of drinking water. Figure 8. (a) The beef tapeworm, Taenia saginata, infects both cattle and humans; T. saginata eggs are microscopic (around 50 μm), but adult worms like the one shown here can reach 4-10 m, taking up residence in the digestive system. b An adult guinea mask, Dracunculus medinensis, is removed by a lesion in the patient's skin by wrapping it around a match. (credit a, b: change of work by the Centers for Disease Control and Prevention) Virus Viruses are acellular microorganisms, which means that they do not consist of cells. Essentially, a virus consists of proteins and genetic material—either DNA or RNA— but never both—which is inert outside of a host organism. However, by incorporating itself into a host cell, viruses can co-opt the host's cellular mechanisms to multiply and infect other hosts. Viruses can infect all types of cells, from human cells to the cells of other microorganisms. In humans, viruses are responsible for many diseases, from the common cold to fatal Ebola (Figure 9). However, many viruses do not cause disease. Figure 9. (a) Members of the Coronavirus family may cause respiratory infections such as the common cold, severe acute respiratory syndrome (SARS), and Middle East respiratory syndrome (MERS). Here they are seen under a transmission electron microscope (TEM). (b) Ebola virus, a member of the Filovirus family, which is visualized using a TEM. (credit a: amendment of work by the Centers for Disease Control and Prevention; credit b: change of work by Thomas W. Geisbert) Think of Helminth's microorganisms? Explain or why not. How is viruses different from other microorganisms? Figure 10. A virologist samples eggs from this nest to be tested for influenza A virus, which causes avian influenza in birds. (credit: U.S. Fish and Wildlife Service) Microbiology is a broad term that includes studies of all different types of microorganisms. But in practice, microbiologists tend to specialize in one of several subfields. For example, bacteriology is the study of bacteria; mycology is the study of fungi; protozoology is the study of protozoa; parasitology is the study of helminths and other parasites; and virology is the study of viruses (Figure 10). Immunology, the study of the immune system, is often included in the study of microbiology because host-pathogen interactions are central to our understanding of infectious disease processes. Microbiologists may also specialize in certain areas of microbiology, such as clinical microbiology, environmental microbiology, applied microbiology, or food microbiology. In this textbook, we are primarily concerned with clinical applications of microbiology, but since the different subfields of microbiology are very interrelated, we will often discuss applications that are not strictly clinical. In the 1940s, the U.S. government was looking for a solution to a medical problem: the presence of sexually transmitted diseases (STDs) among soldiers. Several now infamous government-funded studies used human subjects to research common sexually transmitted diseases and treatments. In one such study, U.S. researchers intentionally exposed more than 1,300 human subjects in Guatemala to syphilis, gonorrhea, and chancroid to determine the ability of penicillin and other antibiotics to fight these diseases. Among the subjects in the study were Guatemalan soldiers, prisoners, prostitutes and psychiatric patients; Researchers exposed subjects to STDs using various methods, from facilitating intercourse with infected prostitutes to inokuculating substances with bacteria known to cause disease. This latter method involved making a small wound on the substance's genitals or elsewhere on the body, and then putting bacteria directly into the wound. In 2011, a U.S. government commission tasked with investigating the experiment revealed that only some of the subjects treated with penicillin, and 83 subjects died of 1953, likely as a result of the study. Unfortunately, this is one of many horrific examples of microbiological experiments that have violated basic ethical standards. Even if this study had led to a life-saving medical breakthrough (it didn't), few would argue that its methods were ethically sound or morally defensible. But not every case is so clear-cut. Professionals working in clinical settings are often confronted with ethical dilemmas, such as working with patients who decline a vaccine or life-saving blood transfusion. These are only two on decisions about life and death death may be crossed with the religious and philosophical beliefs of both the patient and the healthcare professionals. No matter how noble the goal, microbiology studies and clinical practice must be guided by a certain set of ethical principles. Studies must be done with integrity. Patients and research subjects give informed consent (not only agree to be treated or studied, but show an understanding of the purpose of the study and possible risks). Patients' rights must be respected. The procedures must be approved by an institutional review board. When working with patients, proper record keeping, honest communication and confidentiality are paramount. Animals used for research must be treated humanely, and all protocols must be approved by an institutional committee on animal welfare and use. These are just some of the ethical principles explored in eye on ethics boxes throughout this book. This example concludes Coka's story that started in What Our Ancestors Knew and A Systematic Approach. Cora's CSF samples show no signs of inflammation or infection, which can be expected with a viral infection. However, there is a high concentration of a certain protein, 14-3-3 protein, in her CSF. An electroencephalogram (EEG) of her brain function is also abnormal. EEG is similar to a patient with a neurodegenerative disease such as Alzheimer's or Huntington's disease, but Cola's rapid cognitive decline is not consistent with any of these. Instead, her doctor concludes that Cora has Creutzfeldt-Jakob disease (CJD), a type of transmissible spongiform encephalopathy (TSE). CJD is an extremely rare disease, with only about 300 cases in the United States each year. It is not caused by a bacterium, fungus, or virus, but rather by prions—which do not fit neatly into any particular category of microbe. Like viruses, prions are not found on the tree of life because they are acellular. Prions are extremely small, about a tenth of the size of a typical virus. They contain no genetic material and are composed solely of one type of abnormal protein. CJD can have several causes. It can be acquired through exposure to brain or nervous system tissue of an infected person or animal. Consuming meat from an infected animal is one way such exposure can occur. There have also been rare cases of exposure to CJD through contact with contaminated surgical equipment and from cornea and growth-hormone donors who unknowingly had CJD. In rare cases, the disease results from a specific genetic mutation that can sometimes be hereditary. However, in approximately 85% of patients with CJD, the cause of the disease is spontaneous (or sporadic) and has no identifiable cause. Based on her symptoms and their rapid progression, Cora is diagnosed with sporadic CJD. Unfortunately for Cora, CJD is a fatal disease for which there is no approved treatment. Approximately 90% of patients die within 1 year of diagnosis. Her doctor focuses on her pain and cognitive cognitive as her disease progresses. Eight months later, Cora dies. Her CJD diagnosis is confirmed with a brain autopsy. Key Concepts and Summary Microorganisms are very different and are found in all three areas of life: Archaea, Bacteria, and Eukarya. Archaea and bacteria are classified as prokaryotes because they lack a cellular nucleus. Archaea differs from bacteria in evolutionary history, genetics, metabolic pathways, and cell wall and membrane composition. Arkaea inhabits almost every environment on Earth, but no archaea has been identified as human pathogens. Eukaryotes studied in microbiology include algae, protozoa, fungi, and helminths. Algae are plant-like organisms that can be either single-celled or multicellular, deriving energy via photosynthesis. Protozoans are single-celled organisms with complex cell structures; most are motile. Microscopic fungi include molds and yeast. Helminths are multicellular parasitic worms. They are part of the area of microbiology because their eggs and larvae are often microscopic. Viruses are acellular microorganisms that require a host to reproduce. The area of microbiology is extremely wide. Microbiologists usually specialize in one of many subfields, but all health professionals need a solid foundation in clinical microbiology. Which of the following types of microorganisms are photosynthetic? yeast virus helminth algae [reveal-response q=631912]View Response[/reveal-response] [hidden-response a=631912]Reply d. Algae are photosynthetic. [/hidden response] Which of the following is a prokaryotic microorganism? helminth protozoan cyanobacterium mold [reveal-response q=59562]View Response[/reveal-response] [hidden-response a=59562]Reply c. The cyanobacterium is a prokaryotic microorganism. [/hidden response] Which of the following is acellular? virus bacterial fungus protozoan [reveal-answer q=89748]View Response[/reveal-answer] [hidden-answer a=89748]Reply a. Viruses are acellular. [/hidden response] Which of the following is a type of fungal microorganism? bacterial protozoan alga yeast [reveal-response q=69693]Show Response [/reveal-response] [hidden-answer a=69693]Reply d. Yeast is a type of fungal microorganism. [/hidden response] Which of the following is not a subfield of microbiology? bacteriology botany clinical microbiology virology [reveal-response q =680920]View Response[/reveal-response] [hidden-response a= 680920]Answer b. Botany is not a subfield of microbiology. [/hidden response] A _____ is a pathogenic micro-organism. [reveal-response q=207161] Show Answer[/reveal-answer] [hidden-answer a=207161]A pathogen is a disease-causing microorganism. [/hidden response] Multicellular parasitic worms studied by microbiologists are called _____ [reveal-response q=262594] View Answers[/reveal-answer] [hidden-answer a=262594]Multicellular parasitic worms studied by microbiologists called helminths. [/hidden response] The study of viruses is _____. [reveal-response q=170063] View Answers[/Reveal Response] a=170063]The study of viruses is virology. [/hidden response] The cells of prokaryotic organisms lack a _____. [reveal-response q=729248] Show Answers[/reveal-answer] [hidden-answer a=729248]The cells in prokaryotic organisms do not have a kernel. [/hidden response] Describe the differences between bacteria and archaea. Name three structures that different protozoa use for movement. Describe the actual and relative sizes of a virus, a bacterium and a plant or animal cell. Contrast the behavior of a virus outside versus inside a cell. Where would a virus, bacterium, animal cell and a prion belong on this diagram? Chart?

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