Chapter I: Major bacteria pathogenic to humans (General characteristics and pathogenicity).

-Definition of Bacteria

Bacteria are living microorganisms, just like viruses and fungi. They were discovered in the late 17th century by *Antonie van Leeuwenhoek*, a Dutch naturalist who invented microscopy.

They are prokaryotic organisms that lack a nucleus but possess circular chromosomal DNA located in the cytoplasm. Many bacteria contain another type of extrachromosomal DNA structure called a plasmid. They are surrounded by a complex cell wall and often possess flagella.

I.1. Classification of the Main Bacteria of Medical Interest

Bacteria can be classified—and thus identified—based on several parameters:

- Microscopic morphology: cocci, bacilli, single cells, paired cells, chains, clusters, etc. **(Fig. 01)**.
- Macroscopic morphology: size, shape, and color of colonies on culture.
- Gram stain result: Gram-positive – Gram-negative.
- Growth temperature.
- Respiratory requirements: strict aerobic – strict anaerobic – facultative aerobic/anaerobic – microaerophilic.
- Motility.
- Presence of spores.
- Nutritional requirements: need for specific substances.

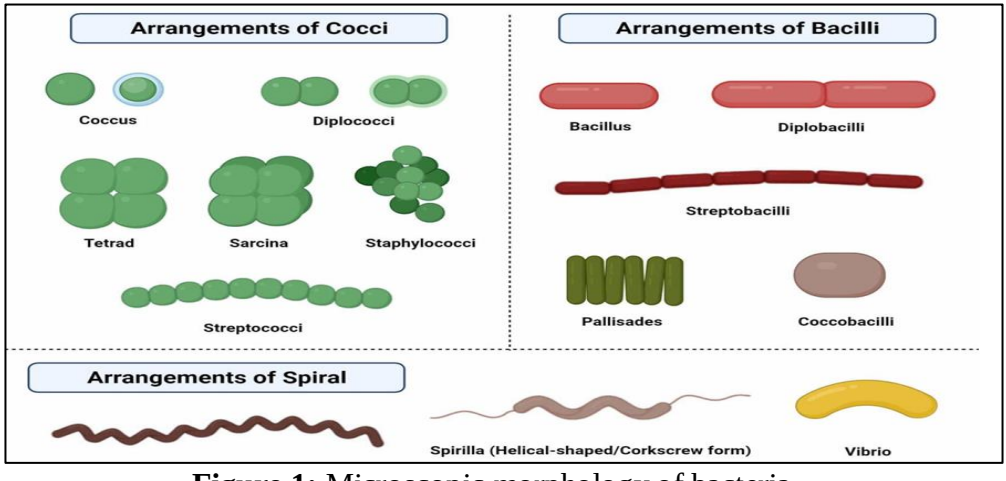


Figure 1: Microscopic morphology of bacteria.

Table 01: Classification of bacteria.

Gram-Positive Cocci		
Morphology	**Genus**	**Species**
Clustered	*Staphylococcus*	*Staphylococcus aureus, coagulase-negative staphylococcus*
In chains	*Streptococcus*	*Beta-hemolytic streptococci: Group A (pyogenes), Group B (agalactiae), Other groups: C, G, F, etc.* *Alpha-hemolytic streptococci:* *mutans, oralis, sanguis, salivarius, Miller's complex (anginosus, constellatis, intermidius)*
Diplococci	*Streptococcus*	*pneumoniae*
Short chain stitches	*Enterococcus*	*faecalis* *faecium*

Gram-negative cocci		
Morphology	**Genus**	**Species**
Diplococci	Neisseria	*meningitidis* *gonorrheae*

Gram-negative bacillus		
Morphology	**Family**	**Genus and Species**
Coccus	*Enterobacteriaceae*	*Escherichia coli* (E. coli) Klebsiella Citrobacter, *Enterobacter,Proteus, Serratia, Providencia, Morganella* Salmonella (typhimurium), *Shigella* (sonnei) *Yersinia (enterolitica)*
Coccobacilli		*Brucella melitensis,* Haemophilus (influenzae), Moraxella (catarrhalis), *Pasteurella multocida,* *Bordetella pertussis, Legionella pneumoniae,* Kingella
Strictly aerobic bacilli	*Pseudomonaceae*	*Pseudomonas aeruginosa (pyocyanic bacillus)* *Others* (Burkholderia – Stenotrophomonas, etc.)

		Acinetobacter baumannii
Vibrio	*Vibrionaceae*	*Vibrio cholerae*, Other Vibrio species, Campylobacter, *Helicobacter*

Gram-positive bacillus		
Morphology	**Genus**	**Species**
Small	*Listeria*	*monocytogenes*
	Erysipelothrix	*rhusiopathiae: swine erysipelas bacillus*
	Corynebacterium	*diphteriae: Loeffler's bacillus* *Others: coryneform bacteria*
Large	*Bacillus*	*Anthracis: anthrax bacillus* *Others*
	Nocardia	

Mycoplasmas		
Morphology	**Genus**	**Species**
Non-cell-walled	*Mycoplasma*	*pneumoniae* *hominis* *Others*
	Ureaplasma	*urealyticum*
Mycobacteria		
Morphology	**Genus**	**Species**
Alcohol- and acid-fast bacilli	*Mycobacterium*	*Tuberculosis: Koch's bacillus (BK), "atypical" bovis, BCG* *Leprae: Hansen's bacillus*
Strictly anaerobic bacteria		
Morphology	**Genus**	**Species**
Gram-positive cocci	*Peptostreptococcus*	

Gram-negative cocci	*Veillonella*	
Gram-positive bacilli	*Clostridium*, *Actinomyces*, *Peptococcus*, *Propionibacterium*	*tetani, perfringens, botulinum, difficile* *acnes*
Gram-negative bacilli	*Bacteroides, Prevotella, Fusobacterium, Porphyromonas, Eubacterium*	

- **Review of bacterial cell wall structure**

The structure of the bacterial cell wall depends on whether the bacteria belong to the Gram-positive or Gram-negative group. Both groups share an essential component specific to the bacterial world: peptidoglycan. This component gives the bacterium its shape and rigidity, enabling it to withstand intracellular osmotic pressure.

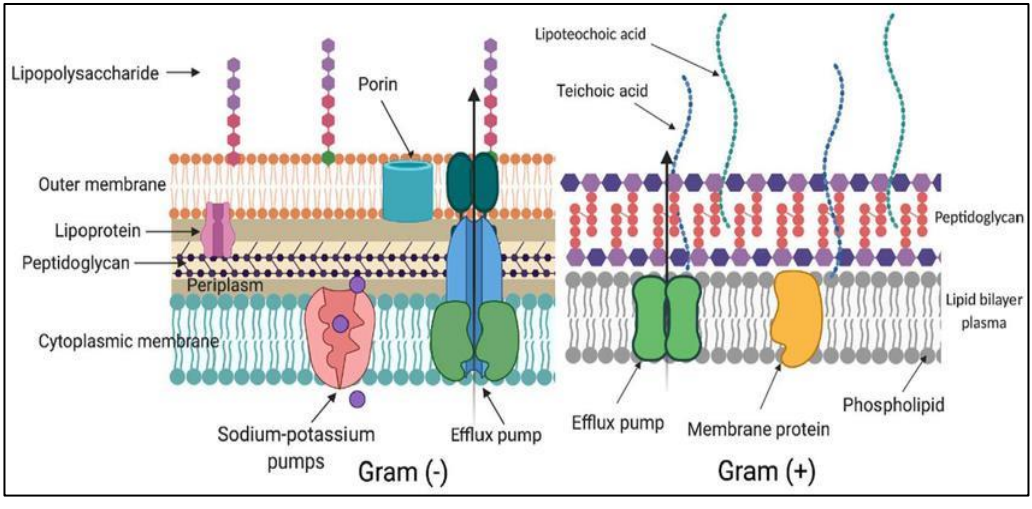


Figure 2: Structure of the bacterial cell wall in Gram-positive and Gram-negative bacteria.

-Gram-positive bacteria (GPB): Peptidoglycan is the outermost layer of the bacterium. It is thicker than in Gram-negative bacteria and surrounds the

bacterium's cytoplasmic membrane.

-Gram-negative bacteria (GNB): The bacterial cell wall contains an additional component, the outer membrane, which surrounds the peptidoglycan layer—which is thinner than in Gram-positive bacteria. The outer membrane plays a very important role in the physiology of GNBs, providing resistance to the host's defense mechanisms. Its inner layer is primarily composed of phospholipids, and its outer layer consists mainly of lipopolysaccharides (or endotoxins), which are responsible for endotoxic shock in Gram-negative infections. The space between the two membranes is called the periplasmic space; it contains not only peptidoglycan but also numerous enzymes, including beta-lactamases.

-Penicillin-binding proteins (PBPs): These are proteins anchored in the cytoplasmic membrane that protrude into the periplasmic space; they all possess enzymatic activities, notably the synthesis of peptidoglycan.

I.2. The Main Bacteria Pathogenic to Humans

I.2.1. Gram-positive cocci

I.2.1.1. Staphylococci

Staphylococci are Gram-positive cocci that are highly resistant in the external environment. The genus *Staphylococcus* comprises two species:

- *Staphylococcus aureus* (coagulase-positive staphylococcus), which has significant pathogenic potential and is implicated in community-acquired and nosocomial infections.
- **Coagulase-negative staphylococci:** opportunistic pathogens involved in nosocomial infections.

➢ **Habitat**

Humans are the primary reservoir, whether they are sick or asymptomatic carriers harboring staphylococci in the nasal passages, intestines, skin, or glandular appendages (armpits, perineum). Staphylococci also contaminate surfaces, the air, and water. Transmission occurs primarily through direct person-to-person contact and via the hands.

➢ **Bacteriological Characteristics**

They are Gram-positive cocci, grouped in clusters (grape-like clusters), tetrads, or diplococci **(Fig. 3)**; they are nonmotile, spore-free, and possess a capsule.

Staphylococci are undemanding microorganisms and can be isolated in broth or on simple solid media such as ordinary agar, blood agar, or selective agar (Chapman). They are facultative aerobes and anaerobes, ferment glucose and glycerol, and possess catalase.

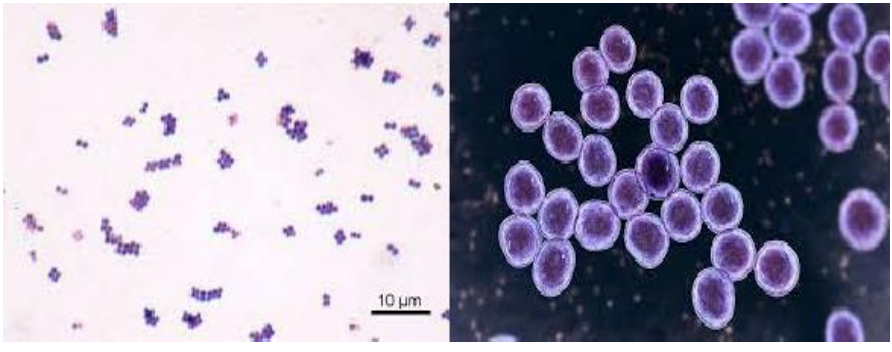


Figure 3: Staphylococci.

➢ **Pathogenicity**

These are quintessential pyogenic bacteria; *S. aureus* is the microbe responsible for suppuration. Certain strains also act by releasing one or more toxins (food poisoning, toxic shock syndrome, impetigo).

The frequency and severity of staphylococcal infections are linked to three main factors:

- the ubiquitous nature of the bacterium,
- the suppression of local and systemic immune defenses in patients undergoing intensive care, major surgical procedures, etc.,
- and the frequent antibiotic resistance of staphylococci, particularly hospital-acquired staphylococci.

The different forms of staphylococcal infections are:

•**Skin forms:** more or less severe involvement of the pilosebaceous follicles (folliculitis, boils, carbuncles), periungual involvement (onychitis, perionychitis), and involvement of the subcutaneous tissue (whitlow, phlegmons). Some superficial forms (impetigo) can lead to severe bullous lesions when the staphylococcal strain produces exfoliatin.

•**Mucosal forms:** otitis, sinusitis, conjunctivitis.

•**Generalized forms:**

- **Septicemia** following an initial cutaneous-mucosal focus: spread via the veins. This is observed primarily in individuals with weakened immune systems, those who have suffered trauma, those undergoing major surgery, patients in intensive care units, diabetics, etc., as well as the elderly and infants.
- **Intestinal forms:** either food poisoning due to the absorption of preformed toxins in food contaminated by enterotoxin-producing staphylococci, or acute pseudomembranous staphylococcal enterocolitis.

I.2.1.2. Streptococci

Bacteria of the genus *Streptococcus* are Gram-positive, catalase-negative cocci with anaerobic metabolism. The genus *Streptococcus* includes streptococci in the strict sense and pneumococci.

➢ **Habitat**

Streptococci comprise numerous species. Some are pathogens of humans (Lancefield groups A, C, and G streptococci), while others are commensals of the oral mucosa (Group B streptococci and ungrouped, non-hemolytic streptococci), the genital mucosa (Group B), or the intestine (formerly Group D streptococci or enterococci, now considered part of a separate genus, Enterococcus). Still others are commensals of animals or saprophytic.

➢ **Bacteriological Characteristics**

Streptococci are Gram-positive cocci of irregular size and shape, grouped in more or less long and sinuous chains; they are nonmotile, acapsular, and asporulate **(Fig. 4).**

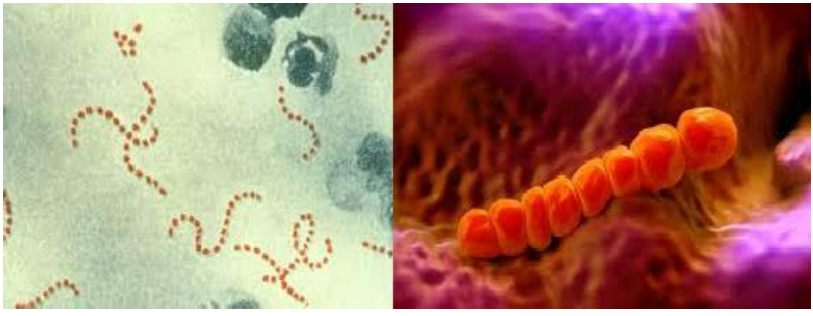


Figure 4: Streptococci.

Streptococci are fastidious bacteria that do not grow on ordinary culture media. These media must be supplemented with serum or fresh blood. On blood agar, they form small, grayish, translucent, semolina-like colonies surrounded by a zone of complete hemolysis (beta hemolysis) for Group A, C, and G streptococci, whereas other streptococci produce partial hemolysis (alpha hemolysis) or no hemolysis at all.

➢ **Pathogenicity**

Streptococci are the second most common pyogenic bacteria after staphylococci. The most pathogenic among them is Lancefield Group A beta-hemolytic streptococcus, known as *Streptococcus pyogenes*, which is responsible for the majority of streptococcal infections.

- **Diseases caused by Group A, C, and G streptococci.**

Group A, C, and G streptococci, which are beta-hemolytic, have similar pathogenicity. They are responsible for the following conditions:

- **Angina (acute tonsillitis):** This is the most common streptococcal infection, characterized by a fever of 39–40°C, difficulty swallowing due to tonsillar inflammation, regional lymphadenopathy, headache, and fatigue.

-Scarlet fever is an infectious disease caused by a bacterium: group A beta-hemolytic streptococcus. It presents with high fever, sore throat, and a rash. It primarily affects children aged 5 to 10 during the winter.

-Bacteremia is often secondary to a local infection. This is the case with puerperal fever, which follows a postpartum genital infection. Acute endocarditis and meningitis should also be mentioned.

-Other acute infections: cutaneous, mucosal, or septicemic. Some are localized, such as impetigo (in children: lesions on the face and hands), or infections of wounds and burns.

- **Diseases caused by other streptococci**

These may include acute infections:

• genital infections caused by Group B streptococci,

• severe neonatal infections: sepsis, meningitis caused by Group B streptococci,

• affecting various sites (brain abscesses, cholecystitis, etc.).

I.2.1.3. Pneumococci

Streptococcus pneumoniae is commonly known as pneumococcus and shares the metabolic properties of bacteria of the genus Streptococcus. It is the leading cause of pneumonia, meningitis, otitis, and sinusitis.

- **Habitat**

A strictly human commensal bacterium of the upper respiratory tract. It colonizes the nasopharynx of 5 to 10% of adults and 20 to 50% of children, with seasonal variations.

Transmission is strictly person-to-person and non-epidemic, but pneumococcal disease most often has an endogenous origin.

- **Bacteriological characteristics**

Lanceolate, candle-flame-shaped diplococci; Gram-positive, encapsulated, non-spore-forming, non-motile **(Fig. 5)**. Primarily anaerobic but oxygen-tolerant. These are fastidious bacteria that require nutrient agar enriched with fresh blood and selective agar for growth. The colonies are alpha-hemolytic, sometimes mucoid. The polysaccharide capsule allows pneumococci to be classified into 91 serotypes.

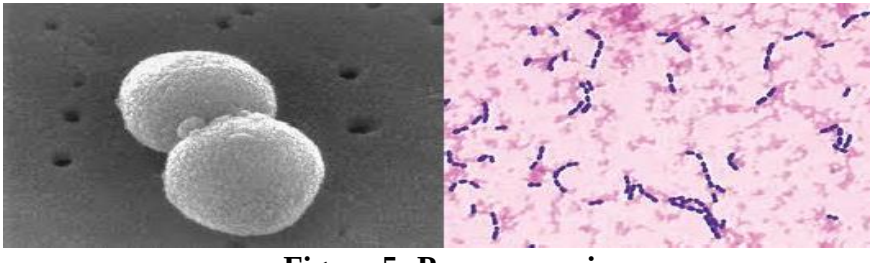


Figure 5: Pneumococci.

- **Pathogenicity**

When general or local immunity is compromised—due to abnormalities of the respiratory tract, intoxication (alcohol), circulatory disorders, malnutrition,

splenectomy, etc.—pneumococci can actively multiply in the respiratory tract. They cause:

- Local and regional conditions (respiratory tract infections): bronchitis, tracheobronchitis, sinusitis, otitis, conjunctivitis, acute lobar pneumonia (accompanied by bacteremia in 15 to 25% of cases), and pleurisy. Pneumococcal pneumonia accounts for 60 to 80% of all bacterial pneumonias.

-Distant complications:

- **Neuromeningeal infections:** primary or secondary meningitis
- **Bacteremia**
- **Others**: Arthritis, urethritis, peritonitis.

I.2.1.4. Enterococci

Enterococci are Gram-positive cocci that are commensals of the gastrointestinal tract. They cause urinary tract infections and endocarditis. The most commonly isolated species are: *Enterococcus faecalis* (80–90%) and, to a lesser extent, *Enterococcus faecium* (5–10%).

➢ Habitat

These are ubiquitous bacteria. They are primarily found in the digestive flora of humans and animals. They colonize the skin through contact contamination, particularly in the perineal region and the vagina. They are also found in the environment—sewage, freshwater, soil—and can contaminate food.

➢ Bacteriological Characteristics

Ovoid, Gram-positive cocci, arranged in short chains, rarely encapsulated, non-spore-forming, and non-motile **(Fig. 6)**.



Figure 6: Enterococci.

These bacteria are facultative aerobes and anaerobes; they grow on nutrient agar and selective agar media. They are hardy bacteria that thrive in harsh conditions and hydrolyze esculin. The colonies are non-hemolytic (though some strains are beta-hemolytic).

- **Pathogenicity**

-Urinary tract infections: The most common site of infection, often occurring in situations with a high risk of complications, such as those related to medical procedures (following urological examinations), catheter-associated infections, recurrent infections, or in patients who have received antibiotic therapy that promotes the proliferation of enterococci at the expense of enterobacteria.

-Subacute **endocarditis** affecting native or prosthetic valves, occurring following gastrointestinal or urological procedures.

-Abdominal and pelvic infections: Enterococcal superinfections are frequently polymicrobial in nature.

-Infections of the skin and soft tissues.

-Neonatal infections

-Bacteremias: These are associated with a high mortality rate, which is more closely linked to the patient's underlying condition than to the bacterium's pathogenicity.

I.2.2. Gram-negative cocci: *Neisseria*

Bacteria of the genus *Neisseria* are characterized by a distinctive morphology: flattened diplococci resembling coffee beans; they are strict aerobes and oxidase-positive.

Two species are pathogenic to humans:

Neisseria meningitidis, a pathogen frequently identified in cases of cerebrospinal meningitis.

Neisseria gonorrhoeae, the causative agent of gonococcal infection, blennorrhea, or gonorrhea.

I.2.2.1. *Neisseria meningitidis*

The meningococcus, *Neisseria meningitidis*, is the causative agent of meningitis.

- **Habitat**

A bacterium found exclusively in humans that cannot survive in the environment. Its only known niche is the human nasopharynx, where it colonizes approximately 5 to 15 percent of a given population. Many individuals are asymptomatic carriers and play a crucial role in the epidemiology of the disease.

- **Bacteriological characteristics**

These are nonmotile, Gram-negative cocci, occurring as flattened diplococci or tetrads (Fig. 7), and are strict aerobes (though they require CO_2 enrichment). They are fragile bacteria that are sensitive to temperature fluctuations, hence the need for rich culture media such as cooked blood agar or chocolate agar, with or

without supplements.

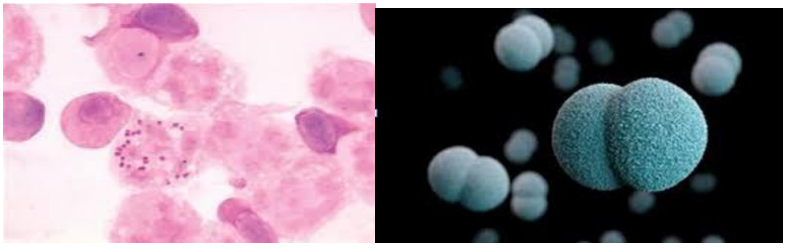


Figure 7: *Neisseria meningitidis*.

The capsule plays a key role in the bacterium's virulence by conferring resistance to phagocytosis. All virulent strains are encapsulated.

Capsular polysaccharides allow meningococci to be classified into serogroups based on agglutination: At least 12 different serogroups (A, B, C, X, Y, Z, 29 E, W135, etc.) have been identified. Infections are caused by serogroups A, B, C, and, more recently, W135.

- **Pathogenicity**

-Meningitis is the most common complication of meningococcal infection. It onset abruptly and causes headaches, vomiting, and neck stiffness; if left untreated, it progresses to coma within a few hours.

In some individuals, particularly young people living in communal settings, meningococcal bacteria multiply and cause contagious nasopharyngitis, which can be epidemic or sporadic. This condition occurs mainly during the winter and spring.

In a very small percentage of cases (1%), the bacteria can enter the bloodstream, leading to bacteremia (meningococcemia) with fever and a hemorrhagic rash (petechiae, purpura).

I.2.2.2. *Neisseria gonorrhoeae*

Neisseria gonorrhoeae is a bacterium very closely related to N. meningitidis and should be considered a "subtype" of N. meningitidis that has adapted to a different niche, since its preferred site is the urogenital tract. There is no routine typing technique. A major difference is the absence of a polysaccharide capsule in N. gonorrhoeae.

- **Habitat**

As with *N. meningitidis*, the only known host for *N. gonorrhoeae* is humans, and the bacterium does not survive in the environment. However, its niche is different, as it is the urogenital tract.

- **Bacteriological characteristics**

These are diplococcal cocci with flattened ends, Gram-negative, and nonmotile **(Fig. 8)**. They are strict aerobic bacteria (but require CO_2 enrichment). These are fragile bacteria that are highly sensitive to temperature fluctuations and grow slowly over 3 to 4 days on selective enriched media (boiled blood agar and chocolate agar). The colonies are grayish, shiny, and irregular. *N. gonorrhoeae* lacks a polysaccharide capsule.

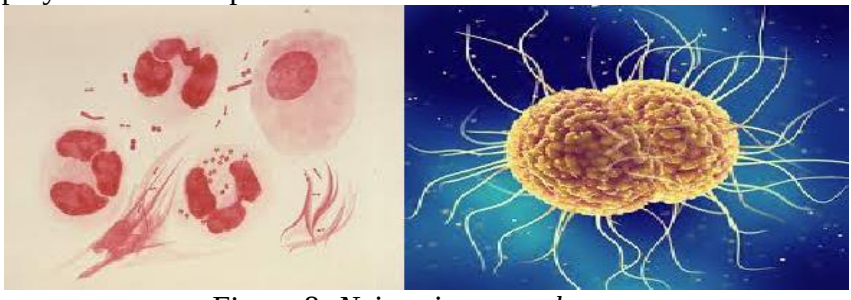


Figure 8: *Neisseria gonorrhoeae*.

- **Pathogenicity**

Neisseria gonorrhoeae is the causative agent of the most common sexually transmitted disease (STD), gonorrhea. Transmission occurs exclusively through sexual contact.

In women, the risk of infection after sexual intercourse with an infected partner is 75 to 90 %. The infection is most often asymptomatic or presents with only mild symptoms. In men, however, the risk of infection averages 35%, and the infection is accompanied by severe inflammation leading to urethritis

I.2.3. Spore-forming Gram-positive bacilli: *C. perfringens, C. tetani, C. botulinum, C. difficile*.

- Gram-positive bacilli of the genus *Clostridium.*
- Four species: *C. perfringens, C. tetani, C. botulinum, C. difficile.*
- Most species are motile and possess peritrichous flagella.
- They are anaerobic, soil-dwelling, spore-forming bacteria found in soil, air, and dust.

- **Habitat**

- Human and animal intestines
-Environment: soil, plants, etc.

- **Bacteriological characteristics**

Clostridium tetani	Very slender, Gram-positive, encapsulated bacilli with a pinhead-shaped terminal spore; highly motile. Strictly anaerobic; forms a mat on blood agar; has a smell of burnt horn.
Clostridium perfringens	Gram-positive, encapsulated bacilli; spores not visible; nonmotile. Strictly anaerobic; grows on blood agar, forming large colonies.
Clostridium botulinum	Straight, stout bacilli; Gram-positive, encapsulated, and spore-forming; motile. Strictly anaerobic; grows on blood agar, forming large, hemolytic colonies.
Clostridium difficile	Fairly slender, straight bacilli, encapsulated and spore-forming, motile. Strictly anaerobic; grows on blood agar, which is highly sensitive to oxygen, with a manure-like odor.

- **Pathogenicity**

Clostridium tetani	Tetanus: is a toxic infection that affects humans and other animals. It is caused by a local infection with the bacterium *C. tetani*, which produces a neurotoxin—tetanospasmin—that targets the central nervous system.
Clostridium perfringens	Gas gangrene, postpartum bacteremia, necrotizing pneumonia (toxin A), necrotizing enterocolitis (toxin B), mild cases of food poisoning.
Clostridium botulinum	Botulism: generally caused by toxin poisoning (ingestion of preformed toxin in food) but much more rarely by a toxin-mediated infection: due to a wound, in newborns, or in immunocompromised individuals.
Clostridium difficile	Pseudomembranous colitis following antibiotic therapy Rarely: peritonitis, intra-abdominal abscess, surgical wound infection.

I.2.4. Non-spore-forming Gram-positive bacilli: *Corynebacterium diphtheriae*.

- **Habitat**

Corynebacterium diphtheriae is a strict human pathogen. It is transmitted from

person to person via the respiratory route (through saliva particles from infected individuals or carriers). Sources of infection include patients and asymptomatic carriers. It is relatively resistant in the external environment. It is rarely isolated from soil contaminated with various human excretions.

- **Bacteriological Characteristics**

Gram-positive, nonmotile bacillus, without spores or a capsule, coryneform in shape (slightly curved with rounded ends), arranged in palisade formations **(Fig. 09)** or in a letter-like pattern; catalase-positive; grows under both aerobic and anaerobic conditions: at , it exhibits both respiratory and fermentative metabolism.

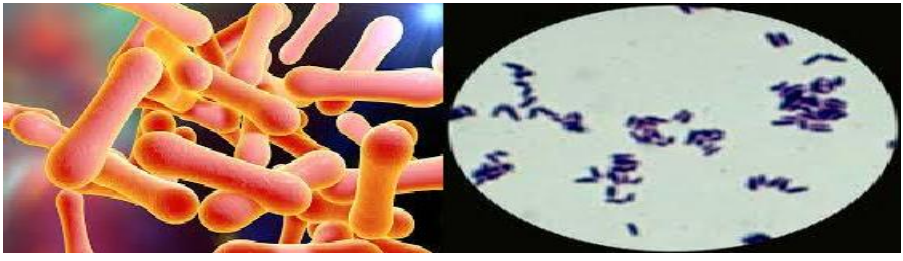


Figure 09: *Corynebacterium diphtheriae*.

Corynebacteria encountered in pathology are demanding with regard to many growth factors; they grow well only on rich media (blood agar), producing small, grayish, granular colonies with irregular edges.

- **Pathogenicity**

Corynebacterium diphtheriae is the causative agent of diphtheria. This respiratory disease has become rare due to the implementation of mandatory vaccination. Diphtheria is caused by strains that produce diphtheria toxin originating from a pharyngeal focus (pseudomembranous tonsillitis), with systemic effects of the toxin in peripheral tissues (paralysis—ocular and cardiac disorders).

The disease begins with a febrile sore throat with pseudomembranes, usually located on the pillars of the soft palate, accompanied by a significant lymph node reaction (known as a “proconsular” neck). Signs of toxicity appear rapidly and lead to prostration. They may be accompanied by dyspnea due to obstruction of the upper airways (larynx and trachea) by the pseudomembrane (croup). Aside from croup, cardiac (myocarditis) and neurological (dysphagia and paralysis) complications dominate the prognosis. In vaccinated individuals, diphtheria presents as a mild sore throat or pseudomembranous sore throat but without systemic symptoms.

Non-toxin-producing strains cause bacteremia affecting various sites (endocarditis, arthritis, etc.), often originating from a cutaneous focus.

I.2.5. Gram-negative bacilli: Enterobacteria.

➢ General Characteristics and Classification of Enterobacteria

Enterobacteria belong to a large family of Gram-negative bacilli (GNB). This family comprises several genera, species, and serotypes. The most recent classification (DNA-DNA hybridization) identifies 31 genera and more than 140 species. Of all the described genera and species, about twenty are involved in human disease: *Escherichia coli*, *Shigella*, *Salmonella*, *Citrobacter*, *Klebsiella*, *Enterobacter*, *Proteus*, etc.

➢ Habitat

The name "enterobacteria" was given because these bacteria are generally normal or pathogenic inhabitants of the digestive tract of humans and animals. The environment (soil, water, plants) can be contaminated by fecal matter and constitutes a source of indirect contamination.

➢ Bacteriological Characteristics

Enterobacteria, which comprise several genera, are Gram-negative bacilli that are motile due to peritrichous cilia; some are nonmotile (*Klebsiella*, *Shigella*, *Yersinia pestis*). They are facultative aerobes and anaerobes and grow on standard media. They lack oxidase and are capable of fermenting glucose, as well as reducing nitrates to nitrites. The differences among the numerous genera and species are based on more specific criteria, such as the fermentation of various sugars, the production or absence of sulfide, and the presence or absence of metabolic enzymes.

➢ Pathogenicity

In humans, it is important to distinguish between:

- **Opportunistic pathogenic enterobacteria** may originate from the normal resident commensal gut flora (*E. coli*, *Klebsiella*, *Enterobacter*, *Serratia*, *Proteus*, etc.)

The infections they can cause have an endogenous origin; examples include:

- Urinary tract infections
- Intra-abdominal infections (cholecystitis, appendicitis)
- Sepsis originating in the urinary tract or intra-abdominal cavity
- Respiratory superinfection

-Specific pathogenic enterobacteria that are not found as commensals (except in healthy carriers) and whose presence in the external environment is only temporary. The diseases they cause are due to poor hygiene, and contamination occurs either through direct contact or via a vector (food or animal). Examples include: typhoid fever caused by *Salmonella Typhi*, and foodborne illnesses caused by minor

Salmonella species, *Shigella*, and Yersinia.

I.2.5.1. *Escherichia coli*

Escherichia coli (*E. co*li) is a motile enterobacterium capable of fermenting lactose and producing indole; it is oxidase-negative, facultatively aerobic and anaerobic, and grows on standard media, forming smooth, rounded colonies with regular edges.

- **Habitat**

E. coli is a commensal of the digestive tract in humans and many animals. It alone accounts for the majority of the aerobic bacterial flora of the intestine (dominant aerobic species), at a concentration of 10^8per gram of feces (total flora: 10^{11} to 10^{12}bacteria per gram).

- **Pathogenicity**

Enterocolic infections, urinary tract infections, foodborne illnesses, intra-abdominal infections (cholecystitis, peritonitis, etc.), septicemia, neonatal infections (meningitis).

I.2.6. Mycobacteria: *Mycobacterium tuberculosis*, atypical mycobacteria.

The genus *Mycobacterium* is the only genus in the family Mycobacteriaceae. In practice, mycobacteria are classified as:

- Tuberculous mycobacteria: tubercle bacilli (TB). This is a complex comprising the following species: *M. tuberculosis*, *M. bovis*, *M. africanum*.
- Nontuberculous mycobacteria: *M. leprae* (the causative agent of leprosy),
- **Other atypical mycobacteria**: opportunistic infections in immunocompromised patients.

I.2.6.1. *Mycobacterium tuberculosis*

- **Habitat**

M. tuberculosis is a strict parasite of humans. Transmission is direct: from person to person via the airborne route (inhalation of contaminated respiratory droplets). Pets may occasionally become infected.

- **Bacteriological characteristics**

Bacteria of the genus *Mycobacterium* are nonmotile, straight or slightly curved bacilli that are strictly aerobic, non-spore-forming, and non-encapsulated **(Fig. 10)**.

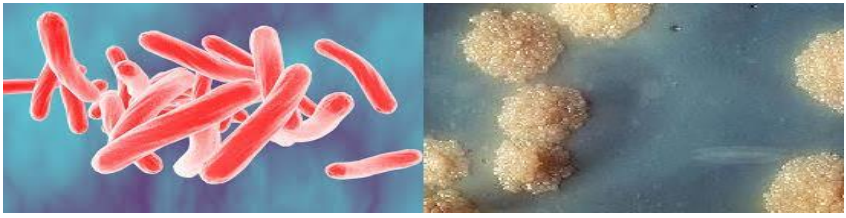


Figure 10: Morphology and colonies of *Mycobacterium tuberculosis*.

Their cell wall is rich in long-chain fatty acids (60 to 90 carbon atoms). These fatty acids, called mycolic acids, make the cell wall relatively impermeable to stains: acid-fast resistance. *M. tuberculosis* does not grow on standard media. It requires highly enriched media. The most commonly used medium is the Lowenstein-Jensen medium. On this medium, it produces distinctive cream-beige, dry colonies with a rough, cauliflower-like surface. Importantly, colonies appear only after an average of 21 days (*M. tuberculosis* division time = 20 hours).

- **Pathogenicity**

The pathogenicity of mycobacteria is not linked to the secretion of toxins, enzymes, or other metabolites; rather, it depends on the host's anti-tuberculosis immunity (the role of macrophages and competent T lymphocytes).
M. tuberculosis causes two types of infections:

- **Pulmonary tuberculosis:** the most common form (90% of cases), characterized by a slowly progressive cough plus general symptoms (fever of 38°C, profuse night sweats, loss of appetite and weight loss, and weakness)
- **Extrapulmonary tuberculosis:** sometimes, hematogenous spread is responsible for extrapulmonary forms involving multiple sites: meningitis, lymph node involvement, peritoneal involvement, and osteoarticular involvement.

I.2.6.2. Atypical Mycobacteria

There are many mycobacteria in nature other than those causing human tuberculosis, and their cultural and biochemical characteristics are quite distinctive. These mycobacteria have been termed atypical mycobacteria.
Some are animal parasites (*M. avium*, *M. marinum*, etc.), while others are saprophytes (*M. gordonae*, *M. chelonae*, *M. flavescens*, etc.). They are usually isolated as contaminants in cultures, but to varying degrees, all are capable of multiplying in humans and causing diseases that mimic tuberculosis, known as mycobacterioses. These conditions occur primarily in individuals with local immune deficiency (residual pulmonary cavitary lesions) or generalized immune deficiency of a therapeutic nature (organ transplant recipients) or pathological

origin (cancer, AIDS).
Their diagnosis is purely bacteriological. *M. avium* is the atypical mycobacterium most frequently isolated in patients with AIDS, in whom it causes generalized septicemic infections. Blood culture is therefore the best method for diagnosis. The treatment of mycobacterial infections is very difficult due to the typical natural resistance of atypical mycobacteria to antituberculosis antibiotics. Clarithromycin, a new macrolide similar to erythromycin, is, however, active against *M. avium*.