STM JOURNALS

Research & Reviews: A Journal of
Microbiology & Virology

https://journals.stmjournals.com/rrjomv/

ISSN: 2230-9853 (Online)
ISSN: 2349-4360 (Print)
Volume 14, Issue 1, 2024
January–April
DOI (Journal): 10.37591/RRJoMV

Review RRJoMV

Microbes: A General Review

Gyanendra Kumar Gupta[1,*], Gagan Devi[2]

Abstract

The exploration of microbes has been a vibrant field of study for over 250 years. Microbiology has made significant strides in recent decades, enabling precise diagnosis and treatment of numerous infectious diseases. Today, infectious diseases continue to pose challenges for human health. To mitigate the risks of various infections, there is a growing emphasis on enhancing the production and utilization of antibiotics, which are synthesized from microbial sources. This abstract delves into the conceptual study of microbes, focusing on bacteria and fungi. Bacteria, with their diverse metabolic capabilities and structural variations, form a cornerstone of microbial ecology. Methods for assessing microbial sensitivity to antimicrobial agents are vital for effective treatment strategies. Staphylococcus aureus, a common bacterium often found in the human microbiome, exemplifies both commensal and pathogenic behaviors, causing a range of infections. Fungi, characterized by chitin-containing cell walls, also play pivotal roles, particularly dermatophytes, which cause skin diseases in humans and animals. Among these, tinea corporis, or ringworm, stands out as a common fungal infection affecting various body parts. Understanding the causes and transmission routes of these microbial infections underscores the importance of preventive measures. Moreover, the discussion emphasizes the ubiquitous nature of microorganisms and their essential contributions to ecological processes. In conclusion, microbes represent a diverse array of organisms intricately intertwined with life on Earth, exerting profound effects on human health, ecology, and daily existence. Continued research and understanding of these microorganisms are crucial for addressing infectious diseases and harnessing their beneficial aspects.

Keywords: Microorganisms, microbiological study, diagnostic techniques, contagious illnesses, and antibacterial medications

INTRODUCTION

The term “microbes” originates from the Greek words “*micros*,” meaning “small,” and “*organism*,” referring to any living structure. Thus, a microorganism is a minuscule living entity that exists either as a single cell or multicellular. Microbes are imperceptible to the naked human eye and are visible only under magnification because of their microscopic size [1].

***Author for Correspondence**
Gyanendra Kumar Gupta
E-mail: gyanender.gupta@gmail.com

[1]Professor, Department of Kriya Sharir, Shri Babu Singh Jay Singh Ayurvedic Medical College & Hospital, Farrukhabad, Uttar Pradesh, India
[2]Assistant Professor, Department of Rachna Sharir, Bharat Ayurveda Medical College Hospital & Research Centre, Muzaffarnagar, Uttar Pradesh, India

Received Date: February 21, 2024
Accepted Date: April 09, 2024
Published Date: May 01, 2024

Citation: Gyanendra Kumar Gupta, Gagan Devi. Microbes: A General Review. Research & Reviews: A Journal of Microbiology & Virology. 2024; 14(1): 48–54p.

Microbiology, the discipline dedicated to the examination of microorganisms, derives its name from the Greek words “*micros*” (meaning small), “*bios*” (life), and “*logos*” (study). Microbiology encompasses the investigation of various microscopic life forms. Microorganisms include bacteria, viruses, fungi, algae, and protozoa. They populate various habitats worldwide, ranging from hot springs on the ocean floor to the depths of the Earth’s crust, wherever liquid environments are present [1].

Microbes, despite being the earliest inhabitants of the planet and initially dominating it, have

continued to positively and negatively impact human existence since ancient times. Humans have been acquainted with the influence of microbes since the inception of the toasting and baking of bread, humans have been acquainted with the influence of microbes [2–3].

CONCEPTUAL STUDY

Numerous microorganisms, commonly referred to as microbes, exist in various forms, such as single-celled entities, multicellular organisms, and viruses, which lack a definitive cellular structure. Certain organisms, known as anaerobes, thrive without the presence of oxygen, whereas others possess the ability to synthesize vital compounds from atmospheric sources such as nitrogen and carbon dioxide. Additionally, viruses and certain bacteria rely entirely on the cells of higher organisms for survival [4].

Certain bacteria play a crucial role in enhancing the natural environment by releasing carbon, nitrogen, oxygen, and other elements into the air through metabolic processes, thus creating a conducive atmosphere for other life forms. Additionally, specific bacteria contribute to the fermentation of milk and maturation of cheese, aiding in the development of these dairy products. Moreover, organisms present in natural water are introduced through rainfall, whereas soil microorganisms may also be present in natural water sources.

BACTERIA

Bacteria are single-celled non-chlorophyll-containing organisms that possess both DNA and RNA. They can perform all essential life functions such as growth, metabolism, and reproduction. Encased within a rigid cell wall containing muramic acid, bacteria were initially categorized within plant and animal kingdoms [5]. The multiplication and growth of bacteria necessitates suitable nutrition, optimal pH levels, temperature, and oxygen availability.

Bacteria can be categorized into various types based on their nutritional requirements:

1. *Energy Sources*
   i. Phototrophic bacteria derive energy from photochemical reactions.
   ii. Chemotrophic bacteria obtain energy from chemical reactions.

2. *Ability to Synthesize Essential Metabolites*
   i. Autotrophic bacteria synthesize all essential metabolites from inorganic sources.
   ii. Heterotrophic bacteria are unable to synthesize certain essential metabolites and rely on external sources for organic compounds, such as proteins, peptones, amino acids, vitamins, and growth factors. It is noteworthy that most bacteria that cause diseases in humans are heterotrophic.

3. *Size of Bacteria*
   i. Bacteria are typically minute-sized and are often measured in microns. Coccus bacteria are approximately 1 micron in diameter, while bacilli range from 2 to 10 microns in length and 0.2 to 0.5 microns in width [6].

Bacteria Exhibit Various Shapes

1. *Cocci:* These bacteria were spherical. Depending on the arrangement of the individual organisms, they are classified as staphylococci, streptococci, diplococci, tetrads, and sarcina.
2. *Bacilli:* These bacteria are cylindrical or rod-shaped. These can be further categorized as follows.
   i. *Coccobacilli:* Their length may approximate the width of the organisms.
   ii. *Vibrio:* These bacteria are comma-shaped curved rods, named for their characteristic vibratory motility.
   iii. *Spirochaetes:* These bacteria are elongated, thin, flexible organisms with multiple coils.
   iv. *Actinomycetes:* Branching filamentous bacteria.
   v. *Mycoplasma:* These bacteria are round or oval bodies with interlacing filaments.

They lack a cell wall and consequently do not have a stable morphology: differences between gram-positive and gram-negative bacteria are explained in Table 1.

Table 1. Gram-positive and gram-negative bacteria.

Characteristic	Gram-positive bacteria	Gram-negative bacteria
Thickness	15-25 nm	10-15 nm
Variety of Amino acid	Few	Several
Aromatic and Sulfur	Absent	Present
Lipids	Low 2-4 percent	High 15-20 percent
Teichoic acid	Present	Absent
Periplasmic space	Absent	Present
Enzyme digestion	Protoplast	Spheroplast

Tests for Microbial Sensitivity to Antimicrobial Agents

There could be significant differences in the sensitivity of various strains belonging to the same bacterial species to antibiotics. Essential to the choice of drug is information about the pattern of sensitivity of the infecting microorganisms. Various tests are currently available to assess bacterial susceptibility to antimicrobial agents. The two most frequently employed methods are the disk diffusion test and agar or broth dilution test [7].

The disk diffusion test is a straightforward and cost-effective method to determine bacterial susceptibility to antibiotics. It yields qualitative or semiquantitative data on the effectiveness of a particular antibiotic against a specific microorganism. In this assay, filter paper discs containing specific quantities of the antibiotic were positioned on agar plates inoculated with the microorganism. After 18–24 h of incubation, the diameter of the clear zone around the disk was measured, indicating the sensitivity of the microorganism to the antibiotic. Sensitivity standards vary for each microorganism and are based on safe plasma drug concentrations without causing toxicity.

The dilution test involves serially diluting antibiotics in solid agar or broth media containing microorganism culture. The minimum inhibitory concentration (MIC) was defined as the lowest concentration of the antibiotic that inhibited visible growth following incubation. The minimal bactericidal concentration (MBC) refers to the lowest concentration that leads to a 99.9% reduction in bacterial population. for the bacterial population. Although the clinical utility of MBC is not firmly established, it may be valuable in certain scenarios where precise knowledge of the ability of antibiotics to eliminate a specific clinical isolate is crucial, such as in the treatment of bacterial endocarditis. Dilutions can be prepared in either broth or agar medium, and the test includes assessing MIC, MBC, and the zone of inhibition [8–9].

Interpretation of Results

All cultures were incubated under optimal atmospheric conditions for the minimum time required for the control tube containing no antibiotic to show good growth; they may be re-incubated after recording the results if desired. If desired, results can be obtained by identifying the endpoint, known as the MIC, which is the lowest concentration at which no visible growth is observed to the naked eye. However, practical considerations may necessitate slight modifications of this criterion.

Staphylococcus aureus

Staphylococcus aureus, a spherical gram-positive bacterium classified within the Firmicutes group, is frequently present in the body's microbiome, notably in the upper respiratory tract and skin. It typically exhibits catalase and nitrate reduction characteristics and is capable of thriving under both aerobic and anaerobic conditions. While typically behaving as a harmless member of the microbiota, S. aureus can opportunistically become pathogenic, causing various infections, ranging from skin conditions such as abscesses to more severe illnesses such as pneumonia, meningitis, and sepsis [10].

Morphology: Staphylococcus aureus, also known as "golden staph" or "*oro staphira*," is a Gram-positive, round-shaped bacterium with the characteristic appearance of grape-like clusters when viewed under a microscope. It is non-motile, lacks spore formation, and typically forms large, round, golden-yellow colonies with hemolysis when cultured on blood agar plates.

Cultural characteristics: S. aureus is capable of aerobic and facultative anaerobic growth on simple media. It thrives optimally at 37°C, with a temperature range of 10–40°C.

Resistance: S. aureus is susceptible to temperatures of 78°C for one minute and 64°C for ten minutes but exhibits resistance to freezing. Some strains are resistant to chlorine disinfection.

Pathogenicity: Although *S. aureus* commonly exists as a harmless commensal bacterium in approximately 30% of the human population, it can transition to a pathogenic state, causing diseases such as bacteremia, infective endocarditis, and various skin and soft-tissue infections, particularly when the skin or mucosal barriers are compromised.

Infections caused by S. aureus can disseminate through different routes, such as exposure to discharge from an infected wound, direct contact with the skin of an infected individual, and contact with contaminated items, such as towels, bedding, clothing, or sports gear utilized by an infected individual. Patients with joint implants are especially prone to developing septic arthritis, staphylococcal endocarditis (infection of the heart valves), and pneumonia.

Preventive measures involve frequent handwashing with soap and maintaining daily hygiene practices such as bathing or showering. S. aureus is a major contributor to persistent biofilm infections in medical implants, and toxin suppression contributes to the infection mechanism. This bacterium can remain dormant in the body for prolonged periods without being detected. Once symptoms appear, the infected individual remains contagious for approximately two weeks, and the illness typically lasts for several weeks. However, if not addressed, the illness can lead to lethal outcomes. Severe S. aureus infections that penetrate deep into tissues can be particularly dangerous.

Skin infections induced by *S. aureus* encompass a range of conditions, such as boils, folliculitis, impetigo, cellulitis, and more severe and invasive soft-tissue infections. *S. aureus* is also a common cause of food poisoning.

Infections involving the bones and joints may manifest as osteomyelitis, septic arthritis, or infections following joint replacement surgeries. Furthermore, *S. aureus* is associated with bacteremia and infections related to medical implants.

Fungus

A fungus, or fungi (plural), encompasses a diverse group of eukaryotic organisms, including microorganisms, such as yeasts and molds, as well as more recognizable mushrooms. Unlike plants, bacteria, and certain protists, fungi are characterized by the inclusion of chitin in their cell walls. Like animals, fungi are heterotrophs, acquiring nutrients through the absorption of dissolved molecules and the release of digestive enzymes into their environment. Unlike plants, these plants do not engage in photosynthesis. Fungi rely on growth for movement, although some spores, a few of which are flagellated, can disperse through the air or water. Fungi play a crucial role as primary decomposers in ecosystems. Molecular phylogenetics strongly supports the classification of fungi into a distinct group called Eumycota or true fungi, separated from structurally similar organisms, such as slime molds and water molds. The scientific study of fungi is known as mycology, derived from the Greek word for mushroom, "*mykes*." Although traditionally classified within the realm of botany, contemporary research acknowledges that fungi are genetically more akin to animals than plants [11].

Dermatophytes, derived from the Greek words "*derma*" meaning "skin" and "*phyton*" meaning "plant," constitute a group of fungi responsible for causing skin diseases in both animals and humans. This group includes three common types: Microsporum, Epidermophyton, and Trichophyton, totaling approximately 40 species. While these fungi reproduce asexually, those capable of sexual reproduction belong to the teleomorphic genus Arthroderma within Ascomycota.

Dermatophytes feed on keratinized material found in skin, hair, and nails. They typically inhabit the superficial layers of the epidermis, inciting inflammation as the host reacts with their metabolic byproducts. Virulence factors, such as acid proteinases, elastases, and keratinases, aid in tissue invasion and nutrient acquisition. The host's cell-mediated immunity plays a significant role in combating dermatophyte infections, with a robust immune response correlating with clinical recovery [12].

Although commonly referred to as ringworm or tinea, these infections do not involve worms; the term "*tinea*" originates from a Latin word, describing the serpentine appearance of dermatophytes on the skin. Nail infections caused by dermatophytes are known as onychomycosis. Although dermatophytes typically remain confined to the outer layers of the skin, they may occasionally penetrate subcutaneous tissues, resulting in kerion development.

Classification

Dermatophytes are categorized based on their natural habitat as anthropophilic (associated with humans), zoophilic (associated with animals), or geophilic (found in the soil).

Anthropophilic dermatophytes primarily infect humans, resulting in mild and chronic inflammation. Zoophilic organisms predominantly inhabit animals and can cause significant inflammatory reactions in humans who come into contact with infected animals, including cats, dogs, cattle, horses, and birds. Infections may also spread indirectly through contact with the hair of infected animals and usually resolve rapidly.

Geophilic species are typically found in soil but may occasionally infect both humans and animals. They provoke pronounced inflammatory reactions, which help contain the spread of the infection and may lead to spontaneous healing, although scarring may occur in some cases.

Different types of infections caused by dermatophytes include:

- Athlete's foot, also known as *Tinea pedis*.
- Jock itch is also referred to as *Tinea cruris*.
- Ringworm of the body, known as *Tinea corporis.*
- Facial ringworm, termed as *Tinea faciei*.
- Scalp ringworm, also called *Tinea capitis* or "black dot" ringworm.
- Ringworm of the hands, known as *Tinea manuum.*
- Nail infections, termed onychomycosis, *Tinea unguium*, or ringworm of the nail.

Tinea Corporis

Ringworm, also known as *Tinea corporis*, is a fungal infection that mainly affects the arms and legs but can also affect any part of the body. It shares similarities with other types of *Tinea* infections [12].

Signs and Symptoms

The infection may present with various appearances; however, the most recognizable feature is the development of raised red rings with a central area of clearing, resembling a classic ringworm. A similar ring-like appearance may also occur on the scalp (*Tinea capitis*), beard area (*Tinea barbae*), or groin (*Tinea cruris*, also known as jock itch or dhobi itch).

Other typical features of *Tinea corporis* include:

- Itching in the affected area.
- Elevated and scaly edges of the rash.
- Dry and flaky skin surrounding the rash.
- Hair loss often accompanies the infection in affected areas.

Causes

Tinea corporis is caused by a microscopic fungus called a dermatophyte, which typically resides on the surface of the skin. Under favorable conditions, these organisms can trigger rashes or infections.

Direct skin contact with an infected person is the most common way for the disease to spread from person to person. Transmission from animals to humans is also common. Ringworms are commonly found in pets, such as dogs and cats, and humans can acquire the fungus while petting or grooming these animals. It can also be transmitted by horses, pigs, ferrets, and cows. The fungus can also spread through contact with contaminated objects such as personal care items, bedding, combs, sports equipment, or hairbrushes used by an infected person.

Individuals at a higher risk of contracting ringworms include those living in crowded and humid environments. Excessive sweating can also contribute to the development of ringworms, as damp conditions created by sweat provide an ideal environment for pathogenic fungi to thrive. This is particularly common in areas such as the armpits, groin creases, and abdominal skinfolds.

They participate in close-contact sports, such as soccer, rugby, or wrestling. Wear tight constrictive clothing with poor aeration. Have a weakened immune system (e.g., those infected with HIV or taking immunosuppressive drugs).

Discussion: Microscopic life forms are abundant in almost all known environments, including soil, water, food, and air. This is because many of these organisms thrive under conditions similar to those in which humans typically live. It is not unusual to find these microscopic forms on the surface of our bodies and in the mouth, nose, digestive tract, and other body regions. Microorganisms and their actions play crucial roles in virtually every process on Earth.

CONCLUSION

Microbes, including bacteria, archaea, algae, fungi, protozoa, and viruses represent a diverse array of generally diminutive and straightforward organisms. They play an indispensable role in the Earth's ecology, as they decompose animal and plant remains, transforming them into simpler substances that can be reused by other organisms, thus intricately intertwining with daily life processes.

REFERENCES

1. Diggle SP, Buckling A, Gardner A, Griffin AS. The social lives of microbes. Annu Rev Ecol Evol Syst. 2007;38:53–77.
2. Kinnunen M, Dechesne A, Proctor C, Hammes F, Johnson D, Quintela-Baluja M, Graham D, Daffonchio D, Fodelianakis S, Hahn N, Boon N, Smets BF. A conceptual framework for invasion in microbial communities. ISME J. 2016;10:2773–5. DOI: 10.1038/ismej.2016.75, PubMed: 27137125.
3. Nielsen PH, Mielczarek AT, Kragelund C, Nielsen JL, Saunders AM, Kong Y, Hansen AA, Vollertsen J. A conceptual ecosystem model of microbial communities in enhanced biological phosphorus removal plants. Water Res. 2010;44:5070–8. DOI: 10.1016/j.watres.2010.07.036, PubMed: 20723961.
4. Schulz HN, Jørgensen BB. Big bacteria. Annu Rev Microbiol. 2001;55:105–37. DOI: 10.1146/annurev.micro.55.1.105, PubMed: 11544351.
5. Novick A. Growth of bacteria. Annu Rev Microbiol. 1955;9:97–110. DOI: 10.1146/annurev.mi.09.100155.000525.

6. Foster T. Staphylococcus aureus. In: Sussman M, editor. Molecular Medical Microbiology. 4th ed. New York: Academic Press; 2002. p. 839–88. DOI: 10.1016/B978-012677530-3/50258-0.
7. Dinges MM, Orwin PM, Schlievert PM. Exotoxins of Staphylococcus aureus. Clin Microbiol Rev. 2000;13:16–34. DOI: 10.1128/CMR.13.1.16, PubMed: 10627489.
8. Adams BB. Tinea corporis gladiatorum. J Am Acad Dermatol. 2002;47:286–90. DOI: 10.1067/mjd.2002.120603, PubMed: 12140477.
9. Leung AK, Lam JM, Leong KF, Hon KL. Tinea corporis: An updated review. Drugs Context. 2020;9. DOI: 10.7573/dic.2020-5-6, PubMed: 32742295.
10. Salton MR. Studies of the bacterial cell wall. IV. The composition of the cell walls of some Gram-positive and Gram-negative bacteria. Biochim Biophys Acta. 1953;10:512–23. DOI: 10.1016/0006-3002(53)90296-0, PubMed: 13059016.
11. Azam A, Ahmed AS, Oves M, Khan MS, Habib SS, Memic A. Antimicrobial activity of metal oxide nanoparticles against Gram-positive and Gram-negative bacteria: A comparative study. Int J Nanomedicine. 2012;7:6003–9. DOI: 10.2147/IJN.S35347, PubMed: 23233805.
12. Ruhal R, Kataria R. Biofilm patterns in gram-positive and gram-negative bacteria. Microbiol Res. 2021;251:126829. DOI: 10.1016/j.micres.2021.126829, PubMed: 34332222.

