

UNIT I – GENERAL MICROBIOLOGY

1. Introduction, History, Scope, Aim & Objectives

Landmark Contributions (Father-of List)

Antony van Leeuwenhoek — First to see 'animalcules' with simple microscope — Father of Microbiology. **Louis Pasteur** — Disproved spontaneous generation (swan-neck flask), pasteurisation, attenuated vaccines (anthrax, rabies), sterilisation — Father of Bacteriology / Immunology. **Robert Koch** — Solid media, pure culture, Koch's postulates, discovered tubercle bacillus & cholera vibrio — Father of Medical Microbiology.

Joseph Lister — Antiseptic surgery using carbolic acid (phenol) — Father of Antiseptic Surgery. **Edward Jenner** — Cowpox inoculation → smallpox vaccine — Father of Immunisation. **Paul Ehrlich** — Salvarsan (arsphenamine) for syphilis, side-chain theory — Father of Chemotherapy.

Alexander Fleming — Penicillin from *Penicillium notatum* (1929); lysozyme. **Elie Metchnikoff** — Phagocytosis — cellular theory of immunity. **Hans Christian Gram** — Gram stain (1884)

W.D. Miller — Chemico-parasitic theory of dental caries — Father of Oral Microbiology. **Miller & Black** — Established microbial basis of caries & periodontal disease.

Koch's Postulates & Their Limitations

Organism found in all cases of disease, absent in healthy — Carriers exist (*S. typhi*, *N. meningitidis*); commensals turn pathogenic. **Must be isolated in pure culture** — *M. leprae*, *T. pallidum*, viruses cannot be grown on artificial media. **Must reproduce disease in susceptible animal** — No animal model for gonorrhoea, typhoid.

Must be re-isolated from experimental animal — Not fulfilled for many viral/prion diseases. **(Added) Specific antibody must develop** — Molecular Koch's postulates now used for virulence genes.

Branches & Scope Relevant to Dentistry

Bacteriology — Deals with: Bacteria; Dental Relevance: Caries, periodontitis, abscess, osteomyelitis. **Virology** — Deals with: Viruses; Dental Relevance: Herpes labialis, HBV/HIV cross-infection, mumps. **Mycology** — Deals with: Fungi; Dental Relevance: Oral candidiasis, denture stomatitis.

Parasitology — Deals with: Protozoa & helminths; Dental Relevance: *Entamoeba gingivalis*, *Trichomonas tenax*. **Immunology** — Deals with: Host defence; Dental Relevance: Vaccination, hypersensitivity to LA/latex, autoimmune oral lesions. **Oral microbiology** — Deals with: Oral ecosystem; Dental Relevance: Plaque biofilm, caries, halitosis, focal infection.

High-Yield Pearls

Aim of Microbiology in BDS: understand aetiology, transmission, diagnosis, prevention & control of oral and systemic infections and to practise safe, infection-free dentistry. Spallanzani & Redi opposed spontaneous generation; Pasteur finally disproved it. Nobel Prize: Koch (1905, TB), Fleming–Florey–Chain (1945, penicillin), Metchnikoff & Ehrlich (1908, immunity).

CLINICAL IMPORTANCE OF THIS CHAPTER FOR DENTAL SURGEONS

1. Microbiology is the scientific foundation of every infection-control protocol the dental surgeon follows daily.
2. Koch's postulates explain why dental caries and periodontitis are 'polymicrobial' — no single organism fulfils them, which is why treatment targets the biofilm, not one species.
3. Understanding that commensals turn opportunistic explains post-antibiotic candidiasis and post-extraction infections.
4. Lister's antiseptic principle is the direct ancestor of chlorhexidine rinses, surgical scrubbing and operator disinfection.
5. Pasteur's attenuation principle underlies the BCG and hepatitis B vaccination that protect dental personnel.
6. W.D. Miller's chemico-parasitic theory remains the working basis of caries prevention — diet counselling, fluoride and plaque control.

MCQs FOR MDS ENTRANCE EXAMINATIONS

1. Father of Oral Microbiology is

- (a) Louis Pasteur (b) W.D. Miller (c) Robert Koch (d) Joseph Lister

Ans. (b) W.D. Miller — W.D. Miller proposed the chemico-parasitic theory of dental caries and is regarded as the Father of Oral Microbiology.

2. Koch's postulates CANNOT be applied to

- (a)
- Staphylococcus aureus*
- (b)
- Mycobacterium leprae*
- (c)
- Escherichia coli*
- (d)
- Vibrio cholerae*

Ans. (b) *Mycobacterium leprae* — *M. leprae* cannot be cultured on artificial media, so the second postulate cannot be satisfied.

3. Antiseptic surgery using carbolic acid was introduced by

- (a) Lister (b) Semmelweis (c) Jenner (d) Ehrlich

Ans. (a) Lister — Joseph Lister used phenol (carbolic acid) spray, founding antiseptic surgery.

4. Swan-neck flask experiment disproved

- (a) Germ theory (b) Spontaneous generation (c) Phagocytosis (d) Humoral theory

Ans. (b) Spontaneous generation — Pasteur's swan-neck flask showed microbes come from the air, disproving abiogenesis.

5. 'Animalcules' were first described by

- (a) Koch (b) Leeuwenhoek (c) Fleming (d) Metchnikoff

Ans. (b) Leeuwenhoek — Antony van Leeuwenhoek first visualised bacteria with his simple microscope in 1676.

6. Salvarsan was introduced for the treatment of

- (a) Tuberculosis (b) Syphilis (c) Leprosy (d) Diphtheria

Ans. (b) Syphilis — Paul Ehrlich's arsphenamine (Salvarsan, '606') was the first effective drug for syphilis.

7. Phagocytosis as a defence mechanism was described by

- (a) Ehrlich (b) Metchnikoff (c) Bordet (d) Landsteiner

Ans. (b) Metchnikoff — Elie Metchnikoff proposed the cellular (phagocytic) theory of immunity.

8. Solid culture media and pure culture technique were introduced by

- (a) Pasteur (b) Koch (c) Gram (d) Neisser

Ans. (b) Koch — Robert Koch introduced solid media, enabling isolation of pure cultures.

9. Molecular Koch's postulates are applied to

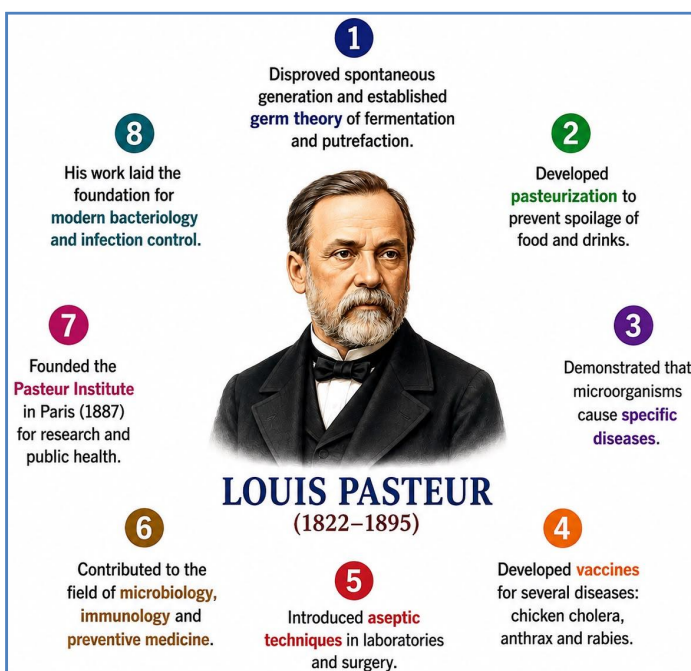
- (a) Vaccine strains (b) Virulence genes (c) Culture media (d) Antisera

Ans. (b) Virulence genes — Falkow's molecular postulates link specific genes to virulence rather than whole organisms.

10. Penicillin was discovered from

- (a)
- Penicillium notatum*
- (b)
- Aspergillus niger*
- (c)
- Streptomyces griseus*
- (d)
- Bacillus subtilis*

Ans. (a) *Penicillium notatum* — Fleming observed lysis of staphylococci around *Penicillium notatum* in 1929.



LOUIS PASTEUR
(1822–1895)

- Disproved spontaneous generation and established germ theory of fermentation and putrefaction.
- Developed **pasteurization** to prevent spoilage of food and drinks.
- Demonstrated that microorganisms cause **specific diseases**.
- Developed **vaccines** for several diseases: chicken cholera, anthrax and rabies.
- Introduced **aseptic techniques** in laboratories and surgery.
- Contributed to the field of **microbiology, immunology and preventive medicine**.
- Founded the **Pasteur Institute** in Paris (1887) for research and public health.
- His work laid the foundation for **modern bacteriology and infection control**.



ANTONY VAN LEEUWENHOEK
(1632–1723)

- First person to observe and describe microorganisms using a single-lens microscope of his own design.
- Observed **bacteria** in dental plaque, soil, water, and other places.
- Discovered and described **protozoa**, such as *Amoeba* and *Paramecium*.
- First to observe **spermatozoa** in semen of animals.
- Made over **300 detailed** drawings of microorganisms that he observed.
- Considered the "**Father of Microbiology**".
- His observations laid the foundation for the **science of microbiology**.
- Demonstrated that microorganisms are **ubiquitous in nature**.

UNIT I – GENERAL MICROBIOLOGY

2. Morphology & Physiology of Bacteria

Bacterial Cell Structures – Structure vs Function

Cell wall — *Composition*: Peptidoglycan (murein) = NAG + NAM + tetrapeptide; *Function / Clinical Note*: Shape & rigidity; target of penicillin; absent in Mycoplasma. **Gram +ve wall** — *Composition*: Thick peptidoglycan (50–80%), teichoic acid; *Function / Clinical Note*: Retains crystal violet; teichoic acid = adhesion & antigenicity. **Gram -ve wall** — *Composition*: Thin peptidoglycan + outer membrane, LPS, periplasm; *Function / Clinical Note*: LPS (endotoxin) = lipid A (toxic) + core + O antigen; decolourised by alcohol.

Capsule — *Composition*: Polysaccharide (polypeptide in B. anthracis); *Function / Clinical Note*: Antiphagocytic; virulence; Quellung reaction; vaccine antigen. **Flagella** — *Composition*: Flagellin protein; *Function / Clinical Note*: Motility; H antigen; arrangements: monotrichous, lophotrichous, amphitrichous, peritrichous. **Fimbriae / Pili** — *Composition*: Pilin; *Function / Clinical Note*: Common pili = adhesion; sex pilus = conjugation (F factor)

Spore — *Composition*: Dipicolinic acid + Ca^{2+} , keratin coat; *Function / Clinical Note*: Resistance to heat/chemicals; sterilisation control (B. stearothermophilus). **Cell membrane** — *Composition*: Phospholipid bilayer (no sterols except Mycoplasma); *Function / Clinical Note*: Permeability, respiration, mesosome formation. **Ribosome** — *Composition*: 70S (50S + 30S); *Function / Clinical Note*: Target of aminoglycosides, macrolides, tetracyclines.

Nucleoid / Plasmid — *Composition*: Circular ds-DNA, haploid; *Function / Clinical Note*: Plasmids carry R (resistance) & virulence genes.

Shapes, Arrangements & Examples

Coccus — *Arrangement*: Clusters (grape-like); *Example*: Staphylococcus aureus. **Coccus** — *Arrangement*: Chains; *Example*: Streptococcus mutans, S. pyogenes. **Coccus** — *Arrangement*: Pairs — lanceolate; *Example*: Streptococcus pneumoniae.

Coccus — *Arrangement*: Pairs — kidney/coffee-bean; *Example*: Neisseria. **Bacillus** — *Arrangement*: Chinese-letter / cuneiform; *Example*: Corynebacterium diphtheriae. **Bacillus** — *Arrangement*: Bamboo-stick chains; *Example*: Bacillus anthracis.

Bacillus — *Arrangement*: Drumstick (terminal spore); *Example*: Clostridium tetani. **Spirochaete** — *Arrangement*: Regular coils; *Example*: Treponema pallidum. **Vibrio** — *Arrangement*: Comma / fish-in-stream; *Example*: Vibrio cholerae.

Filamentous — *Arrangement*: Branching, sulphur granules; *Example*: Actinomyces israelii.

Growth, Nutrition & Physiology

Growth curve — Lag → Log (exponential; most sensitive to antibiotics) → Stationary (toxin/spore formation) → Decline. **Generation time** — E. coli 20 min; M. tuberculosis 15–20 h; M. leprae ~14 days. **O₂ requirement** — Obligate aerobe (M. tuberculosis), obligate anaerobe (Clostridium, Bacteroides), facultative (E. coli), microaerophilic (Campylobacter), capnophilic (5–10% CO₂ — Brucella abortus, A. actinomycetemcomitans)

Temperature — Mesophiles 25–40 °C (most pathogens, optimum 37 °C); psychrophiles; thermophiles. **pH** — 6.8–7.4 optimum; lactobacilli acidophilic (grow at pH 4–5 — caries). **Reproduction** — Binary fission; genetic exchange by transformation, transduction, conjugation.

Mnemonics & Memory Aids

Anaerobes of dental interest — 'BAP-VF': Bacteroides, Actinomyces, Peptostreptococcus, Veillonella, Fusobacterium.

The Prokaryotic Cell

Bacteria are prokaryotes — they lack a membrane-bound nucleus and membrane-bound organelles. The bacterial chromosome is a single circular double-stranded DNA (dsDNA) molecule located in an electron-dense region called the nucleoid. Ribosomes are 70S (50S + 30S subunits), which is clinically important as the target of many antibiotics.

Table — Prokaryote vs Eukaryote Comparison

Feature	Prokaryote (Bacteria)	Eukaryote (Human/Fungal cells)
Nucleus	No membrane-bound nucleus; nucleoid region	True membrane-bound nucleus
Chromosome	Single circular dsDNA; no histones	Multiple linear dsDNA; with histones
Ribosome	70S (50S + 30S) — antibiotic target	80S (60S + 40S)
Cell wall	Peptidoglycan (absent in Mycoplasma)	Absent (animals); chitin (fungi); cellulose (plants)

Feature	Prokaryote (Bacteria)	Eukaryote (Human/Fungal cells)
Membrane sterols	Absent (except Mycoplasma)	Present — cholesterol (animals); ergosterol (fungi)
Size	0.2–10 µm	10–100 µm
Division	Binary fission	Mitosis / meiosis
Plasmids	Common	Rare

Bacterial Shapes & Arrangements

Shape	Term	Arrangement Terms	Clinical Examples
Sphere	Coccus	Diplococcus, Streptococcus, Staphylococcus, Tetrad, Sarcina	<i>S. aureus</i> , <i>S. pyogenes</i> , <i>N. gonorrhoeae</i>
Rod	Bacillus	Single, diplobacillus, streptobacillus, palisade	<i>E. coli</i> , <i>Salmonella</i> , <i>Bacillus anthracis</i>
Comma-shaped	Vibrio	Single curved rod	<i>Vibrio cholerae</i>
Spiral (rigid)	Spirillum	Short helical	<i>Spirillum minus</i> (rat-bite fever)
Spiral (flexible)	Spirochaete	Long flexible helix	<i>Treponema</i> , <i>Borrelia</i> , <i>Leptospira</i>
Pleomorphic	Variable	Irregular	<i>Mycoplasma</i> , <i>Corynebacterium</i>

CLINICAL IMPORTANCE OF THIS CHAPTER FOR DENTAL SURGEONS

1. Cell-wall structure determines antibiotic choice — β -lactams act on peptidoglycan, so *Mycoplasma* (no wall) is intrinsically resistant.
2. Gram staining of pus from a dentoalveolar abscess gives a presumptive diagnosis within minutes and guides empirical therapy.
3. Capsule and fimbriae explain bacterial adhesion to pellicle and acrylic — the first step in plaque and denture stomatitis.
4. Endotoxin (lipid A) from Gram-negative anaerobes in the pocket drives alveolar bone resorption in periodontitis.
5. Spore resistance is the reason autoclaving, not boiling, is mandatory for dental instruments.
6. The log phase is when bacteria are most susceptible to antibiotics — a rationale for early, adequate dosing in odontogenic infections.
7. Anaerobic and capnophilic growth requirements explain why routine aerobic culture of pocket samples often reports 'no growth'.

Bacterial Growth Curve

Phase	Description	Key Events
Lag phase	Adaptation to new medium	Metabolic activity high; no cell division; enzyme synthesis

Phase	Description	Key Events
Log (Exponential) phase	Rapid geometric doubling	Maximum growth rate; most susceptible to antibiotics; generation time calculated here
Stationary phase	Growth rate = Death rate	Nutrient depletion; waste accumulation; spore formation begins
Decline (Death) phase	Death rate > Growth rate	Lysis; autolysis; accumulation of toxic products

Bacterial Nutrition & Classification

Classification	Criterion	Examples
Aerobes (obligate)	Require O ₂	<i>M. tuberculosis</i> , <i>Pseudomonas aeruginosa</i>
Anaerobes (obligate)	Killed by O ₂	<i>Clostridium</i> , <i>Bacteroides</i> , <i>Actinomyces</i>
Facultative anaerobes	Grow with or without O ₂ (prefer aerobic)	<i>E. coli</i> , <i>S. aureus</i> , most Enterobacteriaceae
Microaerophiles	Require reduced O ₂ (5–10%)	<i>Campylobacter</i> , <i>H. pylori</i>
Capnophiles	Require elevated CO ₂ (5–10%)	<i>N. gonorrhoeae</i> , <i>Brucella</i> , <i>H. influenzae</i>
Mesophiles	Optimal growth 20–40°C	Most human pathogens (37°C optimal)
Thermophiles	Optimal growth >45°C	<i>Bacillus stearothermophilus</i> (autoclave testing)

KEY POINT: Antibiotics work best in the LOG PHASE when bacteria are actively dividing and synthesising cell wall/proteins.

MCQs FOR MDS ENTRANCE EXAMINATIONS

1. Peptidoglycan is composed of

- (a) NAG and NAM (b) Chitin and glucan (c) Ergosterol (d) Mycolic acid

Ans. (a) NAG and NAM — Murein is alternating N-acetylglucosamine and N-acetylmuramic acid cross-linked by peptides.

2. Teichoic acid is found in

- (a) Gram-negative wall (b) Gram-positive wall (c) Capsule (d) Flagella

Ans. (b) Gram-positive wall — Teichoic and lipoteichoic acids are characteristic of Gram-positive cell walls.

3. Endotoxic activity of LPS resides in

- (a) O antigen (b) Core polysaccharide (c) Lipid A (d) Peptidoglycan

Ans. (c) Lipid A — Lipid A is the toxic moiety responsible for fever, shock and bone resorption.

4. Bacterium with terminal spore giving drumstick appearance

- (a) *C. perfringens* (b) *C. tetani* (c) *B. anthracis* (d) *C. botulinum*

Ans. (b) *C. tetani* — *C. tetani* has a round terminal spore producing the classical drumstick form.

5. Dipicolinic acid is present in

- (a) Capsule (b) Spore (c) Flagella (d) Pili

Ans. (b) Spore — Calcium dipicolinate confers heat resistance to bacterial endospores.

6. Sex pilus is concerned with

- (a) Motility (b) Adhesion (c) Conjugation (d) Sporulation

Ans. (c) Conjugation — The F (sex) pilus mediates plasmid transfer during conjugation.

7. Generation time of *Mycobacterium tuberculosis* is approximately

- (a) 20 minutes (b) 2 hours (c) 15-20 hours (d) 14 days

Ans. (c) 15-20 hours — *M. tuberculosis* divides once in about 15-20 hours, hence its slow growth.

8. Bacterial ribosome is

- (a) 80S (b) 70S (c) 60S (d) 40S

Ans. (b) 70S — Prokaryotic 70S ribosome (50S + 30S) is the target of aminoglycosides and macrolides.

9. Only bacteria containing sterol in the cell membrane

- (a) *Mycoplasma* (b) *Chlamydia* (c) *Rickettsia* (d) *Nocardia*

Ans. (a) *Mycoplasma* — *Mycoplasma* lacks a cell wall and incorporates cholesterol into its membrane.

10. Toxin/spore production typically occurs in which phase of growth

- (a) Lag (b) Log (c) Stationary (d) Decline

Ans. (c) Stationary — Secondary metabolites such as toxins and spores appear in the stationary phase.