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Bacteria and Antibiotics: Classification, Mechanisms, and Clinical Relevance

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Article Details

ABSTRACT

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This article provides a comprehensive description of the bacterial composition and antibiotics, highlighting their clinical significance and applications. Bacteria are single-celled microorganisms, microscopic in size, and are primarily classified as aerobes and anaerobes based on their oxygen requirement for growth and survival. Anaerobes such as *Clostridium* species, *Treponema pallidum*, and *Bacteroides* are responsible for tetanus, syphilis, and abdominal infections. Gram staining and Ziehl-Neelsen acid-fast staining diversify aerobic bacteria into Gram-positive and Gram-negative bacilli and cocci, for example, clinically relevant pathogens such as *Mycobacterium tuberculosis*, *Staphylococcus*, *Streptococcus*, and *Escherichia coli*. Antibiotic discovery and classification have been a significant part of bacterial infection control. Cephalosporins are classified into four generations with an increasingly broadened antibacterial spectrum. Aminoglycosides and tetracyclines, more useful for Gram-negative and intracellular infections, are no less an integral part of antibacterial therapy. This survey emphasizes the critical role of accurate bacterial classification and proper antibiotic choice in clinical medicine for optimizing therapeutic effectiveness, restricting resistance, and benefiting patients. Sensitivity towards both the microbiological pattern of bacteria and antibacterial spectrum supports diagnostic and therapeutic planning in modern medicine.

INTRODUCTION

Bacteria are microscopic single-celled organisms that are found in every environment. They are prokaryotic, meaning their nucleus is not enclosed in a membrane. Some types of bacteria are beneficial to humans, animals, and plants, while some cause disease. Various shapes and types of bacteria play a critical role in science. Antibiotics are chemical compounds used to kill or inhibit the growth of bacteria and other pathogens. They are derived from certain fungi and bacteria or are synthesized artificially. Antibiotics play a vital role in treating infections in human and animal health and are a fundamental requirement of modern medicine. They effectively treat dangerous diseases caused by bacteria, such as pneumonia, strep throat, wound infections, and blood poisoning. Antibiotics protect patients from infection during surgery and other complex medical procedures. Their proper use saves human lives. Bacteria are classified based on various characteristics. They are classified based on cell wall structure (Gram-positive and Gram-negative), shape (cocci, bacilli, spirilla), oxygen requirement (aerobic, anaerobic), temperature tolerance, and disease-causing ability. This classification is helpful in the treatment and research of diseases. Bacteria are divided into two major groups based on the structure of their cell walls: Gram-positive bacteria and Gram-negative bacteria. Gram-positive bacteria have a thick peptidoglycan layer, while Gram-negative bacteria have a thinner wall with an additional lipid membrane on the outside. This division simplifies the choice of treatment.

Among the Gram-positive bacteria, *Staphylococcus aureus* and **Streptococcus pyogenes* are important examples. Their cell walls consist of a thick peptidoglycan layer, which stains them purple in a Gram stain. They commonly cause tonsillitis, sore throats, and skin infections. They are highly susceptible to antibiotics and can be easily identified. Gram-negative bacteria include *Escherichia coli* and *Pseudomonas aeruginosa*. Their cell walls consist of a thin peptidoglycan layer and an outer lipopolysaccharide membrane, which makes them stain pink in the Gram stain. They cause urinary tract, lung, and wound infections and often show antibiotic resistance. Bacteria are divided into three types based on their shape. **Cocci** are round bacteria, including *diplococci* (pairs), *streptococci* (chain-shaped), and *staphylococci* (clusters). **Bacilli** are rod-shaped bacteria, such as *coccobacilli* and *filamentous bacilli*. **Spirilla and spirochetes** are spiral-shaped bacteria, such as *Treponema pallidum*, which causes syphilis. Bacteria are divided into different types based on their need for oxygen. Aerobic bacteria require oxygen to survive. Anaerobic bacteria grow without oxygen, including obligate aerobes (those that survive only without oxygen) and facultative aerobes (those that grow with or without oxygen). Microaerophilic

bacteria require small amounts of oxygen. Bacteria are divided into three types based on their temperature preferences. Psychrophiles are cold-loving bacteria that grow at low temperatures. Mesophiles are moderate-temperature bacteria, found mostly in the human body. Thermophiles are warm-loving bacteria that grow at high temperatures, such as those found in hot springs. Bacteria are divided into three types based on their ability to cause disease. Pathogenic bacteria are those that cause disease in humans and animals. Nonpathogenic bacteria are not harmful and can sometimes be beneficial. Opportunistic pathogens are harmless under normal circumstances but can cause disease in people with weakened immune systems. Bacteria are divided into two types based on their ability to form spores. Spore-forming bacteria such as *Bacillus* and *Clostridium* form spores to survive in difficult conditions, which can survive even in extremely harsh environments. Non-spore-forming bacteria do not form spores and usually survive in less harsh environments. This division is used to estimate the severity and survival of the disease. Antibiotics are divided into three types based on their origin. Natural antibiotics, such as penicillin, are obtained from the *Penicillium* fungus. Semisynthetic antibiotics such as amoxicillin are made by chemical modification of natural compounds. Synthetic antibiotics such as sulfonamides and fluoroquinolones are produced entirely in the laboratory. Antibiotics are divided into two types based on the breadth of their activity. Narrow-spectrum antibiotics affect specific bacteria, such as penicillin G, which is effective against most Gram-positive bacteria.

Broad-spectrum antibiotics, such as tetracycline and amoxicillin, affect both Gram-positive and Gram-negative bacteria, making them effective in treating a variety of infections. Antibiotics are divided into five groups based on their mechanism of action: cell wall inhibitors (penicillins, cephalosporins), protein inhibitors (tetracyclines, macrolides), nucleic acid inhibitors (fluoroquinolones, rifampin), antimetabolites (sulfa drugs), and cell membrane inhibitors (polymyxins). Commonly used antibiotics include penicillins such as penicillin G, amoxicillin. Cephalosporins such as ceftriaxone, cefazolin are used. Macrolides include erythromycin, azithromycin. Tetracyclines such as doxycycline, aminoglycosides such as gentamicin, amikacin, fluoroquinolones such as ciprofloxacin, and sulfa drugs such as sulfamethoxazole are used. The mechanisms of action of antibiotics target different parts of bacteria, such as the cell wall, proteins, or DNA. Some antibiotics are bactericidal, which kill bacteria, such as penicillin. Some are bacteriostatic, which stop bacteria from growing, such as tetracycline. Each mechanism affects a specific bacterium and disease. Antibiotics are used clinically to treat various diseases

such as respiratory tract infections, urinary tract infections, skin and soft tissue injuries. They are also given to prevent infections before surgery. They are of particular use in patients with weakened immune systems. They are sometimes used in combination, such as in the treatment of tuberculosis. Antibiotic resistance refers to the development of resistance in bacteria to drugs. Causes include misuse or overuse. Resistance mechanisms: breakdown by enzymes, target substitution, or drug efflux pumps. Examples: MRSA, VRE. It is combated by careful use and new drugs. A few precautions are necessary for the safe and prudent use of antibiotics. Susceptibility testing is crucial to ensure the selection of the most effective antibiotic for a specific bacterial infection. Unnecessary use and incorrect dosage should be avoided as it creates resistance. The patient should take the full course as directed so that the disease is completely cured and does not recur. Bacteria are microbial one-cell organisms living in varied environments. Based on the requirement for oxygen, they are grouped primarily as aerobic and anaerobic bacteria. While aerobic bacteria require oxygen, anaerobic bacteria thrive without oxygen. This is of major importance in clinical microbiology and decides the choice of diagnostic investigations and treatment. These microbes are responsible for severe infections such as gas gangrene and tetanus. Spirochets like pallidum, the etiological agent of syphilis, are anaerobic too. Human intestinal flora normally found bacteria constitute another crucial category that is involved with intraperitoneal infections (Zengler, 2009).

STAINING TECHNIQUES, BACTERIAL CLASSIFICATION, AND THERAPEUTIC APPLICATIONS OF MAJOR ANTIBIOTIC CLASSES

Aerobic bacteria are also classified using staining techniques, such as Gram staining and capsule staining. Gram staining divides bacteria into Gram-positive and Gram-negative groups. Capsule staining reveals the protective coating around the bacteria. These methods are helpful in diagnosis and treatment. Gram staining classifies bacteria based on the structure of their cell walls. Gram-positive bacteria have thick, peptidoglycan-rich cell walls, while Gram-negative bacteria have thin, outer membrane-covered walls. This distinction is helpful in diagnosis and selection of appropriate antibiotics. Among cocci (round-shaped bacteria), gram-positive types include *Staphylococcus*, *Streptococcus*, and *Pneumococcus*, while gram-negative types include gonorrhea bacteria (which infect the genitals) and meningitis bacteria. These bacteria cause a variety of diseases, and staining is important for their diagnosis. Gram-positive aerobic bacteria (*Bacilli*) include *Corynebacterium*, which causes dangerous diseases such as diphtheria. The same group also includes anthrax, also known as charcoal thalassemia, which causes severe rash and

systemic infection. These bacteria grow in the presence of oxygen and can be fatal to human health. *Mycobacterium leprae* has a waxy cell wall, which makes the bacteria visible only with special staining techniques such as the Zell-Nielsen stain. The waxy wall protects the bacteria from the immune system and reduces the effectiveness of antibiotics. This is why the treatment of leprosy is long and meticulous. For this reason, these bacteria do not stain with a Gram stain. They are identified using the Zell-Nielsen staining technique, which makes these bacteria visible. These bacteria cause dangerous diseases such as tuberculosis (TB) and leprosy, and their treatment is carried out with a long and meticulous plan. Penicillin was first discovered by Alexander Fleming in 1929 and was first used in medicine in 1941 after being isolated from *Penicillium notatum*. It is one of the first antibiotics that revolutionized the world of medicine as an antibacterial drug. It made it possible to treat many dangerous bacterial diseases. Penicillin group members include penicillin G, penicillin V, methicillin, nafcillin, oxacillin, cloxacillin, dicloxacillin, ampicillin, amoxicillin, clindamycin, carbenicillin, and ticarcillin. They are used to treat diseases such as syphilis, meningitis, respiratory infections, skin and soft tissue infections, endocarditis, tetanus, and gas gangrene. First-generation cephalosporins include cephalexin, sprazin, cephadroxy, cefazolin, cephalotone, and cephalorin. Second-generation cephalosporins include cefalexime, cefachlor, ceftriaxone, cefotetan, cefamandole, cefoxitin, cefuroxime, and cefdinir. The third-generation cephalosporins include cefotaxime, ceftriaxone, cefoperazone, moxalactam, cefpodoxime-proxetil, cefotiam, cefuroxime, and cefdinir. The fourth-generation cephalosporin, cefepime, is characterized by broad-spectrum activity and beta-lactamase resistance. Tetracycline classes include tetracycline, chlortetracycline, oxytetracycline, demeclocycline, methachlor, doxycycline, and minocycline. These antibiotics are highly effective against Gram-negative bacteria and intracellular pathogens, broadening the therapeutic options for a wide range of infectious diseases.(Dimri et al., 2020).

SIGNIFICANCE OF ACCURATE BACTERIAL IDENTIFICATION AND RATIONAL ANTIBIOTIC USE FOR EFFECTIVE CLINICAL MANAGEMENT AND RESISTANCE CONTROL

In total, bacterial identification and antibiotic identification are critical to effective clinical diagnosis and therapy. Bacterial differentiation based on oxygen requirement, staining reaction, and morphology provides precise identification of etiologic pathogens. Concurrently, information regarding antibiotic classes, including penicillins, cephalosporins, aminoglycosides, and tetracyclines, directs proper therapeutic decisions. Such therapeutic targeting not only enhances

patient results but also serves to minimize antibiotic resistance. Because bacterial infections continue to remain major global health issues, the marriage of microbiological knowledge and pharmacological creativity remains critical for maximum patient care and public health. Continued education and research are essential for improving antimicrobial stewardship (Váradi et al., 2017).

BACTERIAL CLASSIFICATION: MORPHOLOGY, PHYSIOLOGY, AND CLINICAL RELEVANCE

Bacteria are the most diverse and most ubiquitous microbes of our planet and find important applications in ecological, industrial, and medical fields. Bacterial classification is a critical field within microbiology, enabling researchers to accurately identify, study, and apply bacteria for various industries. Advances in microscopy, biochemical research, and molecular and genetic techniques have significantly enhanced bacterial classification. Bacteria have been categorized historically on the basis of the following phenotypic characteristics: morphology, color characteristics, metabolic processes, and ecological roles. The essential morphological requirements are formal. Bacteria have been categorized into spherical (rich), rod-shaped (e.g., *Bacillus*), spiral-shaped (e.g., *Spirillum*), vibrio-shaped (e.g., *Vibrio*), and filamentous forms. These basic morphologies are typically arranged in characteristic patterns. For example, cocci may occur singly, in pairs (*Diplococcus*), in chains (*Staphylococcus*), or in clusters. *Bacilli* occur either in singles or as chains of bacilli referred to as streptobacilli. The Gram staining method, developed by Hans Christian Gram in 1884, remains a cornerstone of bacterial classification to this day. Examples include *E. coli* and *Salmonella* species. Another identifying feature is oxygen requirements. Bacteria are aerobic, anaerobic, or facultative anaerobic, requiring trace warmth or air flow. To support the growth of obligate aerobes such as *Mycobacterium tuberculosis*, oxygen is essential, whereas obligate anaerobes such as *Clostridium botulinum* cannot survive in its presence. Facultative anaerobes such as *E. coli* grow with or without oxygen and shift their metabolism accordingly. When *Helicobacter pylori* grows well under hypoxia, we are looking for textile properties, but aerobic and anaerobic properties, as some lactic acid bacteria utilize oxygen and presence for respiration. Autotrophic bacteria generate their food. It can be used to describe automatic nutritional photos (e.g., cyanobacteria) that utilize photosynthesis or chemotherapy (e.g., nitrosomone) to chemically synthesize inorganic compounds. Heterotrophic bacteria are dependent on organic compounds and nutrition. Semlin bacteria destroy dead organic matter, and parasitic bacteria strip away postnatal nutrients, which typically leads to illness. Pathogenic

bacteria are an important subclass of clinical interest and are classified according to the nature of the disease and infection they produce. For example, *Streptococcus pneumoniae*, *Neisseria gonorrhoeae* result in disease, while cholera results in cholera (Barberán et al., 2014).

TEMPERATURE ADAPTATION AND MOTILITY AS CRITERIA FOR BACTERIAL CLASSIFICATION

Temperature preference is another classification criterion. Cycon - Rich bacteria are those that can grow in low temperatures (0-15°C), and central bacteria have moderately high temperatures (20-45°C), and most human pathogens, and heated bacteria can grow at high temperatures (45-80°C). High-temperature illness can withstand temperatures of more than 80°C, typically in hot springs and hydrothermal ventilation slots. Another division is based on motility. Some bacteria can be observed to date back to such structures as flagella, various arrangements: monotrich (single flagella), loffara butterfly (groups towards one point), both ends (flagellates at both ends), or peritrich (flagellates all over). Others of the bacteria demonstrate population movement and motility, while others are not motile (Hokanson, 1977).

ROLE OF SPORE FORMATION AND GENETIC METHODS IN MODERN BACTERIAL CLASSIFICATION

Spore formation is a vital function of classification. Certain bacteria, including species of *Bacillus* and *Clostridium*, form highly resilient endospores (robust venous structures) that enable them to survive extreme and unfavorable environmental conditions. These spores enable survival and severe injuries to nutrition. Uncharted bacteria do not have such a survival mechanism and are comparatively less resistant. 16S-rRNA gene sequencing emerged as the gold standard for phylogenetic studies that initiate evolutionary relationships, and new bacteria have been discovered. Genome-wide sequencing provides information about genetic make-up, resistance genes, and metabolic pathways. Molecular taxonomy classifies bacteria into major phyla such as proteobacteria (*Salmonella*, *E. coli*), solid parts (*Bacillus*, *Staphylococcus*), actinomycete (phylogenetic systems, mycobacteria), and bacteroides. Soil bacteria such as *Azotobacter* fix nitrogen. Aquatic bacteria encompass both freshwater and marine species, with certain organisms adapted to extreme environments such as high salinity (e.g., *Halobacterium*), elevated acidity (acidophilic bacteria), or extreme hydrostatic pressure (barophilic bacteria). Symbiotic bacteria live together with other organisms and have mutual benefits. For example, the nitrogen in knot species gets fixed on the nodes of legume roots (Checinska et al., 2015).

APPLICATIONS OF BACTERIAL CLASSIFICATION IN INDUSTRY, BIOTECHNOLOGY, AND PUBLIC HEALTH

In industrial and biotechnology applications, bacteria are classified by profit. *Streptococcus* and thermal coagulation of lactic acid bacteria are essential in milk fermentation. Vinegar is produced through the metabolic activity of bacteria belonging to the genus *Acetobacter*. *E. coli* is an organism to be manipulated in gene engineering and recombinant DNA technology. Biobacteria such as mimetics can act on impurities and toxins and facilitate environmental adaptation applications. Bacteria are commonly classified based on their antimicrobial resistance or susceptibility profiles. Multidrug-resistant groups such as MRSA (methicillin-resistant *Staphylococcus aureus*) and MDR-TB (multidrug-resistant *Mycobacterium tuberculosis*) are a cause of serious healthcare concern and require individualized management regimens. technology. Appropriate classification of bacteria not only aids in understanding microbial diversity but also facilitates better optimization of health, agriculture, industry, and environmental management applications. Advances in genomics and microbiology are continually reshaping bacterial taxonomy, revealing novel insights while presenting new challenges for global health (Agrawal., 2024).

IMPACT OF ANTIBIOTIC USE IN FOOD ON HUMAN HEALTH AND SAFETY PRACTICES

The use of antibiotics in food can have profound health effects. Antibiotics are given to livestock and poultry to protect them from disease and promote growth. This leaves antibiotic residues in meat, milk, and eggs, which can lead to antibiotic resistance in humans. Safe food habits and monitoring are essential (Phillips et al., 2025).

IMPORTANCE OF BACTERIAL KNOWLEDGE AND RATIONAL ANTIBIOTIC THERAPY IN CLINICAL PRACTICE

The clinical integration of knowledge regarding bacterial pathogens and antimicrobial agents is pivotal in contemporary medical practice. It helps in the accurate diagnosis of diseases, effective treatment, and prevention of infections. Medical practitioners prescribe antibiotics tailored to the patient's condition to ensure rapid disease resolution and prevent antibiotic resistance. This principle underpins medical research. Bacteria are classified into various types, such as Gram-positive, Gram-negative, aerobic, anaerobic, and cocci.. Their pathogenicity, resistance, and sensitivity to antibacterial compounds vary. Therefore, choosing the right antibiotic for treatment is essential. Its classification plays an important role in clinical diagnosis and effective

treatment. This information enables doctors to choose appropriate and specific treatments according to the patient's condition. This allows for early treatment of the disease and reduces unnecessary use of antibiotics. In this way, the growth of resistant bacteria can be prevented. With the help of accurate data, effective and safe treatment can be provided. This is of utmost importance for the development of drug resistance worldwide and the effective treatment of patients. With accurate information and timely diagnosis, doctors can prescribe the right medicine to the patient, which can quickly cure the disease and avoid unnecessary use of antibiotics. This improves the quality of health. Healthcare professionals commonly test resistant bacteria such as MRSA (methicillin-resistant *Staphylococcus aureus*) against glycopeptides and beta-lactam antibiotics (e.g., penicillin, cephalosporin). The goal is to select the appropriate drug, avoid treatment failure, and prevent the spread of antibiotic resistance.

EVIDENCE-BASED ANTIBIOTIC USE AND BACTERIAL RESISTANCE MANAGEMENT IN CLINICAL PRACTICE

Data on bacterial strains helps clinicians understand resistance mechanisms, such as beta-lactamase production. Based on this information, they select effective antibiotics. This increases the chances of treatment success, avoids unnecessary drug use, and can reduce antibiotic resistance. These bacteria exhibit multiple resistance mechanisms, including extended-spectrum β -lactamases and carbapenemases, rendering them refractory to most conventional antibiotics and thereby complicating therapeutic management.. Specific and powerful antibiotics have to be used to treat such infections to control the disease. Therefore, physicians are forced to use modern drugs such as carbapenems, aminoglycosides, and combination therapy. These drugs are given based on the sensitivity reports of the patient's bacteria to control the infection. This can also reduce the risk of antibiotic resistance and enable better treatment. Without proper classification and knowledge of anaerobic and aerobic metabolism, it is not possible to properly control infections. It is important for clinicians to understand the types of bacteria and their nutritional requirements to select effective antibiotics and ensure successful treatment. For example, first-generation cephalosporins such as cefazolin are given before clean surgical procedures to prevent wound infection. These drugs are particularly effective against bacteria such as dermatitis and *Staphylococcus aureus*. This method helps the wound heal faster and prevents complications. Anaerobic therapy is considered essential in intestinal surgery. For this purpose, metronidazole is given with cefotetan to eliminate anaerobic bacteria in the intestines. This combination reduces the chances of infection and helps prevent complications after surgery.

Pneumococcus and *Pseudomonas* mergatoids are the most common causes of meningitis in the community. They are usually treated with high doses of ceftriaxone, vancomycin, and cephalosporins. These drugs help kill the bacteria and improve the patient's condition quickly. The Institute of Clinical Microbiology produces antibiotic maps that show the amount and sensitivity of bacteria present in a hospital or area. These maps help doctors choose effective antibiotics and help control resistant bacteria, which improves patient treatment. Evidence-based practice facilitates empirical treatment, as doctors have better evidence. At the same time, continuous improvement through cultural testing improves treatment outcomes. This approach also reduces unnecessary use of broad-spectrum antibiotics and reduces the risk of developing resistance.

CONTROL OF DRUG-RESISTANT INFECTIONS AND TUBERCULOSIS IN HOSPITALS

In addition, clustering, which involves dividing germs into groups, is highly beneficial for infection control. It detects the spread of the disease in the hospital or area, and immediate measures can be taken. In this way, timely treatment and preventive measures are taken, which ensure the safety of patients and staff. For example, if MRSA (methicillin-resistant *Staphylococcus aureus*), VRE (vancomycin-resistant enterococcus), or carbapenem-resistant bacteria are identified in a hospital or area, immediate action is taken. Detection of these resistant bacteria enables the development of more effective treatment protocols, as well as targeted quarantine and prevention strategies. Strict isolation control can effectively prevent the spread of infection in the hospital. By keeping patients separate, using protective clothing, and adopting strict hygiene rules, other patients and staff are kept safe. In this way, the transmission of germs and the emergence of epidemic situations in the hospital can be avoided. Tuberculosis (TB) is a serious disease that can affect the bones, breasts, and joints, in addition to the lungs. When tuberculosis develops into mycobacterial arthritis, it causes inflammation, pain, and difficulty in joint movement. It is treated promptly with anti-TB drugs and joint care. The bacterium has a multicolored regimen greater than that of some drug treatments. This extensive knowledge undermines microbiology and clinical medicine, while prioritizing public health in light of the emergence of bacterial hazards..

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REFERENCES

- Agrawal, R. (2024). Emerging Technologies for Improvement of Microbial Strains Using Omic Sciences and Measuring Methods for Maximum Product Formation. *Textbook of Industrial Microbiology*, 13-39.
- Barberán, A., Ramirez, K. S., Leff, J. W., Bradford, M. A., Wall, D. H., & Fierer, N. (2014). Why are some microbes more ubiquitous than others? Predicting the habitat breadth of soil bacteria. *Ecology letters*, 17(7), 794-802.
- Checinska, A., Paszczynski, A., & Burbank, M. (2015). Bacillus and other spore-forming genera: variations in responses and mechanisms for survival. *Annual review of food science and technology*, 6(1), 351-369.
- Dimri, A. G., Chaudhary, S., Singh, D., Chauhan, A., & Aggarwal, M. L. (2020). Morphological and biochemical characterization of food borne gram-positive and gram-negative bacteria. *Science Archives*, 1(1), 16-23.
- Hanif M, Maqbool S, Arif M (2007). Side effects of antimicrobial drugs, *Pediatrics*, 1(5):230-231
- Hanif M, Maqbool S, Arif M (2007). Antimicrobial drugs and their sensitivity, *Pediatrics*, 1(5):319-320.

- Hokanson, K. E. (1977). Temperature requirements of some percids and adaptations to the seasonal temperature cycle. *Journal of the Fisheries Board of Canada*, 34(10), 1524-1550.
- Nathwani D, Wood MJ (1993). Penicillins. A current review of their clinical pharmacology and therapeutic use, *Drugs*;45(6):866-894
- Phillips, I., Casewell, M., Cox, T., De Groot, B., Friis, C., Jones, R., ... & Waddell, J. (2004). Does the use of antibiotics in food animals pose a risk to human health? A critical review of published data. *Journal of antimicrobial chemotherapy*, 53(1), 28-52.
- Zengler, K. (2009). Central role of the cell in microbial ecology. *Microbiology and Molecular Biology Reviews*, 73(4), 712-729.

TABLE 1: SIDE EFFECTS OF ANTIMICROBIAL DRUGS (HANIF ET AL., 2007)

Drugs	Side effects
Penicillin G	Anaphylaxis, skin rashes, occasional hepatotoxicity
Cephalexin	GI disturbance, genital and anal pruritis, rash, fever, angioedema, neutropenia
Aztreonam	Skin rash, GI upset, local reaction at injection site
Erythrocin	GI disturbance, diarrhea, nausea, vomiting, ototoxicity
Clindamycin	Diarrhea, nausea, vomiting
Vancomycin	Ototoxicity, nephrotoxicity, phlebitis, skin rash, chills, red neck syndrome
Oxytetracycline	Tooth staining, decreased bone growth, GI upset, photosensitivity
Chloromycetin	Hematopoietic toxicity, reversible bone marrow suppression, irreversible aplasia, idiosyncratic aplastic anemia and peripheral neuritis
Gentamycin	Ototoxicity, nephrotoxicity, arachnoiditis, phlebitis and neuromuscular blockade
Trimethoprim sulfamethoxazole	Megaloblastic anemia, leucopenia, thrombocytopenia
Fusidic acid	Nausea, vomiting, rashes, jaundice and reversible hepatic dysfunction
Nalidixic acid	Nausea, vomiting, hypersensitivity reaction, rashes, pulmonary infiltration, allergic liver damage

TABLE 2: ANTIMICROBIAL DRUGS AND THEIR SENSITIVITY (HANIF ET AL, 2007)

Organism	Antibiotics are likely to be useful
<i>Rickettsia spp.</i>	Tetracycline, chloramphenicol
<i>Mycoplasma spp.</i>	Azithromycin, clarithromycin, erythromycin
<i>Strept. pneumonia</i>	Vancomycin, penicillins, erythromycin, cephalosporins, ampicillins
<i>Streptococci</i> (most species)	Penicillins, erythromycin, clindamycin, cephalosporins, ampicillins
<i>Staph. Aureus</i>	Linezolid, vancomycin, trimethoprim sulfamethoxazole, rifampin, erythromycin, clindamycin, cephalosporin, dicloxacillin, oxacillin, nafcillin
<i>Shigella spp.</i>	Quinolones, TMP-SMZ, tetracycline, chloramphenicol, cephalosporins, ampicillins
<i>Salmonella spp.</i>	Quinolones, trimethoprim-sulfamethoxazole, chloramphenicol, cephalosporins, ampicillins
<i>P. aeruginosa</i>	Quinolones, Imipenem, ceftazidime, aztreonam, piperacillin-tazocin, piperacillin, penicillins, aminoglycosides
<i>N. meningitides</i>	Rifampicin, penicillins, chloramphenicol, cephalosporins, ampicillins
<i>N. gonorrhoeae</i>	Trimethoprim sulphamethoxazole, tetracycline, spectinomycin, penicillins, cephalosporins, ampicillins
<i>Moraxella catarrhalis</i>	Trimethoprim sulfamethoxazole, erythromycin, cephalosporins, ampicillins
<i>H. influenzae</i>	Trimethoprim sulfamethoxazole, cephalosporin, ampicillin
<i>Enterobacteraceae</i>	Trimethoprim sulfamethoxazole, cephalosporins, ampicillins, aminoglycosides
<i>B. pertussis</i>	Azithromycin, clarithromycin, erythromycin
Anaerobic bacteria	Penicillins, metronizole, clindamycin, chloramphenicol