Pharma Pulse - Topper's Tonic

COMPREHENSIVE PHARMACEUTICS

Volume 2

- Pharmaceutical Microbiology
- Pharmaceutical Jurisprudence
- Dispensing and Hospital Pharmacy
- Cosmetics science
- Pharmaceutical Management
- Drug regulatory affairs
- Pharmaceutical Biotechnology
- Pharmaceutics Miscellaneous

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M. Pharm. Ph.D

A COMPLETE BOOK

Theory and Practice MCQs for GPAT and Other Pharma Competitive Exams

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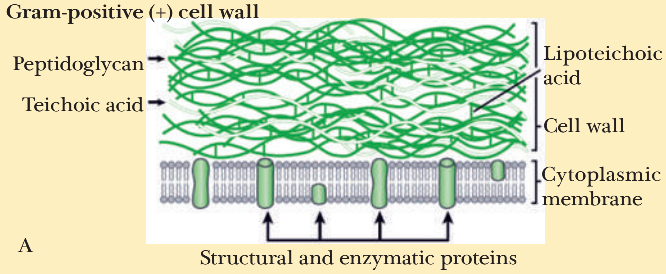
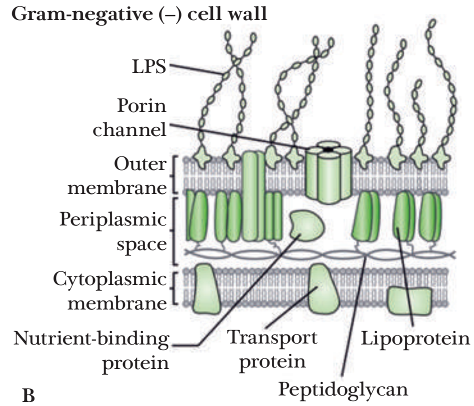
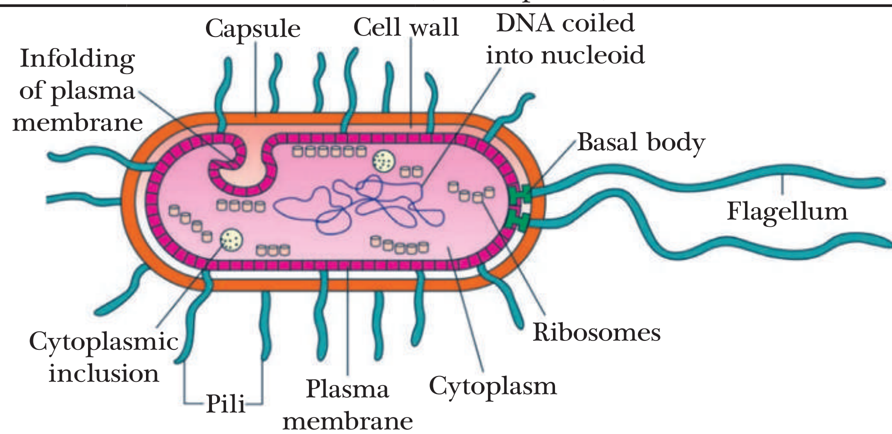
BACTERIA

3

BACTERIA

I. Bacterial Morphology	Overview	Bacteria are **prokaryotes**, lacking **nucleus** and **organelles**. Differ from **eukaryotes** like fungi, protozoa.
	Size	Range: **0.2 µm** (Mycoplasma) to **3 µm** (Bacillus anthracis); E. coli ~**1 µm**
	Shape & Arrangement	Cocci, bacilli, spirilla; varied arrangements (chains, clusters)
	Gram Staining	**Gram-positive:** Thick wall, purple; **Gram-negative:** Thin wall, red; **Mycobacteria/Mycoplasma:** Gram-resistant
II. Bacterial Ultrastructure	Internal Structures	**Nucleoid** (DNA), **No nuclear membrane, Single circular chromosome, No histones; Coupled transcription/translation; 70S ribosomes, Plasmids**
	Plasma Membrane	Similar to eukaryotes but **no sterols** (except **Mycoplasma**); contains **ETC, ATPase, Permeases**
	Cell Wall (Gram+)	**Thick peptidoglycan, Teichoic acids, Lipoteichoic acids**, antigenic, weak endotoxin activity 
	Cell Wall (Gram-)	**Thin peptidoglycan, Outer membrane** with **LPS, Porins, Periplasm, Lipoproteins** 

	Mycobacteria	Waxy coat with mycolic acid, acid-fast stain, virulence factor
III. Cell Surface Structures	Capsule	Polysaccharide or protein layer; prevents phagocytosis; virulence factor
	Pili (Fimbriae)	Short protein filaments; common pili: adherence; F pili: conjugation
	Flagella	Long protein appendage for motility, chemotaxis, antigenic
IV. Peptidoglycan	Structure	Glycan chains (NAG, NAM) + tetrapeptides + cross-links
	Biosynthesis	Involves bactoprenol, transpeptidase (PBP), 4 stages
	Inhibition by Drugs	Vancomycin, β-lactams, Bacitracin inhibit different steps
V. Lipopolysaccharide (LPS)	Structure	3 parts: Lipid A (toxic), Core polysaccharide, O antigen (strain specific); LOS in Neisseria



Anatomy of Bacterial Cell

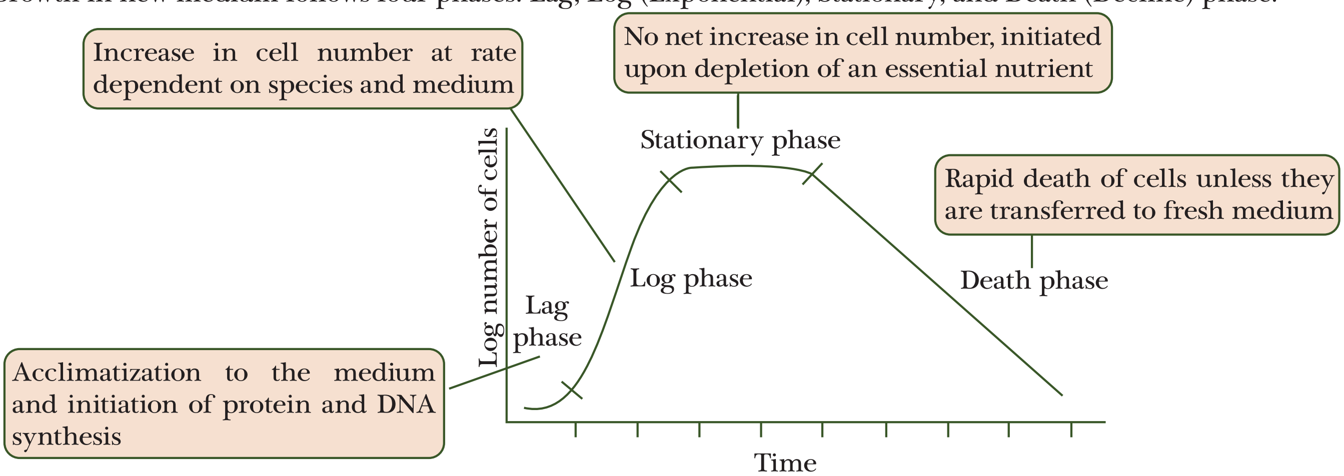
Types of bacteria

Class	Key Characteristics	Examples / Diseases
Gram-Negative Bacteria		
1. Spirochetes	Corkscrew-shaped, axial filaments	Treponema pallidum – *Syphilis*, Borrelia burgdorferi – *Lyme disease*, Leptospira – *Leptospirosis*
2. Aerobic/Microaerophilic, Helical/Vibrioid	Helical (flagella), vibrioid (comma-shaped)	Campylobacter jejuni – *Diarrhea*, Helicobacter pylori – *Gastric ulcers*
3. Aerobic Rods & Cocci	Diverse, aerobic group	Bordetella pertussis – *Whooping cough*, Neisseria – *Gonorrhea, Meningitis*, Pseudomonas – *Infections*
4. Facultative Anaerobic Rods	Fermentative, includes enterics	E. coli, Salmonella – *Typhoid*, Shigella – *Dysentery*, Klebsiella – *Pneumonia*, Vibrio – *Cholera*
5. Anaerobic Rods	Straight/curved/helical rods, intestinal flora	Bacteroides – *Gingivitis, Intestinal infections*
6. Rickettsias & Chlamydias	Obligate intracellular, tiny, spread by arthropods or direct contact	Rickettsia – *Typhus*, Chlamydia – *NGU, Trachoma*, Coxiella – *Q fever*
7. Mycoplasmas	No cell wall, pleomorphic, contains sterols	Mycoplasma pneumoniae – *Walking pneumonia*

Gram-Positive Bacteria		
1. Cocci	Thick peptidoglycan, clusters/chains	Staphylococcus – *Skin infections*, Streptococcus – *Strep throat*, *Pneumonia*
2. Endospore-Forming Rods & Cocci	Spore-forming, heat-resistant, anaerobic/aerobic	Clostridium – *Tetanus*, *Botulism*; Bacillus – *Anthrax*
3. Nonsporing Rods	No spores, rod-shaped	Listeria monocytogenes – *Listeriosis*
4. Irregular Nonsporing Rods	Club-shaped, pleomorphic	Corynebacterium – *Diphtheria*, Propionibacterium – *Acne*
Other		
1. Mycobacteria Acid-Fast Bacteria	Acid-fast, waxy coat	Mycobacterium tuberculosis – *TB*, Mycobacterium leprae – *Leprosy*
2. Actinomycetes with Sporangia	Fungus-like, sporangia at filament tips	Dermatophilus – *Skin infections*
3. Streptomyces & Related Genera	Soil bacteria, antibiotic producers, earthy odor	Streptomyces – *Source of antibiotics*

Bacterial Growth, Division & Spore Formation

Growth in new medium follows four phases: Lag, Log (Exponential), Stationary, and Death (Decline) phase.



Bacteria have distinct nutrient requirements and metabolic outputs, useful in bacterial identification.

Cell Division	Bacteria divide by binary fission (simpler than mitosis).
1. Chromosome Duplication	Starts at replication origin. Can reinitiate DNA synthesis even before prior round finishes. Continues even during starvation once initiated.
2. Septum Formation	Membrane and cell wall synthesis forms septum, dividing cell into two daughter cells, each with a full chromosome.
Bacterial Spores (Endospores)	Produced by some gram-positive bacteria. Highly resistant to heat, drying, and chemicals.
1. Sporulation	Triggered by nutrient depletion. Antibiotics and toxins may be made during sporogenesis.
2. Germination	Triggered by damage (e.g., trauma, aging) and requires specific nutrients. Once germination begins, spore becomes susceptible like vegetative cells.

Factors Affecting Bacterial Growth

Factor	Definition/Effect	Details & Examples
1. Temperature	Growth occurs within a specific range; optimum temperature varies per species.	❍ Mesophiles: 10–45°C (optimum 20–40°C) – most human pathogens (*E. coli, S. aureus*). ❍ Psychrophiles: –5 to 30°C (optimum 10–20°C). ❍ Thermophiles: 45–80°C (e.g., *Thermus aquaticus*).
2. pH	Bacteria grow best near neutral pH; extremes affect enzyme activity and membrane transport.	❍ Most pathogens grow best at pH 7.2–7.6. ❍ Acidophiles: e.g., Lactobacillus (acidic pH). ❍ Alkaliphiles: e.g., Vibrio cholerae ($pH > 8$). ❍ Fungi: pH 4–5.
3. Light	UV and ionizing radiation are harmful; some bacteria require light for pigment production.	❍ UV light is bactericidal. ❍ Ionizing radiation damages DNA. ❍ *Mycobacterium kansasii:* pigment only after light exposure (photochromogenic).
4. Osmotic Pressure	Affects water movement; cell wall provides resistance.	❍ Plasmolysis: In hypertonic solution, water exits cells, shrinking membrane. ❍ Gram-negative bacteria more sensitive. ❍ Mycoplasma lacks wall – osmotically fragile.
5. Oxygen	Required or toxic depending on bacterial type.	❍ Obligate aerobes: Require O_2 (*Mycobacterium tuberculosis*). ❍ Obligate anaerobes: Killed by O_2 (*Clostridium*). ❍ Facultative anaerobes: Can use O_2 or grow anaerobically (*E. coli*). ❍ Microaerophiles: Require low O_2.
6. Carbon Dioxide (CO_2)	Needed by capnophilic organisms; enhances growth in some bacteria.	❍ Some bacteria (e.g., *Neisseria, Haemophilus*) require 5–10% CO_2. ❍ Grown in CO_2 incubators or candle jars.
7. Moisture (Water Activity)	Essential for metabolic processes and transport.	❍ Most bacteria require high water activity ($aw > 0.91$). ❍ Desiccation inhibits growth. ❍ Fungi can tolerate lower moisture than bacteria.
8. Drying / Desiccation	Removal of water can kill or preserve bacteria depending on species.	❍ Spores: Extremely resistant (e.g., *Bacillus, Clostridium*). ❍ *Staphylococcus* tolerates drying well. ❍ Lyophilization used for long-term preservation of cultures, vaccines, antibiotics, sera.

Bacterial Genetics

Bacterial Chromosome	
1. Structure	❍ Single, double-stranded, circular DNA ❍ ~5 million base pairs (~5000 kb) ❍ *Mycoplasma* has the smallest chromosome (~1/4 the size)
2. Operons	❍ Multiple operons in chromosome ❍ Polycistronic operons: encode multiple structural genes → transcribed into single mRNA → multiple proteins ❍ Transcription (e.g., lac operon) regulated by metabolite levels

Other Genetic Elements

1. Plasmids

- Extrachromosomal, self-replicating DNA
- Some are episomes (e.g., E. coli F factor) → can integrate into host chromosome
- Carry drug resistance and toxin genes
- Used in gene cloning

2. Bacteriophages

- Viruses that infect bacteria
- Lytic phage: replicates independently, causes host lysis
- Lysogenic phage (e.g., λ phage): integrates into host
- Can carry toxin genes (e.g., corynephage β → diphtheria toxin)
- Under stress, lysogenic phage becomes lytic

3. Transposons

- Jumping genes: move within or between DNA molecules
- No replication origin
- Simple transposons: only encode mobility proteins
- Complex transposons: carry extra genes (e.g., antibiotic resistance)
- Pathogenicity islands: large transposons → include entire pathogenic gene clusters → regulated by temperature, metabolism, etc.

Genetic Transfer Mechanisms

Though binary fission is asexual, bacteria have mechanisms for horizontal gene transfer

Recombination

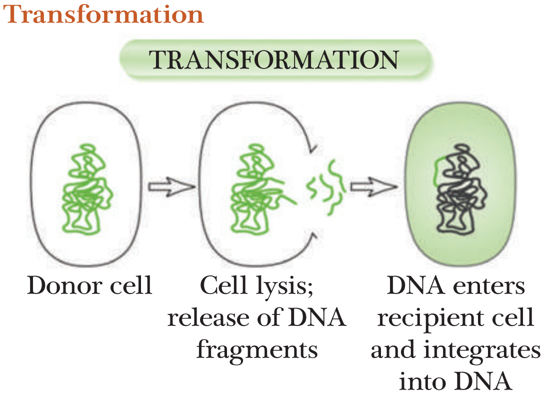
1. Homologous Recombination

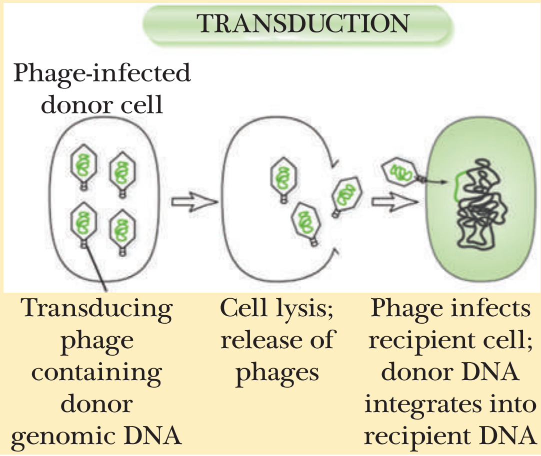
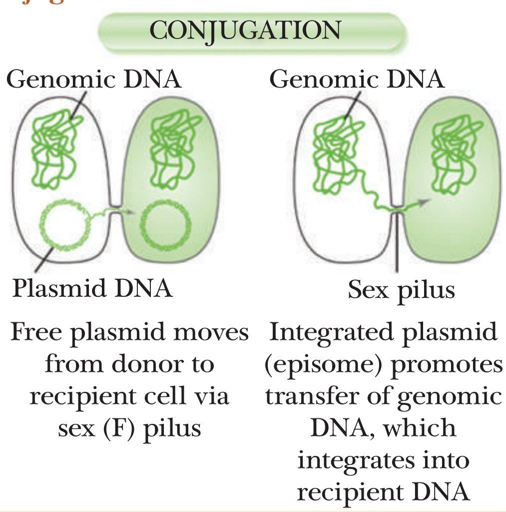
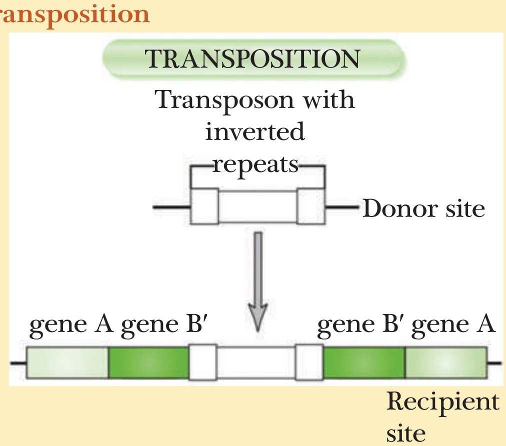
- Occurs between similar sequences
- Leads to substitution
- Basis for antigenic variation in *Salmonella, Neisseria gonorrhoeae*

2. Nonhomologous Recombination

- Occurs between unrelated sequences
- Leads to insertion or deletion
- Used in phage integration, transposon mobility

Genetic Transfer Mechanisms in Bacteria

Mechanism	Definition	Key Features & Examples
Transformation 	Uptake of naked DNA fragments from the environment and incorporation into the bacterial chromosome	❍ Requires a competent cell ❍ DNA integrates by homologous recombination ❍ Can occur naturally in *Streptococcus pneumoniae* or be induced artificially ❍ Example: *S. pneumoniae* acquiring capsule genes; widely used in molecular cloning techniques.

Transduction 	Transfer of bacterial DNA via bacteriophages (viruses that infect bacteria)	❍ Involves phage-mediated DNA transfer ❍ Two types: ❖ **Generalized:** Random DNA is transferred during the **lytic cycle** (e.g., T4 phage in *E. coli*) ❖ **Specialized:** Specific genes are transferred via **lysogenic phage** (e.g., λ phage in *E. coli*, *Salmonella*)
Conjugation 	Direct transfer of DNA from one bacterium to another via sex pilus (F pilus)	❍ Requires cell-to-cell contact ❍ Mediated by conjugative plasmids (e.g., F plasmid) ❍ Can transfer plasmids or chromosomal genes (in Hfr cells) ❍ **Example:** *E. coli* transferring F plasmid; Hfr × F– crosses used to map bacterial chromosomes.
Transposition 	Movement of DNA segments (transposons) within or between DNA molecules	❍ Involves "jumping genes" with inverted repeats ❍ Occurs via non-homologous recombination ❍ May carry antibiotic resistance genes ❍ **Example:** Transposons on R plasmids spreading drug resistance in *Shigella*, *Enterococcus*.
Plasmid Transfer	Independent circular DNA transferred during conjugation or transformation	❍ R (resistance) plasmids carry antibiotic resistance genes ❍ F (fertility) plasmids enable conjugation ❍ **Example:** Plasmid-mediated β-lactamase resistance; F+ plasmid transfer in *E. coli* enables DNA sharing among bacteria.

Bacterial Virulence Mechanisms & Immunopathogenesis

Mechanism	Details / Examples
Bacterial Virulence	
1. Adherence	❍ Attachment to epithelial/endothelial linings (bladder, intestine, oropharynx, etc.) ❍ Mediated by **pili/fimbriae** (*N. gonorrhoeae, enteric bacteria*) ❍ Also via **adhesins:** lectins, lipoteichoic acid, slime layers
2. Invasion	❍ Entry into host tissues or sterile body sites ❍ Enteric bacteria → invade GI tract ❍ Can cause **bacteremia, meningitis, pneumonia** ❍ Source of toxin release or systemic spread
3. Tissue Damage	❍ **Metabolites:** acids, gases ❍ **Enzymes:** ❖ *C. perfringens:* lecithinase (α-toxin) ❖ *Streptococci:* hemolysin, streptokinase, hyaluronidase ❖ *Staphylococci:* hyaluronidase, lipases, enterotoxins
	❍ **Exotoxins:** ❖ Cytolytic: destroy membranes ❖ A-B toxins: A = Active (enters cell), B = Binding (binds host) ❖ Superantigens: hyperactivate T cells → cytokine storm (TSST, enterotoxins)
4. Spread via Blood (Bacteremia)	❍ Spreads infection throughout body ❍ Tissue/blood vessel damage promotes this
5. PAMPs (Pathogen Patterns)	❍ Molecules recognized by TLRs → cytokine release ❍ Examples: peptidoglycan, **LPS**, teichoic acids, **flagellin, CpG DNA**
6. Endotoxin (Lipid A of LPS)	❍ Found in Gram-negative bacteria ❍ Strong PAMP → triggers complement & clotting ❍ Causes fever, sepsis via **IL-1, IL-6, TNF-α**
7. Antibiotic Resistance	❍ Spread via plasmids, conjugation, transduction ❍ Antibiotics eliminate non-resistant flora → selective survival
8. Immune Evasion	a. **Capsules** (e.g., *S. pneumoniae*): inhibit phagocytosis b. **Biofilms** (e.g., *P. aeruginosa*, dental plaque): resist immune cells & antibiotics c. **Intracellular survival** (*M. tuberculosis*) → phagolysosome inhibition d. **IgA Proteases:** *N. gonorrhoeae, H. influenzae* e. **Protein A** (*S. aureus*): binds Fc region of IgG f. **Complement Inhibition**: LPS prevents MAC lysis g. **Antigenic Variation:** pilin (Neisseria), flagella (Salmonella)
Antibacterial Immunopathogenesis	
1. Inflammation	❍ Host innate responses (complement, neutrophils, macrophages) cause tissue damage ❍ **Granulomas** in chronic intracellular infections (*M. tuberculosis*)

2. Tissue-Damaging Immune Response	❍ **Chronic immune stimulation** by bacteria like: ❖ *Chlamydia* (LGV) ❖ *Treponema* (syphilis) ❖ *Borrelia* (Lyme disease)
3. Cross-Reactive Antibodies	❍ Autoimmune mimicry → e.g., **Rheumatic fever** due to M protein antibodies cross-reacting with cardiac tissue
4. Immune Complex Deposition	❍ **Post-streptococcal glomerulonephritis** → antigen-antibody complexes deposit in kidney glomeruli
5. Sepsis (Cytokine Storm)	❍ Triggered by LPS, peptidoglycan → activates TLRs ❍ Release of **TNF-α, IL-1, IL-6** → systemic inflammation
6. Superantigens	❍ Non-specific T cell activation → massive cytokine release ❍ Examples: TSST-1 (*S. aureus*), erythrogenic toxin (*S. pyogenes*)

IMPORTANT MCQS FOR PRACTICE

1. The principal structural component of the cell wall in bacteria is made up of [GATE 1997]
   (*a*) simple protein
   (*b*) peptidoglycan polymer
   (*c*) complex polysaccharides
   (*d*) glycoprotein

2. Match the process of reproduction and genetic exchange under Column-I with the explanation under Column-II: [GPAT 2023]

Column-I (Process of reproduction and genetic exchange)	Column-II (Explanation)
I. Binary fission	P. Transfer of genetic material from the donor to recipient bacterium through cell contact
II. Transformation	Q. Common vegetative reproduction
III. Transduction	R. Transfer of genetic material in bacteria through virus
IV. Conjugation	S. Horizontal gene transfer by taking up of foreign genetic material (naked DNA)

   Choose the correct answer from the options given below:
   (*a*) I-P, II-R, III-S, IV-Q
   (*b*) I-R, II-P, III-S, IV-Q
   (*c*) I-II-S, III-P, IV-R
   (*d*) I-II-S, III-R, IV-P

3. Match List-I with List-II: [GPAT 2023]

List-I (Classification of Bacteria)	List-II (Example)
A. Gram positive spherical shaped nonmotile bacteria	I. Clostridium tetani
B. Gram positive sporulating obligate anaerobic bacteria	II. Bacillus anthracis
C. Gram positive rod shaped nonsporulating bacteria	III. Streptococcus sp.
D. Gram positive sporulating rod shaped motile bacteria	IV. Corynebacterium diphtheriae
	V. E.coli

   Choose the correct answer from the options given below:
   (*a*) A-III, B-IV, C-I, D-V
   (*b*) A-IV, B-I, C-II, D-III
   (*c*) A-III, B-I, C-IV, D-II
   (*d*) A-I, B-IV, C-II, D-III

4. The optimum temperature for rapid growth of mesophiles is: [GPAT 2024]
   (*a*) 25 to 40°C
   (*b*) 50 to 60°C
   (*c*) 15 to 20°C
   (*d*) 40 to 50°C

5. Gram positive bacteria typically contain [GATE 2008]
   (*a*) cell walls that lack peptidoglycan
   (*b*) repeating units of arabinogalactan & mycolates in their cell walls
   (*c*) peptidoglycan containing muramic acid & D-amino acids in their cell walls
   (*d*) cell walls containing predominantly polysaccharides & glycoproteins

6. Endotoxin is produced by the following bacteria except [ISRO Pharmacist exam 2021]
   (*a*) Salmonella typhi
   (*b*) Bordetella pertussis
   (*c*) Yersinia pestis
   (*d*) Clostridium tetani

7. Without this, many disease-causing bacteria loose their ability to infect because they are unable to attach to the host tissue [Delhi Government Pharmacist exam 2021]
   (*a*) Pili
   (*b*) Nucleoid
   (*c*) Flagella
   (*d*) Plasmids

8. Spherical shaped bacteria are termed as [Vadodara MC Pharmacist exam 2021]
   (*a*) Bacilli
   (*b*) Cocci
   (*c*) Spirochaetes
   (*d*) Vibrios

9. The substance that is present only in Gram-positive bacteria cell wall is [MP Pharmacist exam 2020_P1]
   (*a*) Cellulose
   (*b*) Techoic acid
   (*c*) Lipopolysaccharides
   (*d*) Peptidoglycan

10. Plasmids are
   (*a*) Viruses
   (*b*) New type of micro-organisms
   (*c*) Extra chromosomal genetic element of bacteria
   (*d*) None of these

11. The bacteria that commonly live in animal and human intestine is
   (*a*) Vibrio cholerae
   (*b*) Bacillus anthracis
   (*c*) Corynebacterium
   (*d*) Escherichia coli

12. The smallest living cells with cell wall are
   (*a*) Mycoplasma
   (*b*) Viroids
   (*c*) Blue green algae
   (*d*) Bacteria

13. One among the following is absent in eukaryotes. [Maharashtra PSC 2023]
   (*a*) Circular chromosome
   (*b*) Golgi apparatus
   (*c*) Endoplasmic reticulum
   (*d*) Mitochondria

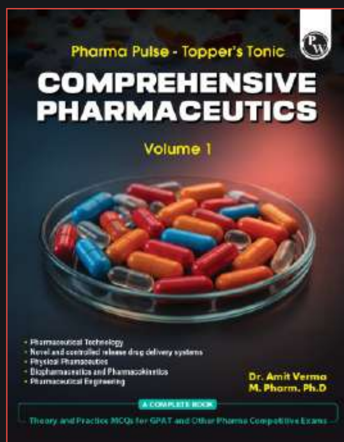
14. The plasmids conferring drug resistance are called [MH DI 2008]
   (*a*) R-plasmids
   (*b*) Col-plasmids
   (*c*) cryptic-plasmids
   (*d*) degradative plasmids

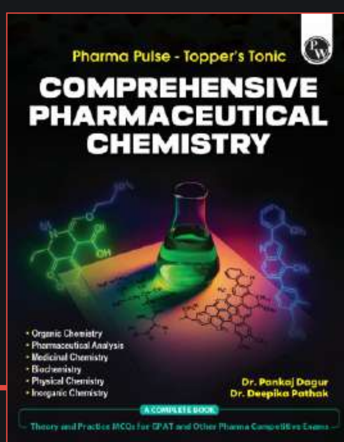
15. Which of the following bacteria lacks a cell wall? [Bihar DI 2023]
   (*a*) Escherichia
   (*b*) Pseudomonas
   (*c*) Mycoplasma
   (*d*) Mycobacterium

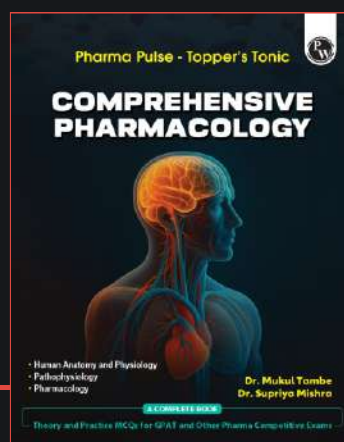
ANSWER KEY

1. (*b*)	**2.** (*d*)	**3.** (*c*)	**4.** (*a*)	**5.** (*c*)	**6.** (*d*)	**7.** (*a*)	**8.** (*b*)	**9.** (*b*)	**10.** (*c*)
11. (*d*)	**12.** (*d*)	**13.** (*a*)	**14.** (*a*)	**15.** (*c*)					

Important Books For This Series







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