Chapter 12

Microorganisms and Diversity of Bacteria

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Abstract

Microbiology is the branch of science that investigates microscopic organisms known as microorganisms and their isolation by various methods Microorganisms can have single or multicellular eukaryotic cell structure as well as prokaryotic unicellular structure. When prokaryotic cells are examined, they are cells that do not have organelles surrounded by membranes and whose genetic material is dispersed in the cytoplasm. Until 30-35 years ago, Archaea, which were included in a different class, were defined as having a prokaryotic cell structure and considered bacteria. It has been observed that some archaea can cause diseases in humans, animals, and many plant species. It is possible to come across many areas in nature. Microbiology is also divided into different branches within itself. Virology, mycology, bacteriology, and parasitology are examined from four primary areas. This study provides basic information for understanding the diversity and characteristics of microorganisms and bacteria. In this way, it is tried to recognize the interest of humanity in the world of microorganisms and to explain basic information in this way. Currently, when scientists classify species based on microorganisms and consider that only about 5% of the microorganisms existing in the world have been identified, it will be easily understood how important a field of study microbiology is.

Introduction

According to the Turkish Language Association Dictionary of Veterinary Medicine Terms, microorganisms are living organisms including bacteria, fungi, protozoa and microscopic algae. Although there have been various information about some effects and usage areas of microorganisms for centuries, microorganisms were first seen and started to be studied in 1675 with Leewenhoek's discovery of the microscope. In approximately 200 years, Louis Pasteur proved some functions of microorganisms in the emergence of undesirable flavors in

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https://doi.org/10.58830/ozgur.pub81.c476

winemaking in his studies on the fermentation stage and concluded that heat treatment has an effect on the death of unwanted microorganisms. This practice, called pasteurization, is still accepted today. At that time, Robert Koch's work also made essential contributions to microbiology, and his work in this field has continued with rapid progress until today (Aran, 1993).

Microorganisms and General Properties

This chapter, it is tried to give general content about microorganisms by taking into account the undergraduate programs and considering the basic information that is felt to be lacking in the program. Microorganisms are divided into biological groups such as microscopic algae, viruses, bacteria, fungi (moulds and yeasts), and protozoa (Fung, 1987).

Protozoa

They are single-celled microscopic organisms and are found in both terrestrial and aquatic environments. They have animal characteristics such as movement, ingestion of food and the absence of a cell wall. Some protozoa take their nutrients in dissolved form by absorption. Others feed by swallowing bacteria and other protozoa in their environment. There are free-living species in the sea, fresh water and soil, as well as species living symbiotically or parasitically in or on living host cells or tissues. Protozoa are divided into four branches as flagellates, pseudopods, spores and ciliates according to their movement patterns (Clarholm et al., 2007).

Microscopic Algae

Most algae are considered plant-like protists because they carry chloroplasts and have a cellulose cell wall. More than seven thousand species of green algae have been described. Most of them are aquatic, living in freshwater and seas (Jankovská & Komárek, 2000). Some species can be found symbiotically on the surface of snow, moist soils, green parts on the surface of tree stumps, and some species can be found symbiotically in lichens and protozoa (Hurst, 2021).

Viruses

Since viruses are different from other microorganisms in terms of their structural and general characteristics, they do not belong to any of the above groups (Ulucay et al.). They are expressed as genetic elements located inside and outside the cell containing DNA or RNA. They are not involved in any metabolic activity when outside the cell, but can reproduce within the living host cell (Brown & Bhella, 2016).

Bacteria

They are organisms that can be found in almost every environment. Some of them cause diseases such as typhoid, tuberculosis and cholera. In addition to such harmful activities, they also have many benefits. For example, they transform organic dead residues into reusable materials (Ulucay et al., 2022b). This prevents the loss of essential nutrients. The simplest distinguishing features are their shape and size. Their size varies between 1 and 10 μ. Most bacteria are ready feeders (heterotrophs). They analyse the surrounding organic food sources with their enzymes, convert them into simple organic compounds and then absorb them (Ulucay et al., 2022a). Some bacteria are autotrophs (autotrophs), which can produce their own food by photosynthesis or chemosynthesis from simple inorganic compounds with a special pigment. Bacteria reproduce towards their width. Bacteria are one of the most effective groups of organisms in the life of living organisms, both beneficial and harmful. Although their harms are emphasized more, they also have many benefits (Oztas Gulmus & Gormez, 2020). In vaccine production, disease-causing bacteria are either killed or rendered harmless. For example, typhoid and cholera vaccines are produced from dead bacteria, while tuberculosis (= tuberculosis) vaccine is produced from weakened live bacteria. In the production of some serums, weakened disease bacteria are inoculated into some animals such as horses and cows, and then the serum obtained from the liquid part of the blood taken is used in the treatment of some diseases such as tetanus and diphtheria (Hifumi et al., 2017). Most antibiotics are produced by bacteria. As in the production of antibiotics, bacteria are also utilized in the production of some vitamins (group B, K, etc.), hormones, and amino acids (Singh et al., 2017). It is known that some food spoilage is the result of the harmful activities of bacteria. However, these harmful activities can be controlled and converted into useful ones. For example; yoghurt, cheese, butter, vinegar, pickles, and brine are prepared by this method. Bacteria are also used in the production of some alcohols, acids, and acetone. Is the presence of bacteria in our body beneficial or harmful to us? Bacteria on our skin, which covers our whole body, is actually a shield that protects us from disease factors. In this way, our body is protected from many diseases. There are some bacteria not only on our skin but also in our digestive tract (Probert & Gibson, 2002). Bacteria in small nodules on the roots of plants such as chickpeas or broad beans flick free nitrogen from the atmosphere. Thanks to the nitrogen formed by these bacteria, plants continue their development. On the other hand, the soil is enriched in terms of nitrogenous compounds (Reinikovaite et al., 2023). For this reason, legumes are called green fertilizers. Bacteria are also

utilized in the fight against insects that cause great damage to agricultural and industrial plants. Chemical insecticides (insecticides) are known to cause environmental pollution and even cancer. Therefore, biological control is gaining importance. One of the ways of biological control is the control of pests by using bacteria-containing some toxic substances. These bacteria reproduced under special conditions are sprayed on the plants in the fields. One of the most important activities of bacteria is the cycling of matter (Ulucay et al., 2022a). With the processing of the residues accumulated with the death of living organisms by bacteria, dead organic substances are converted into CO_2, H_2O, and mineral salts that can be used in new nutrient synthesis. Even the formation of oil deposits takes place as a result of the activities of bacteria (Xu et al., 2023).

Fungi (Mould and Yeasts)

Fungi are characteristically filamentous (mycelial) organisms in eukaryotic cell structure (Patel et al., 2023). They have a cell wall like plants and most of them cannot move. Since they lack photosynthetic pigments, they obtain their nutrients from organic substances mostly by absorption. Today, there are more than one hundred thousand species of fungi. The living conditions (habitat) of fungi have some differences. Some of them are aquatic, but most of them live in soil and dead plant residues. Fungi, which can be encountered almost everywhere, generally perform useful activities for us, but some of them can cause various economic losses and jeopardize our health. The useful activities of fungi can be summarised as follows: a) Fungi, most of which live in the soil, together with other soil microorganisms, play a major role in the mineralization of dead organic residues that fall to the ground, thus eliminating garbage heaps. In the meantime, the physical, chemical, and biological properties of the soil improve, and its productivity increases. In addition, the CO_2 they release during these activities passes into the air and regulates the CO_2 balance of the air. b) Fungi are among the organisms we use as food. Some of them are cultured (e.g. *Agaricus bisporus*); some are collected from nature [e.g. *Morchella esculenta* (morel)] and consumed as vegetables. In recent years, some fungi with high protein value have been produced by cell culture method and used as human food or animal feed. (Amara & El-Baky, 2023). Some fungi are used in the preparation of some special cheeses (Rokfort, Gorgonzola, Kamembert, mouldy cheese produced in Anatolia). These provide special flavour and odour to the cheese. Foods such as tempeh and shoyu prepared in some Far Eastern countries are also matured with fungi. c) As we all know, the CO_2 released by the yeast used in bread making

causes the dough to gain a sponge-like appearance and allows the bread to bake inside. Yeast cells also enrich bread with protein and vitamins. Yeasts are also used in the preparation of some beverages such as beer and wine (Satora & Pater, 2023). The first known antibiotic penicillin was obtained by Fleming in 1929 from a mould species *(Penicillium notatum)* (Houbraken et al., 2011). Fungi are also utilized in the production of alcohols, organic acids, vitamins, enzymes, and hormones. As for the harmful activities of fungi; fungi that live as parasites in many living things, including humans, cause their death known. Saprophytic fungi, on the other hand, cause deterioration in various foodstuffs; leather, wood, etc. They cause goods, structures, and clothing made of leather, wood, etc. to become useless by rotting (Kukovinets et al., 2008).

Classification of Bacteria

The categorization of living things according to their characteristics, living conditions, and/or kinship status is called classification, and the field of biology that performs classification is called taxonomy (systematic). The purpose of classification is to find an easy way to understand nature. Living things are classified and named according to their common characteristics and kinship status. The first classifications were made only according to the external appearance of living things and the first classification of living things was made by Aristotle by dividing them into plants and animals. The main element of classifications based on science is species. Organisms that have the same origin, have the same characteristics, have the same number of chromosomes, and produce fertile offspring when mated with each other are called organisms of the same species (Taylor & Ingvarsson, 2003).

Organisms are grouped into 3 super kingdoms according to the type of ribonucleic acid in their cells. Viruses are excluded from this classification because they are acellular (acellular, cell-free). The distinction between eukaryotes and prokaryotes refers to a definition made according to the nucleus. Eukaryotes are those with true nuclei, while prokaryotes are those with primitive nuclei. The distinction between eukaryotes and prokaryotes refers to a definition based on the nucleus (Sapp, 2005).

Prokaryote

It is the upper realm that covers microorganisms that do not have true nuclear membranes and membrane-bound organelles, and whose DNA molecule is free within the cell.

Eukaryote

Their genetic material is contained in a membrane-enclosed nucleus. There are various membrane-enclosed organelles. Studies on the taxonomy and nomenclature (nomenclature) of bacteria were initiated in the early 20th century by Chester, Buchanan, and their teams (Winslow et al., 1917). Bacteria are usually classified according to their shape, although different classes are known. The two main groups of bacteria are cocci (spherical) and bacilli (rod-shaped). These two groups are further subdivided into gram-positive and gram-negative bacteria. Gram staining uses a mixture of purple dye and iodine to stain the magnesium ribonucleate found in some bacteria dark purple. The purple stain cannot be washed with alcohol. Bacteria that stain purple are gram-positive. Those that stain pink are gram-negative. Mycobacteria are not revealed by gram staining and are instead stained by an acid-resistant method called the Ziehl-Nielsen method (Zinserling, 2022). A second subdivision of bacteria is between aerobic and anaerobic organisms.

Characteristics of Bacteria

Morphological Properties

In this method, different colours are applied to different bacteria or bacterial structures according to their staining properties (Gram staining). The two most commonly used differential staining methods are Gram staining and acid-based staining. Gram staining was designed as a method by histologist Christina gram. Gram (+) bacteria are those bacteria that are blue-black or purple in colour on microscopic analysis of Gram-stained media. Gram (+) bacteria get this colour because of a mixture of ultraviolet and iodine in their cell walls. Gram (+) bacteria with thicker cell walls produce more vivid colour. The gram classification system of Gram (+) bacteria is "empirical" and is based on differences in the structure of the "cell wall". They show themselves in purple colour under the microscope (Ulucay et al., 2022b).

Characteristic Properties of Gram (+) Bacteria;

- ✓ Cytoplasmic membrane (membrane or wall)
- ✓ Thick cell Wall
- ✓ Single-ring flagellar structure
- ✓ Polysaccharide capsules
- ✓ They contain teichoic or lipoteichoic acid

For example: *Streptococcus equi, Bacillus anthracis*

Gram (-) bacteria are bacteria that do not take crystal violet stain in the Gram staining stage. In the Gram staining stage; counter dye is added after the crystal violet, so that Gram (-) bacteria have a red-pink colour. Most gram (-) bacteria are pathogenic. Pathogenic gram (-) bacteria have high disease-causing properties in humans. Pathogenicity is due to some properties of a gram (-) bacteria in the cell wall, namely LPS (lipopolysaccharide). They are seen in pink colour under the microscope.

Characteristic Properties of Gram (-) Bacteria;

- ✓ Cell walls contain thinner peptidoglycan than gram (+) bacteria.
- ✓ Outside the peptidoglycan layer there is a "Lipopolysaccharide" membrane.
- ✓ The outer membrane of the cell contains "Porins" that pass certain molecules.
- ✓ There is a "periplasmic space" between the peptidoglycan layer and the outer membrane
- ✓ The S layer is attached to the outer membrane
- ✓ Flanella has 4 rings
- ✓ Teichoic acid or lipoteichoic acid is absent
- ✓ Cytoplasmic membrane

For example: *Brucella abortus, Escherchia coli*

Microscopic Morphology

Cocs: It is called round-shaped bacteria. In microbiology, such as Streptoco and Staphylococ coccus, it is a spherical-shaped bacteria. Many bacterial species have characteristic arrangements that are useful in identification.

(Bacilli (Basil/Bacillus): They are divided into 4 groups according to their physiological characteristics.

- ✓ Acid resistant
- ✓ Gram (+) spore formers
- ✓ Gram (+) non-spore forming
- ✓ Gram (-) bacilli

The Bacillaceae family of endospore-forming rod-shaped bacteria has two main subdivisions: anaerobic spore-forming bacteria of the genus Clostridium

and aerobic or facultatively anaerobic spore-forming bacteria of the genus Bacillus, often known as ASB (aerobic). The bacterial cells of Bacillus cultures are Gram-positive when young, but in some species become Gram-negative as they age (Turnbull, 1996). Most Bacillus species are saprophytes. They have unusual physiological characteristics that enable them to survive or thrive in harsh environments, from Arctic soils and freshwater to marine sediments. The genus includes thermophilic, psychrophilic, acidophilic, alkaliphilic, alkaliphilic, halotolerant, and halophilic representatives that can grow at temperatures, pH values, and salt concentrations where few other organisms can survive (Ulucay et al., 2022b)

Spirochetes

It is an element of the phylum bacteria. Spirochetes, which are diderm (double-membraned) gram-negative bacteria, belong to the long, helical (corkscrew-shaped or spiral-shaped) cells. Spirochetes are chemoheterotrophic, characterized by lengths between 3 and 500 μm and diameters from 0.09 to at least 3 μm in diameter. They are spiral-structured bacteria. For example; Borrelia, Treponema, Leptospira.

Forms of involution (degeneration)

Under the influence of unfavorable conditions (food, pH, osmotic pressure, oxygen depletion, change in surface tension, accumulation of metabolites, etc.) microorganisms undergo many changes in their original form, which are called involution forms. These changes are recognized as abnormal forms such as elongated, oval, branching, swelling, delayed division, etc. If optimal conditions are created in the cultures, the bacteria reach their previous normal form.

Macroscopic Morphology of Bacteria (Colony Morphology)

If a bacterium is grown in a suitable solid medium and under favourable conditions (temperature, time, humidity, oxygen, etc.), it forms a visible cluster (colony) in a short time (Ulucay et al., 2021). Bacterial species form colonies with their own specific colour, odour, size and shape. These types provide genetic control of the cell. Depending on the size, there are millions or billions of microorganisms in a colony. Some bacteria *(E. coli, P. vulgaris, B. subtilis*, etc.) form very large and visible colonies after 24 hours under favourable conditions, while some (Brucellas, corine bacteria, etc.) form colonies that reach the visible stage in 3-5 days. Mycobacteria belonging to human and mammalian animals, on the other hand, form colonies after 15-20 days. The size and shape of the colony is a characteristics of the

species under favorable conditions (composition of the medium, oxygen, temperature, etc.). These are;

- ✓ Flamentöz Bacteria
- ✓ Actinomyces
- ✓ Nocardia
- ✓ Streptomyces

According to Physiological Properties

There are distinctions according to the different physiological states of bacteria. For example, the Bacillaceae family is divided into aerobes (those that need oxygen to reproduce) and anaerobes (those that do not need oxygen) according to their oxygen requirements.

According to Antigenic Structure

They are classified according to their antigenic properties. Serological methods are used for this purpose. By detecting certain antigens formed by bacteria with serological methods, the structure similarity between bacteria is compared.

Numerical Classification

Many characters of bacteria such as morphological, cultural, and biochemical properties are analyzed and the results are transferred to the computer. The origins that are similar to these characteristics are classified. A score of +1 for similarity and -1 for dissimilarity is given and the similarity index is obtained at the end of the general sum of the similarity scores. As a result, bacteria are classified in the range of 100% to 0%.

Genetic Classification

It is found according to the number of G+C in bacterial DNA. The ratio of the sum of Guanine (G) + Cytosine (S) numbers to all DNA numbers is constant for each species. In this case, bacteria with similar or very similar G+C/DNA numbers are referred to as the same group. This ratio differs between different genera.

Nomenclature of Microorganisms

The nomenclature is based on the BINOMINAL system described by CARL von LINNE. Microbe names consist of two words:

For example: *Bacillus anthracis, Brucella abortus,* The genus name can be abbreviated. For example: *B. Anthracis*

Classification of Microorganism Groups

Domain / Prokaryote

A prokaryote is a microorganism without a distinct nucleus and other organelles because it has no internal membranes. Bacteria are among the most recognizable prokaryotic organisms. The absence of internal membranes in prokaryotes distinguishes them from others. In eukaryotes, the prokaryotic cell membrane is composed of phospholipids and forms the cell's primary osmotic barrier. The cytoplasm contains ribosomes, which carry out protein synthesis, and a double-stranded deoxyribonucleic acid (DNA) chromosome, which is usually circular. Many prokaryotes also contain additional circular DNA molecules called plasmids.

Phylum / Gracilicutes

It is a class in bacterial genesis. Traditionally, gram staining results are most commonly used as a classification tool. Consequently, until the advent of molecular genealogies, Kingdom Monera was divided into four phyla;

- ✓ Gracilicutes
- ✓ Firmacutes
- ✓ Mollicutes
- ✓ Mendosicutes

Order / Ricketsiales

The order Rickettsiales of Proteobacteria contains a large number of medically important bacteria, including pathogens responsible for Rocky Mountain spotted fever and typhus. Among them are emerging pathogens that cause similar diseases and share many bacterial characteristics. All organisms are small, Gram-negative coccobacilli or bacilli. Most are transmitted to mammals by an arthropod vector. They multiply by binary fission in eukaryotic cells, either in the cytoplasm or inside vesicles, and have a circular genome of only 1 to 1.6 Mb.

Family / Ricketsiaceae

Rickettsia is a gram-negatively stained, small, obligate intracellular parasites of the Ricketsiaceae family (Ogata et al., 2005). They reproduce in the cytoplasm of endothelial cells and smooth muscle cells of capillaries, arterioles, and small arterioles and cause necrotizing vasculitis. They are transmitted to humans by arthropods such as fleas, lice, ticks, and mites and cause typhus or spotted fever group diseases. They are characterized by

sudden onset of fever lasting for one or several weeks, headache, weakness, muscle pain, and in all cases a characteristic rash.

Species / Coxiella Burnetii

Coxiella burnetii is a gram negative, pleomorphic, necessary intracellular microorganism. Although it was previously known as Rickettsiaceae family, it was determined to be in the Coxiellaceae family with genetic applications

Morphology of Bacteria

Microscopic Morphology;

Depending on their shape, bacteria are divided into several types. Round-shaped bacteria are cocci, rod-shaped bacteria are bacilli and spiral-shaped bacteria are spirochetes. But if we make a general definition, we can make a ranking as follows.

- ✓ Cocci (from kokkos, meaning berry) are spherical or oval cells.
- ✓ Basil (from bacillus, meaning rod) are rod-shaped cells.
- ✓ Vibrios are comma-shaped curved rods and are named after their structure. They are characterized by vibratory motility.
- ✓ Spirilla are rigid spiral forms
- ✓ Spirochetes (from speira, meaning fold, and chaite, meaning hair) are flexible and helical forms.
- ✓ Actinomycetes are branching filamentous bacteria; when seen in tissue, they bear an imaginary resemblance to the radiating rays of the sun (from actis meaning ray, and mykes meaning fungus).
- ✓ Mycoplasmas have a cell wall-deficient and therefore stable morphology. They have the shape of round or oval bodies and interlacing filaments.
- ✓ Cocs, The term cocci is derived from the Greek word kokkos, meaning fruit or seed. Cocci include archaeons or bacteria, usually round, oval, or spherical in shape.
- ✓ Cocci bacteria species Cocci can grow in chains, clusters, or pairs. Depending on the arrangement of cocci cells, they can be further subdivided.
- ✓ Streptococcus - cocci arranged in chains. Streptococcus mutans
- ✓ Diplococci - cocci arranged in pairs. *Neisseria gonorrhoeae*
- ✓ Monocoque - single coke

- ✓ Staphylococci - clusters of cocci. *Staphylococcus aureus*
- ✓ Tetrads - smells in groups of four. Pediococcus
- ✓ Sarcina - cocci in groups of eight. *Sarcina ventriculi*

Streptococci and diplococci are mostly formed because the daughter cells do not separate after cell division. In Sarcinae, cell division is organized in cubic pockets alternating between three vertical planes.

Gram-positive coccus bacteria

Like any other gram-positive bacteria, they also become positive for Gram staining (they retain the violet stain). Bacterial cell walls have thick layers of peptidoglycan. Gram-positive cocci most commonly cause infections in the intestine, vagina, nasopharynx, and in mouth.

- ✓ **Staphylococci** - Gram-positive cocci organized in grape-like clusters. They do not form spores, are immobile, and are about 1 μm in diameter.
- ✓ **Micrococci** - Gram-positive cocci that appear in irregular clusters. They are tetrads and differ from staphylococci in their oxidative attack on sugars.
- ✓ **Streptococci** - Another group of gram-positive cocci that appear in chains. They are usually part of the normal human flora. Some of them are important human pathogens causing pyogenic infections. Their growth in the cellular environment is enhanced by the addition of glucose, serum, or blood.

Some Gram-positive cocci samples; *Parvimonas, Peptonifilus*

There are also some cocci with a thin layer of peptidoglycan (gram-negative cocci). They do not retain the violet stain during Gram staining and instead take up the counterstain such as safranin and appear red in colour. Some gram-negative cocci samples: *Anaeroglobüs, Asidaminokok, Veillonella, Megasfera*

Bacillus

Bacilli (genus Bacillus) are rod-shaped, gram-positive, aerobic, or (under certain conditions) anaerobic bacteria, commonly found in soil and water. The term bacillus has been generally applied to all cylindrical or rod-like bacteria. The largest known Bacillus species, *Bacillus megaterium*, is about 1.5 μm (micrometer; 1 μm = 10^{-6} m) in diameter and 4 μm long. Bacillus often occurs in chains. In 1877, the German botanist Ferdinand Cohn provided

an authorized person with different forms of hay bacillus (*Bacillus subtilis*): the heat-resistant forms, which can be killed by exposure to heat, are called "spores". It is known that these dormant forms can be converted into a vegetative or actively growing state (Cavalier-Smith, 2002). It is now known that all Bacillus species can form spores under unfavorable environmental conditions. These endospores can remain viable for a long time. Endospores are resistant to heat, chemicals, and sunlight and are widely distributed in nature in the soil they invade.

Sporikets

Spirochete, (order Spirochaetales), also spelled spirochaete, are a group of spiral-shaped bacteria, some of which are serious pathogens for humans and cause diseases such as syphilis, yaws, Lyme disease, and relapsing fever. Examples of spirochete genera include Spirochaeta, Treponema, Borrelia, and Leptospira. Spirochetes are gram-negative, motile, spiral bacteria from 3 to 500 m (1 m = 0.001 mm) long. Spirochetes are unique in that they have endocellular flagella (axial fibrils or axial filaments), of which there are between 2 and more than 100 per organism, depending on the species. Each axial fibril is attached to an opposite end and wrapped around the cell body surrounded by an envelope. Spirochetes are characteristically found in a liquid medium (e.g., mud and water, blood, and lymph).

Spirillum

Spirillum, a genus of spiral-shaped bacteria from the family Spirillaceae, causes a type of rat bite fever in humans. The spirillum is microbiologically characterized as a gram-negative, motile spiral cell with whip-like flagella at each end. The spiral of the largest spirillums is 5 to 8 μm (micrometers; 1 μm = 10^{-6} meters) in diameter and 60 μm long.

Vibrio

Their bodies are rigid, with a single curved, comma-shaped body structure. Vibrios harbour a wide variety of genomes as revealed by different genomic techniques including amplified fragment length polymorphism, multilocus sequence typing, repetitive extragenic palindrome PCR, ribotyping, and whole genome sequencing. The 74 species of this group are distributed in four different families such as *Entero vibrionaceae*, *Photo bacteriaceae*, *Salini vibrionaceae* and *Vibrionaceae*. Comparative genome analyses, mutations, chromosomal rearrangements, loss of genes through decay or deletion, and gene gains through duplication or horizontal transfer, are probably important drivers in the evolution and speciation of vibrios.

Bacteria always reproduce in the same cell form under favorable conditions. But sometimes they can be found in different shapes. If bacteria are produced in the presence of substances that inhibit cell wall synthesis (penicillin, chemicals, etc.), there are some differences in their shapes. These are;

L- Form

- ✓ They are capable of normal reproduction but have no cell walls.
- ✓ They are found in shapes such as oval, star, ring, and disc under a microscope.
- ✓ Bacteria are found in different shapes with many environmental effects in the environment where they grow. pH change, oxygen reduction, surface tension, and osmotic pressure changes, and reduction of food in the environment. Bacteria in these environments have irregular shapes (filament, branching, angular form).

Colony Morphology of Bacteria

Bacteria grow in colonies on solid media. A colony is defined as a visible mass of microorganisms all originating from a single mother cell, so a colony forms a genetically similar colony of bacteria. The culture medium plays an important role in the demonstration of bacterial colony characters and the actual morphology of the bacteria. Media consisting of simple components and without any inhibitory substances are suitable for characterizing the colony characters of a bacterium (nutrient agar). Bacterial colonies differ in shape, size (measured in diameter), odour, colour (pigmented), texture and degree of adhesion to the medium (pitting and crusting). Different bacteria show different colony morphologies, such as rhombic (e.g. *Pseudomonas* spp.), large mucoid colonies (e.g. *Klebsiella* spp.), colonies with wavy edges (e.g. *Bacillus anthracis*), fusing colonies (e.g. *Proteus*)); colonies can be mucoid (M colonies), smooth (S colonies) and dry (R colonies). An M colony looks water-like, shimmering, and mingled together (individual or separated colony). S colonies are recognizable by their moist structure and are indicative of freshly isolated bacterial strains. R colonies are rough, dry, granulated, and mutant bacterial strains lacking most surface proteins, including capsules and lipopolysaccharides. R colonies are usually formed by bacteria that are avirulent. The ability of bacteria to vary in both smooth-to-rough (SR) shapes and rough-to-smooth (RS) colonies has also been observed. Rough colonies that form on blood agar and reveal spore-forming gram-positive bacilli (aerobic spore-bearing bacilli) on Gram stain are often overlooked as laboratory contaminants.

Colony Shape

It includes the shape, height, and boundary of the bacterial colony. The form of the bacterial colony: Form refers to the shape of the colony. These four forms represent the most common colony shapes you are likely to encounter. These are circular, irregular, filamentous, and rhizoid. The height of the bacterial colony: Gives information about how high the colony rises on the agar. This describes the "side view" of a colony. The six most common elevations of bacterial colonies and the prevalence theme of bacterial colonies are given (Figure 1)

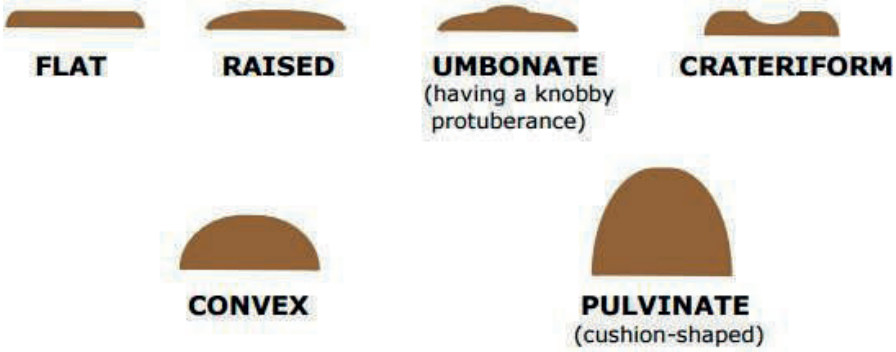

Figure 1. Bacterial Colony Types

Size of the Bacterial Colony

The size of the colony is a useful feature for identification. The diameter of a representative colony can be measured in millimeters or described in relative terms such as pinpoint, small, medium, and large. Point and other types of bacterial colonies are shown in Figure 2.

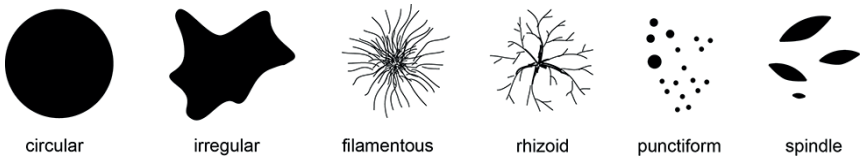

Figure 2. Schematic of Point Bacterial Colonies

Tiny colonies are also called pinpoints. Colonies larger than about 5 mm are likely to be mobile organisms. Pinpoint colonies differ from circular colonies by their very small size.

Colony Morphology

When bacteria are grown in suitable solid nutrient media and under suitable conditions, they come together and form visible clusters called colonies. Bacterial species form colonies with their own colour, smell, size, and structure. These characters are under the genetic control of the cell. The formation time of colonies in solid nutrient media varies according to the bacterial species. For example, *E. coli* can grow in 24 hours, Brucellae in 2-3 days, Mycobacteria in 15-20 days. The size of colonies also varies according to bacterial species.

Colony Forms Observed in Bacteria

S (Smooth) Colony

It is a colony formed by bacteria newly isolated from disease cases. It has a smooth, shiny and homogenous appearance.

R(Rough) Colony

Colonies formed by bacteria that are old or passaged many times. They are granular with rough edges and top. Bacteria forming R-type colonies lose their pathogenicity and are easily phagocytised. Their antigenic ability weakens.

M (Mucoid) Colony

It is seen in bacteria forming capsules or mucoid secretions. When these colonies are touched with a swab, they elongate like threads.

L-Colony

Bacteria can transform into various forms as part of their natural life cycle. One of these stages is L-Colony. L-form bacteria, also known as cell wall-deficient bacteria, are a stage of bacteria that are very small and lack cell walls. Despite being the subject of numerous studies over the last 100 years and implicated in various diseases, L-forms continue to be largely misunderstood by the medical research community. According to Marshall Pathogenesis, L-forms are part of the metagenomic microbiota responsible for chronic diseases (Proal et al., 2011). Their tops and sides are irregular. The size of microorganisms is measured in micrometers (μm, 10^{-6}) in eukaryotic organisms and bacteria in the international metric system. In bacteria, some phages, and viruses, the length of the double-stranded genomic DNA is defined in base pairs (ba, base pair, bp) and in single-stranded genomic phages and viruses in bases.

KAYNAKÇA

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