

DIAGNOSIS AND TREATMENT OF BACTERIAL INFECTIONS | PART 1



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Diagnosis and Treatment of Bacterial Infections

(Part 1)

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CHAPTER 2

Epidemiology and Pathophysiology of Bacterial Infections

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Abstract: Bacterial infections remain a significant cause of global morbidity and mortality, with their prevalence influenced by geography, population dynamics, and medical interventions. The rise in healthcare-associated infections, as well as emerging and re-emerging pathogens, has altered the landscape of bacterial disease. This review focuses on current trends in bacterial infections, particularly those caused by *Mycobacterium tuberculosis*, *Escherichia coli*, and *Staphylococcus aureus*.

Understanding the pathophysiology of bacterial infections is critical for developing effective prevention and treatment strategies. Bacteria have evolved sophisticated mechanisms to evade the host immune system, including toxin production, tissue invasion, and immune manipulation. Quorum sensing plays a key role in coordinating pathogenic behaviour, especially within biofilms, which promote genetic variation and antibiotic resistance. A deeper insight into these biological processes, combined with epidemiological data, is essential for enhancing disease surveillance, refining therapeutic approaches, and reducing the global burden of bacterial infections.

Keywords: Bacteria, Bacterial infection, Epidemiology, Pathogenesis.

INTRODUCTION: BASIC BIOLOGY OF BACTERIA

The most diverse and fundamental biological entities on the planet are bacteria. These unicellular microorganism are strikingly different from other living organisms [1]. They are prokaryotic, meaning their cells lack a true nucleus and contain prokaryotic organelles and structures surrounded by a membrane. Bacteria play essential roles in ecosystems, often cohabiting with other organisms and enabling crucial ecological processes, despite their ancient reputation as causes of disease [2].

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Bacterial Cell Structure

Bacteria have a minimal yet incredibly functional cellular design that helps them grow in diverse environments. A bacterial cell includes the following components [3].

The cell envelope consists of the cell wall, plasma membrane, and an outer membrane in some species. A bacterial cell's plasma membrane consists of a phospholipid bilayer, which is very important for controlling the passage of substances in or out of the cell. It gives the cell its shape and provides structural support surrounding the plasma membrane. Based on the composition of the cell wall, this study will segregate bacteria into two groups: Gram-positive and Gram-negative [4]. The crystal violet is retained based on the thick peptidoglycan surrounding Gram-positive bacteria. In comparison, the outermost layer of gram-negative bacteria comprises lipopolysaccharide and peptidoglycan, which are the thinnest. Safranin may be employed as a counterstain for the bacteria since it is also red. Some bacteria also have an optional second line of defence in the form of a shield outside their cell wall called a capsule. The capsule helps the bacteria stick to surfaces and escape from immune system detection [5].

The gel-like material that is found inside the plasma membrane is home to cell structures, waste products, nutrients, enzymes, and water. The nucleoid, a component of the bacterial cytoplasm, contains the lone circular DNA molecule that makes up the bacterial chromosome. Unlike eukaryotes, bacteria do not have a membrane-bound nucleus; hence, their genetic material is not segregated into a separate compartment [6]. The molecular machinery responsible for producing proteins, known as ribosomes, is found within the cytoplasm of bacteria. These 70S ribosomes are composed of the 30S and the 50S subunits. Inclusion bodies are additional basic structures seen in bacteria. These are granules that are stored in the cytoplasm and contain nutrients or building blocks such as polyphosphate, sulfur granules, or glycogen. Furthermore, some bacteria have tiny, circular DNA molecules called plasmids that reside apart from chromosomal DNA [7]. Plasmids can carry genes that provide advantageous traits to bacteria, such as antibiotic resistance, virulence factors, or distinct metabolic pathways [8].

Flagella are extended, whip-like appendages that aid in movement. One or more flagella, positioned at different locations on the cell surface, can be seen on bacteria [9]. Pili and Fimbriae are hair-like projections that facilitate bacterial adhesion to one another and surfaces. Pili are also involved in conjugation, a procedure that consists of the exchange of genetic material between bacterial cells [10].

Bacterial Growth and Reproduction

Bacteria reproduce primarily through a process called binary fission, where a single cell divides into two genetically identical daughter cells. The basic steps of binary fission are shown in Fig.(1)[11 - 13]:

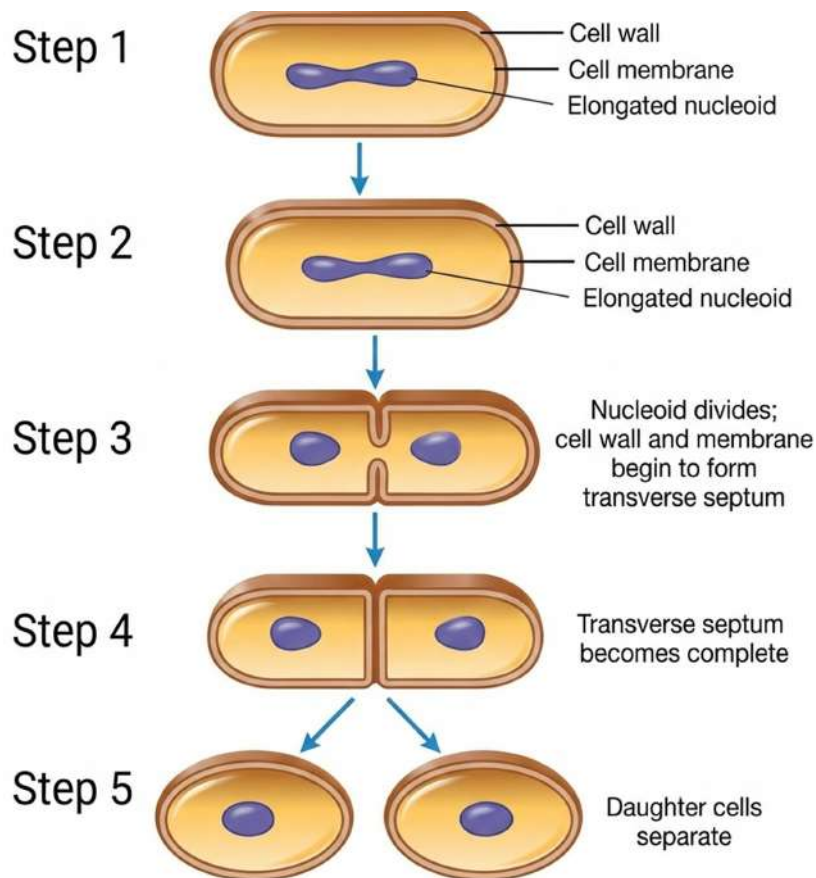


Fig. (1). Steps involved in bacterial growth and reproduction.

1. **DNA Replication:** The bacterial chromosome is replicated, ensuring each daughter cell receives an identical copy.
2. **Cell Elongation:** The cell elongates, and the newly synthesised DNA molecules move to opposite poles of the cell.
3. **Septum Formation:** A septum, or dividing wall, forms in the centre of the cell.
4. **Cell Division:** The septum completes the division, resulting in two separate cells.