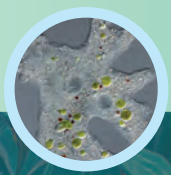

EXPLORE
MICROBIOLOGY
AMERICAN
SOCIETY FOR
MICROBIOLOGY

What *Is* a Microbe?

Domains of Life

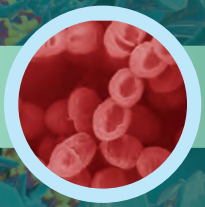
Eukaryotes *(0.8µm — huge!)*

Black bread mold
Fungi



Amoeba
Protozoans (all unicellular)

Bacteria *(0.3 - 300 µm)*

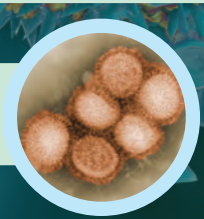


Lactic acid bacteria

Archaea *(0.3 — 15 µm)*

Methanogen

Viruses *(0.017 — 1.2 µm)*



Influenza Virus

100 µm

Microscope *Human eye*

Dust mite
Animals (all multicellular)

Phytoplankton
Chromists

Green algae
Plants

microbe

/ˋmī-krōb/ noun

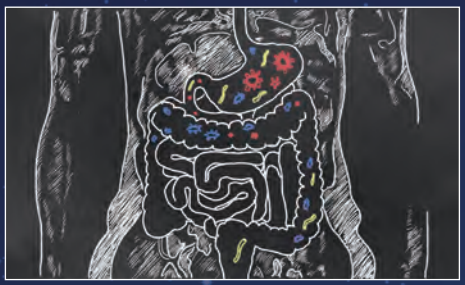
An organism or infectious particle of microscopic size, too small to be seen by the human eye

Syn: microorganism, germ

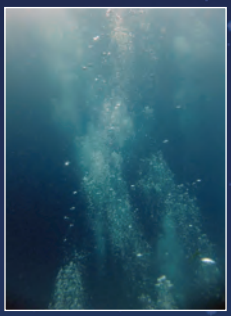
What Are the Differe

Archaea

Archaea are single-celled microbes with free-floating DNA (no nucleus or other cellular compartments, which makes them **prokaryotes**). Archaea are best known for some species' abilities to survive in extreme environments, but other species are found in ordinary places like soil. To date, there are no documented cases of archaea causing human disease.



Methanobrevibacter smithii lives in the human gut as a member of the **human gut microbiome**. It eats the gases produced by bacteria and makes methane. This microbe makes your farts flammable!



Methanopyrus kandleri, an archaea isolated from a deep-sea hydrothermal vent, can grow at 122°C (251.6°F), the highest temperature ever recorded for a living organism.

Bacteria

Bacteria are the type of microbe that most people think of when they think of microbiology. They are single-celled microbes with free-floating DNA (no nucleus or other cellular compartments, which makes them **prokaryotes**). Bacteria are most famous for causing human diseases, but most species are harmless. Bacteria actually do a lot of good, like producing Earth's atmospheric oxygen (*Cyanobacteria*), helping crops grow (*Rhizobium leguminosarum*) and making vitamin K for us (*Escherichia coli*).

nt Kinds of Microbes?

Fungi

Fungi can be single-celled or multicellular, and only some fungi are small enough to be considered microbes. For example, yeast are microbes, but mushrooms are not. Like plants and animals, fungi are **eukaryotes** with specialized cellular compartments, including a nucleus that contains their DNA.

Saccharomyces cerevisiae is used to make bread. The yeast eat sugars in the flour and produces carbon dioxide, which gets stuck in the dough and makes the bread rise, and alcohol, which is baked off.

Penicillium chrysogenum is the mold that led to the accidental discovery of the antibiotic penicillin by Alexander Fleming. Fleming noticed a fungus growing on plates of bacteria that seemed to kill the bacterial cells.

Lactobacillus bulgaricus is used to make yogurt. It eats sugars in milk and makes lactic acid, which gives yogurt its tangy flavor. The lactic acid also causes milk proteins to clump together to make yogurt thick and creamy.

Vibrio harveyi lives in the ocean and may be responsible for the 'milky seas effect' documented by sailors. It glows blue when a lot of individuals are close together, demonstrating a type of communication between bacteria known as **quorum sensing**.

Plants & Animals

Plants can be single-celled or multicellular, and only some plants are small enough to be considered microbes. For example, many species of green algae are microbes, but trees are not.

Animals are all multicellular and only a few of them are small enough to be microbes. Microscopic animals include mites, rotifers and water fleas.

Microscopic plants and animals are **eukaryotes** with cellular compartments, including a nucleus that contains their DNA.

Chlamydomonas reinhardtii is a single-celled green alga that lives in fresh water and swims with two tail-like flagella. It is used in scientific research as a **model organism** to study cell movement and photosynthesis.

Demodex folliculorum is a species of 'face mite' that lives in human hair follicles. These mites are part of our normal skin microbiome that we acquire from family members as children.

Protozoa

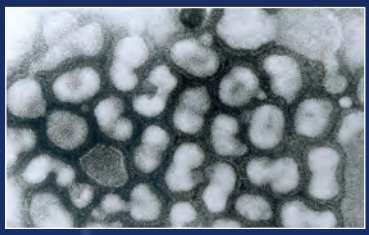
Protozoa are single-celled microorganisms that are **eukaryotes**, with specialized cellular compartments, including a nucleus that contains their DNA. They were previously lumped together with single-celled algae as 'protists.' Some protozoa are parasites, meaning that they live and cause disease within other organisms, while others live on their own.

Viruses

Viruses are very simple, with their genetic material (either DNA or RNA) protected by a protein shell called a **capsid**. Sometimes the capsid is covered with a membrane **envelope** taken from the host cell. Viruses must use the proteins of cells they infect to reproduce, so many scientists do not consider them to be alive. Most are too small to be seen with a light microscope and require an electron microscope instead.

There are viruses that infect every kind of organism, from humans to plants to other microbes, like bacteria and yeast. While we are most familiar with viruses that cause human diseases, some viruses are harmless to their hosts and may even provide benefits.

Tulip breaking virus (TBV) causes a tulip's petals to be streaked rather than one uniform color, a trait that was highly valued during the Dutch Golden Age in the 1600s. Some infected bulbs sold for 10 times the annual salary of a skilled craftsman.



Influenza A virus infects birds, humans and other mammals like pigs. It is one of two types of influenza that cause the flu in humans. An influenza A strain was responsible for the 1918 flu pandemic that killed 3% of the world's population.

Paramecium bursaria is a free-living protozoan covered in hair-like cilia that help it move through its freshwater habitat. It has a unique relationship with a species green algae in which it allows the algae to live inside of it in exchange for energy.

Plasmodium falciparum is a parasitic protozoan that causes malaria in humans. It is the deadliest of the human malaria parasite species and has a complex lifecycle, part of which happens in the gut and salivary glands of mosquitos.

What Do Microbiologists DO?

microbiologist

\ ˌmī-krō-bī-ˈä-lə-jist \ noun

A scientist who studies living organisms and infectious particles, such as bacteria and viruses, that can only be seen with a microscope

Microbiologists work in many sectors, including food production, environmental science, medicine and basic research. They can have many different job titles, from Biosafety Officer to Professor. There are opportunities to work as a microbiologist with as little training as an Associate's Degree (A.S.) or as much training as a doctor of philosophy (Ph.D.). Wages depend on education, job sector and experience, and range from $40,000/year to well over $100,000/year.

Research

Microbiology researchers try to answer scientific questions that no one else has answered before by doing experiments – they are explorers, making discoveries, developing new knowledge and applying it to real-world problems. Some of the questions a microbiology researcher might ask include:

- Which microbes help keep the human body healthy?
- Can this microbe be used to clean up pollution?
- What microbe made these animals sick?
- How can we keep spoilage bacteria out of this food product?

In microbiology, "research" includes:

- writing proposals to get grant funding or approval for experiments
- designing and conducting experiments
- analyzing data
- publishing results in scientific journals and presenting at scientific conferences

Microbiology researchers work in many different places, from colleges and universities, to government agencies like the Centers for Disease Control and Prevention (CDC), to private companies and non-profit organizations. At higher levels, microbiology researchers have the added responsibilities of managing a lab or research group and mentoring graduate students, postdoctoral fellows and others working in their labs.

Job titles include **laboratory technician, research associate, research scientist, professor** (colleges and universities), lead scientist (private company) and principal investigator (government lab, non-profit organizations).

Teaching

Teaching at a college or university involves:

- designing classes
- giving lectures and leading laboratory activities
- writing and grading exams
- mentoring students

Educators at colleges and universities are typically professors, **lecturers** or **laboratory instructors**. Professors do a mix of research (see previous section) and teaching, while lecturers and laboratory instructors only teach. Professors and lecturers teach the classroom portions of large undergraduate courses, such as Biology 101, and small, graduate level electives, such as Environmental Microbiology. Laboratory instructors teach the laboratory sections of a variety of courses, guiding students through experiments and keeping the teaching laboratory in good working order.

At schools that offer professional degrees in nursing, dentistry, pharmacy or medicine, microbiology educators may also guest teach certain parts of courses for professional students.

Biosafety

Biosafety professionals make sure that the work in clinical and research laboratories is done safely using the appropriate equipment and procedures and that all federal, state and local regulations and guidelines are being followed. Their job is to prevent employees from being injured or infected and to prevent microbes and other biological agents from getting outside of the lab. They do this by training researchers and clinical laboratory professionals, putting safety policies and procedures in place and consulting on laboratory design. Biosafety professionals work in many different job sectors, including colleges and universities, private companies, hospitals and government agencies.

Clinical Microbiology & Diagnostics

Clinical laboratory professionals work in hospitals, public health laboratories, private medical or veterinary diagnostic laboratories and private companies. In hospitals and laboratories, they run tests on patient or animal samples sent in by doctors or vets. These tests help identify the microbe making a patient/animal sick and can help the doctor/vet with treatment decisions by determining if the microbe is sensitive or resistant to antimicrobial medicines.

In public health laboratories, clinical laboratory professionals also track and determine the source of disease outbreaks.

At private companies, clinical laboratory professionals perform research (see first career section) to develop new diagnostic tests and procedures.

At higher career levels, these professionals may manage an entire clinical laboratory and its staff.

Hybrid Career Paths

Business analysts help companies and investment firms evaluate a particular scientific or medical market to guide their strategies and decisions. For example, a business analyst with a background in microbiology may help an investment firm decide whether or not to financially support a biotechnology startup. Some business analysts work directly for a particular company, while others work at consulting firms or as freelance consultants. They frequently have Masters of Business Administration (M.B.A.) degrees.

Infectious disease physicians or veterinarians train first as doctors (M.D. or D.O.) or vets (D.V.M.) and then specialize in patient care for people/animals suffering from infectious diseases like HIV/AIDS, tuberculosis or Q-fever. Some infectious disease specialists not only see patients, but also do microbiology research.

Patent lawyers work at law firms or private companies. They protect intellectual property by writing and filing patents on new scientific devices, processes or products. They also pursue or defend lawsuits related to patent infringement. Patent lawyers have a law degree (J.D.) as well as scientific expertise.

Some microbiologists combine their scientific expertise with skills and interests in other fields. These careers typically require a bachelor's degree in microbiology, plus a degree or additional training in a second field.

Public policy and regulatory affairs professionals work at government agencies, non-profit organizations and private companies. In government, these professionals develop policies, legislation and regulations related to biomedical products, healthcare and laboratory research. At non-profits and private companies, these professionals help their organizations understand and advocate for specific policies and regulations.

Science education or outreach professionals work at colleges and universities, non-profit organizations, museums and government agencies. Some also work for the corporate responsibility arms of private companies. These professionals design and organize programs and events that engage public or K-12 audiences with science.

Science writers work for newspapers, magazines and other media companies, as well as for government institutions. They also frequently work as freelancers. They research stories and write articles on technical subjects and must keep up on current events and new research being published.

How Do I Prepare for a Career in Microbiology?

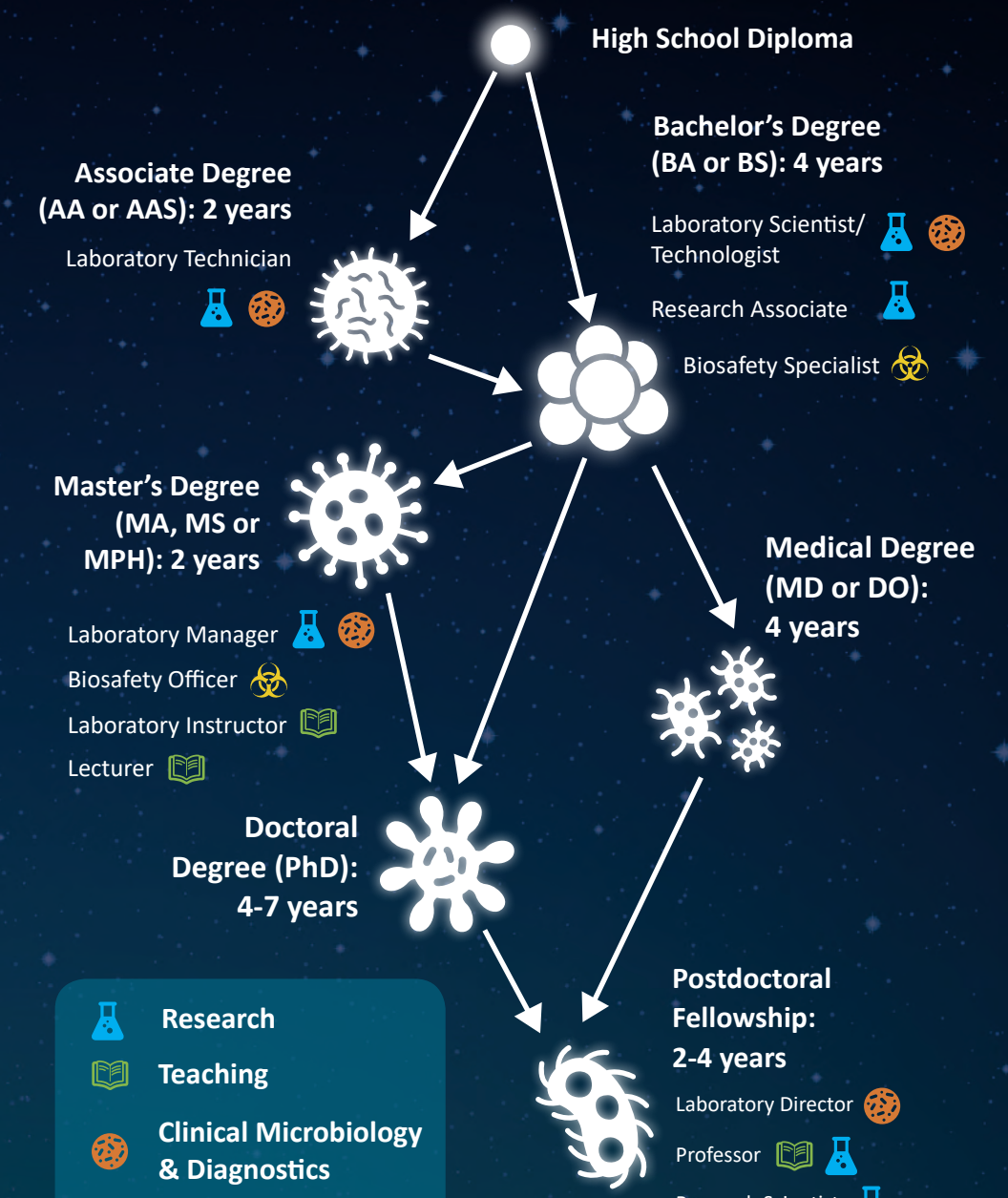
In high school, take:

- 4 years of math
- Biology
- Chemistry
- Physics
- Science or math electives, such as AP Biology or Microbiology
- Also participate in your school's science fair, join extracurricular science clubs and find summer research opportunities

In college, take:

- Calculus
- Biology
- General Microbiology
- Chemistry
- Organic Chemistry
- Biochemistry
- Physics
- Statistics
- Science or math electives, such as Computer Science or Immunology
- Also join local and national scientific societies and seek internships and student research experiences

What Degree Do I Need?



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