



STUDY OF BACTERIA

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ABSTRACT

Bacteria are microscopic, single-celled organisms and are among the earliest known life forms on Earth. They exist in every conceivable environment, with many strains being harmless or even beneficial, such as those that aid human digestion. However, a small fraction (less than 1%) of bacteria can cause illnesses ranging from salmonella and pneumonia to life-threatening diseases like sepsis and meningitis. Structurally, bacteria are prokaryotic organisms that contain their genetic information in a double-stranded circular DNA molecule. They display a wide range of shapes and sizes, from spherical cocci to rod-shaped bacilli and spiral spirochaetes, typically measuring 0.5–5.0 micrometres in length. Bacteria primarily reproduce asexually through binary fission. They often attach to surfaces to form dense aggregations called biofilms, which are clinically significant as the bacteria within them are much harder to kill than isolated cells.

INTRODUCTION

Bacteria are microscopic, single-celled organisms. They are among the earliest known life forms on earth. There are thousands of different kinds of bacteria, and they live in every conceivable environment all over the world^[1]. Some are airborne and others are most prevalent in water, soil, plants, animals, and even people.

Many strains of bacteria are harmless and some are even beneficial, such as those found in the human gastrointestinal tract to aid digestion and produce vitamins. There are few (less than 1% of all bacteria types) that cause illness in humans. Some bacteria can be quite dangerous, resulting in salmonella, pneumonia, or meningitis^[2].

- The global problem of infectious and deadly diseases caused by bacteria are presently major scientific and medical issues.
- Bacterial infections have a large impact on public health.
- As a general rule, bacterial infections are easier to treat than viral infections, since we have an extensive army of antimicrobial agents with activity against bacteria.
- Bacterial resistance to antimicrobials is a rapidly growing problem with potentially devastating consequences.
- The most deadly bacterial disease contracted by human beings is mycobacterium tuberculosis, the world's leading infectious disease with more than 1,700,000 deaths per year. As much as 13% of cases are resistant to most antibiotics, and about 6% are resistant or unresponsive to essentially all treatment^[2].

STRUCTURE

Bacteria are prokaryotic organisms that carry their genetic information in a double-stranded circular molecule of DNA. Some species also contain small circular plasmids of additional DNA. The cell cytoplasm contains ribosomes and there is both a cell membrane and, in all species except Mycoplasma,

a complex cell wall. External to the cell wall, some bacteria have capsules, flagella, or pili. Bacteria normally reproduce by binary fission. Under the proper conditions, some bacteria can divide and multiply rapidly. Consequently, some infections require only a small number of organisms to cause potentially overwhelming infection.

KNOWLEDGE OF BACTERIA

Although an estimated 43,000 species of bacteria have been named, most of them have never been studied. In fact, just 10 bacterial species account for half of all publications, whereas nearly 75% of all named bacteria don't have a single paper devoted to them.^[6] The best-studied species, *Escherichia coli*, has more than 300,000 studies published on it,^[10] but many of these papers likely use it only as a cloning vehicle to study other species, without providing any insight into its own biology. 90% of scientific studies on bacteria focus on less than 1% of species, mostly pathogenic bacteria relevant to human health.^{[6][7]} While *E. coli* is probably the best-studied bacterium, a quarter of its 4000 genes are poorly studied or remain uncharacterized. Some bacteria with minimal genomes (< 600 genes, e.g. *Mycoplasma*) usually have a large fraction of their genes functionally characterized, given that most of them are essential and conserved in many other species

MORPHOLOGY

Size.

Bacteria display a wide diversity of shapes and sizes. Bacterial cells are about one-tenth the size of eukaryotic cells and are typically 0.5–5.0 micrometres in length.

However, a few species are visible to the unaided eye—for example, *Thiomargarita namibiensis* is up to half a millimetre long, *Epulopiscium fishelsoni* reaches 0.7 mm, and *Thiomargarita magnifica* can reach even 2 cm in length, which is 50 times larger than other known bacteria. Among the smallest bacteria are members of the genus *Mycoplasma*, which

measure only 0.3 micrometres, as small as the largest viruses. Some bacteria may be even smaller, but these ultramicrobacteria are not well studied.

Shape.

Most bacterial species are either spherical, called cocci (singular coccus, from Greek *kókkos*, grain, seed), or rod-shaped, called bacilli (sing. bacillus, from Latin *baculus*, stick). Some bacteria, called vibrio, are shaped like slightly curved rods or comma-shaped; others can be spiral-shaped, called spirilla, or tightly coiled, called spirochaetes. A small number of other unusual shapes have been described, such as star-shaped bacteria. This wide variety of shapes is determined by the bacterial cell wall and cytoskeleton and is important because it can influence the ability of bacteria to acquire nutrients, attach to surfaces, swim through liquids and escape predators.

Multicellularity

Most bacterial species exist as single cells; others associate in characteristic patterns: *Neisseria* forms diploids (pairs), streptococci form chains, and staphylococci group together in “bunch of grapes” clusters. Bacteria can also group to form larger multicellular structures, such as the elongated filaments of *Actinomycetota* species, the aggregates of *Myxobacteria* species, and the complex hyphae of *Streptomyces* species. These multicellular structures are often only seen in certain conditions. For example, when starved of amino acids, myxobacteria detect surrounding cells in a process known as quorum sensing, migrate towards each other, and aggregate to form fruiting bodies up to 500 micrometres long and containing approximately 100,000 bacterial cells. In these fruiting bodies, the bacteria perform separate tasks; for example, about one in ten cells migrate to the top of a fruiting body and differentiate into a specialised dormant state called a myxospore, which is more resistant to drying and other adverse environmental conditions.

Biofilms.

Bacteria often attach to surfaces and form dense aggregations called biofilms and larger formations known as microbial mats. These biofilms and mats can range from a few micrometres in thickness to up to half a metre in depth, and may contain multiple species of bacteria, protists and archaea. Bacteria living in biofilms display a complex arrangement of cells and extracellular components, forming secondary structures, such as microcolonies, through which there are networks of channels to enable better diffusion of nutrients. In natural environments, such as soil or the surfaces of plants, the majority of bacteria are bound to surfaces in biofilms. Biofilms are also important in medicine, as these structures are often present during chronic bacterial infections or in infections of implanted medical devices, and bacteria protected within biofilms are much harder to kill than individual isolated bacteria.

METABOLISM

Bacteria exhibit an extremely wide variety of metabolic types. The distribution of metabolic traits within a group of bacteria has traditionally been used to define their taxonomy, but these traits often do not correspond with modern genetic

classifications. Bacterial metabolism is classified into nutritional groups on the basis of three major criteria: the source of energy, the electron donors used, and the source of carbon used for growth. Phototrophic bacteria derive energy from light using photosynthesis, while chemotrophic bacteria breaking down chemical compounds through oxidation, driving metabolism by transferring electrons from a given electron donor to a terminal electron acceptor in a redox reaction. Chemotrophs are further divided by the types of compounds they use to transfer electrons. Bacteria that derive electrons from inorganic compounds such as hydrogen, carbon monoxide, or ammonia are called lithotrophs, while those that use organic compounds are called organotrophs. Still, more specifically, aerobic organisms use oxygen as the terminal electron acceptor, while anaerobic organisms use other compounds such as nitrate, sulfate, or carbon dioxide. Many bacteria, called heterotrophs, derive their carbon from other organic carbon. Others, such as cyanobacteria and some purple bacteria, are autotrophic, meaning they obtain cellular carbon by fixing carbon dioxide. In unusual circumstances, the gas methane can be used by methanotrophic bacteria as both a source of electrons and a substrate for carbon anabolism. In many ways, bacterial metabolism provides traits that are useful for ecological stability and for human society. For example, diazotrophs have the ability to fix nitrogen gas using the enzyme nitrogenase. This trait, which can be found in bacteria of most metabolic types listed above, leads to the ecologically important processes of denitrification, sulfate reduction, and acetogenesis, respectively. Bacterial metabolic processes are important drivers in biological responses to pollution; for example, sulfatereducing bacteria are largely responsible for the production of the highly toxic forms of mercury (methyl- and dimethylmercury) in the environment. Nonrespiratory anaerobes use fermentation to generate energy and reducing power, secreting metabolic byproducts (such as ethanol in brewing) as waste. Facultative anaerobes can switch between fermentation and different terminal electron acceptors depending on the environmental conditions in which they find themselves.

REPRODUCTION AND GROWTH

Many bacteria reproduce through binary fission, which is compared to mitosis and meiosis in this image. Unlike in multicellular organisms, increases in cell size (cell growth) and reproduction by cell division are tightly linked in unicellular organisms. Bacteria grow to a fixed size and then reproduce through binary fission, a form of asexual reproduction. Under optimal conditions, bacteria can grow and divide extremely rapidly, and some bacterial populations can double as quickly as every 17 minutes. In cell division, two identical clone daughter cells are produced. Some bacteria, while still reproducing asexually, form more complex reproductive structures that help disperse the newly formed daughter cells. Examples include fruiting body formation by myxobacteria and aerial hyphae formation by *Streptomyces* species, or budding. Budding involves a cell forming a protrusion that breaks away and produces a daughter cell. In the laboratory, bacteria are usually grown using solid or liquid media. Solid growth media, such as agar plates, are used to isolate pure cultures of a bacterial strain. However, liquid growth media are used when the measurement of growth or large volumes of cells are required. Growth in

stirred liquid media occurs as an even cell suspension, making the cultures easy to divide and transfer, although isolating single bacteria from liquid media is difficult. The use of selective media (media with specific nutrients added or deficient, or with antibiotics added) can help identify specific organisms.

MOVEMENT

Transmission electron micrograph of *Desulfovibrio vulgaris* showing a single flagellum at one end of the cell. Scale bar is 0.5 micrometres long. Many bacteria are motile (able to move themselves) and do so using a variety of mechanisms. The best studied of these are flagella, long filaments that are turned by a motor at the base to generate propeller-like movement. The bacterial flagellum is made of about 20 proteins, with approximately another 30 proteins required for its regulation and assembly. The flagellum is a rotating structure driven by a reversible motor at the base that uses the electrochemical gradient across the membrane for power.

BACTERIAL INFECTION

A bacterium is a single, but complex, cell. It can survive on its own, inside or outside the body. Most bacteria aren't harmful. In fact, we have many bacteria inside our body and on our skin. Bacteria in our intestines (gut) help us to digest our food.⁽¹²⁾ But some bacteria can cause infections. Bacterial infections can affect many parts of your body, including your Throat, lungs, skin, bowel. Many infections are mild, but some are severe.

SYMPTOMS OF BACTERIAL INFECTION

The symptoms of a bacterial infection depend on the location of your infection and the type of bacteria involved. There are some general signs of bacterial infection

- Fever
- Feeling tired
- Swollen lymph nodes in your neck, armpits, groin or elsewhere
- Headache
- Nausea or vomiting

WHAT CAUSE BACTERIAL INFECTION

Bacterial infections occur when bacteria enter your body. Once in your body they increase in number. This causes an immune reaction in your body. Bacteria can enter your body through:

- a cut on your skin
- eating or drinking contaminated food or water
- breathing in droplets from an infected person
- touching dirty surfaces and then touching your eyes, nose, or mouth

Bacteria can also be transmitted by contact with blood and other bodily fluids.

BACTERIAL INFECTION AND WEATHER EVENTS

The risk of getting a bacterial infection increases when you are in contact with flood water. Flood water can come from storms or cyclones. Touching items affected by flooding can also increase your risk of bacterial infection. You should avoid contact with flood water and practice good hand hygiene. Wash your hands with soap and clean water. If clean water isn't

available, use hand sanitiser.

HOW ARE BACTERIAL INFECTION TREATED

Serious bacterial infections can be effectively treated with antibiotics. These medicines either kill the bacteria or stop them multiplying. This helps your body's immune system fight the bacteria. Your doctor's choice of antibiotic will depend on the bacteria that is causing your infection. Antibiotics that work against a wide range of bacteria are called broad-spectrum antibiotics. Antibiotic resistance is a growing problem so antibiotics must always be used appropriately and as prescribed.

COMMON BACTERIAL DISEASES

1) Sepsis

One in five people worldwide die of sepsis, which occurs when bacteria enter the blood and rapidly grow, triggering an inflammatory response cascade that causes septic shock, organ failure, and, if not treated quickly enough, death. In 40 per cent of cases, the type of bacteria causing the infection isn't identified in time, making it difficult to treat and causing the cascade of bodily responses that can become fatal.

2) Neumonia

The leading cause of death in children under five worldwide, pneumonia is an infection of the lungs that can be caused by bacteria or viruses. Symptoms include difficulty breathing, cough, fever or chills and phlegm. Pneumonia caused by bacteria can be treated with antibiotics, and one of the most common types of pneumonia, caused by the bacterium *Streptococcus pneumoniae*, can be prevented by vaccination.

3) Urinary tract infections (UTI)

These infections occur when bacteria enter and multiply in any part of the urinary system, most commonly in the bladder and urethra. UTIs are mainly caused by the bacterium *Escherichia coli* (*E. coli*) and are the most common infection in humans worldwide. Symptoms include a burning sensation when urinating, blood in the urine, and strong-smelling urine. While UTIs can usually be easily treated with antibiotics, they can cause death if they develop into sepsis. An estimated one-third of sepsis cases begin as UTIs.

4) Meningitis

This infection of the membranes surrounding the brain and spinal cord, the meninges, causes fever, neck stiffness and pain, and a rash of purple or red spots that remain when you press on them. While this disease can be caused by a virus or a fungus, bacterial meningitis is the most severe type, and can turn fatal within hours.

DRUGS USED IN TREATMENT

1) Penicillins

Common antibiotics in the penicillin class include

- Amoxicillin
- Ampicillin
- Dicloxacillin
- Oxacillin
- Piperacillin and tazobactam

2) Tetracyclines

Common antibiotic in the tetracyclin class include

- Democlocyline
- Doxycycline
- Minocycline
- Sarecycline

3) Cephalosporins

Common antibiotic in the cephalosporins include

- Cefaclore
- Cefadroxil
- Cefdinir
- Cefprozil
- Cefdinir

4) fluoroquinolones

Common antibiotic in the fluoroquinolones include

- Ciprofloxacin
- Levofloxacin
- Moxifloxacin
- Gemifloxacin

CONCLUSION

Bacteria are fundamental to life, existing in nearly every environment and serving roles that are both beneficial and detrimental to human health. While most bacteria are harmless or aid processes like human digestion, the less than 1% that are pathogenic pose a major scientific and medical challenge globally. The ability of these few strains to cause deadly infectious diseases, such as the more than 1,700,000 deaths caused by *Mycobacterium tuberculosis* annually, underscores their significant impact on public health.