



Goa University
P.O. Goa University, Taleigao Plateau, Goa 403 206, India

Syllabus of B.Sc Microbiology Programme

(Approved by the Board of Studies in Microbiology : Syllabus of F.Y B.Sc
on 13.03.2006 & Syllabus of SY B.Sc and T Y B.Sc on 24.02.2007)

A brief description of the course: Department of Microbiology in Colleges affiliated to Goa University offer three year, full time B.Sc. Microbiology programme. This programme strengthens the basics of Microbiology and its application. It is job & research oriented facilitating placement of students in pollution control & sanitation, agriculture, clinical and & preventive medicine and industries viz. pharmaceuticals, food, beverage and genetic counseling.

- **Purpose :**
 - i) Introduction of world of microbes to students by teaching the basics of microbiology along with its related subjects viz. physiology, biochemistry, molecular biology and genetic engineering through theoretical and practical course contents.
 - ii) Introduction of Microbial techniques
 - iii) Introduction to applications of microbiology in different fields like terrestrial and aquatic environment, medical immunology, agriculture and industries.
- **Prerequisites :** XIIth Science with physics, chemistry and biology as subjects.
- **Credits** (theory, tutorials, practicals): The course is without credits but possesses total 20 Units.
- **Number of semesters and course distribution : Total Six semesters** and course is distributed as shown in the following table:

CLASS	SEMESTER	CODE OF PAPERS OFFERED	NUMBER OF UNITS**
First Year (FY)	I	101, 102	2
First Year (FY)	II	103, 104	2
Second Year (SY)	III	201, 202	2
Second Year (SY)	IV	203, 204	2
Third Year (TY)	V	301, 302, 303,304, 305, 306	6
Third Year (TY)	VI	307, 308, 309, 310, 311, 312	6

***Project** - done during Third Year (semester V and VI).

** Students need to opt for two other subjects in FY & SY with 2 units each

- **Dissertation/ Project : Project is of 100 marks.**
- **Field work :** Visits to relevant academic institutions and industries.

B.Sc Microbiology

List of Courses

In the following tables, L refers to lectures, T to tutorials and P to practicals. Description of a course appears on the page number listed in the tables.

Compulsory Courses

Course Number and Name	L-T-P (hours/week)	Credits	Page number
101 Introduction to Microbiology and Biochemistry I	3-0-3	-	4
102 Basic techniques in Microbiology I	3-0-3	-	5
103 Introduction in Microbiology and Biochemistry II	3-0-3	-	7
104 Basic techniques in Microbiology II	3-0-3	-	9
201 Microbial Physiology I	3-0-3	-	12
202 Microbial Genetics I	3-0-3	-	13
203 Microbial Physiology II	3-0-3	-	14
204 Microbial Genetics II	3-0-3	-	16
301 Environmental Microbiology	4-0-0	-	18
302 Medical Microbiology	4-0-0	-	19
303 Practical (Environmental Microbiology + Medical Microbiology)	0-0-4	-	20
304 Molecular Biology	4-0-0	-	21
305 Industrial Microbiology	4-0-0	-	22
306 Practical (Molecular Biology + Industrial Microbiology)	0-0-4	-	23
307 Ecology and Agricultural Microbiology	4-0-0	-	24
308 Medical Microbiology and Basic Immunology	4-0-0	-	25
309 Practical (Ecology and Agricultural Microbiology + Medical Microbiology and Basic Immunology)	0-0-4	-	26
310 Genetic Engineering	4-0-0	-	27
311 Food Microbiology	4-0-0	-	28
312 Practical (Genetic Engineering + Food Microbiology)	0-0-4	-	29
Project	2/ batch of 5		

Syllabus of B.Sc. Microbiology Programme

Compulsory Courses

COURSE CONTENT

First Year (Semester I)

- 101 Introduction to Microbiology and Biochemistry I
102 Basic Techniques in Microbiology I

First Year (Semester II)

- 103 Introduction to Microbiology and Biochemistry II
104 Basic Techniques in Microbiology II

SEMESTER I

101: Introduction to Microbiology and Biochemistry I

I. Introduction, Historical Aspects and Scope of Microbiology (15)

1. Introduction to Microbiology

Types of Microorganisms; Distribution of microorganisms in nature, Brief description of classification schemes proposed by Linnaeus, Haeckel, Whittaker, Woese.

2. Historical Developments in Microbiology

Development in microscopy; Discovery of the microbial world; theory of spontaneous generation vs. biogenesis; Germ theory of diseases, aseptic surgery, Development of pure culture. Widening horizons - golden age of microbiology, recent discoveries, Nobel Laureates, Landmarks in virology.

3. Scope of Microbiology

Medical, aquatic, domestic and industrial Sewage, water, air, food, soil, agricultural, geochemical transformations, industrial applications.

II Microbial associations (10)

Types of associations: mutualism, commensalism, synergism, syntrophism, competition, antagonism, parasitism, predation; Ectosymbiosis and Endosymbiosis of plants, animal and other microorganisms. Examples of each type of interaction - mycorrhizal, root nodules, ruminant symbiosis, termites, bioluminescent bacteria.

III Microbial cytology (20)

Diversity in microbial cytology. Structure of eukaryotes and prokaryotes (Archaeobacteria and Eubacteria) and differences (Tabular presentation).

Organization and ultrastructure of prokaryotic cell- Bacterial cell. Cell wall: structure and composition in gram positive and gram negative bacteria, sphaeroplast, protoplast, L-forms; Flagella and pili; Cell membrane: architecture, structure & function; Slime and capsule: composition, function; Cytoplasmic organelles; Nuclear material: nature and function; Endospore: structure, sporulation and germination; Reserve materials: glycogen, lipid granules, polyhydroxyalkanoate, volutin, sulphur inclusion.

Practical (101)

Safety in microbiology: good laboratory practices, disposal of infectious wastes.

Working and handling of common laboratory equipments: autoclave, Hot air oven, Incubator, Colony counter, Bacteria proof filters, Laminar air flow.

Use and care of compound microscope, wet mounts, Lactophenol cotton blue staining

Monochrome staining; Negative staining; Gram staining; Hanging drop technique.

Preparation of Laboratory Media: Peptone water, nutrient broth and agar, preparation of slants and butts, Saboraud's broth and agar, MacConkey's broth and agar.

List of Books

1. Microbiology by Prescott, Harley, Klein.
2. Essentials of Microbiology by Frobisher.
3. Microbiology by Pelczar.
4. General Microbiology by Stanier.
5. Microbiology by A. H. Modi.

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SEMESTER I
102 : Basic Techniques in Microbiology I

I) Microbial nutrition, cultivation, isolation, enumeration and preservation (22)

Nutrition

Nutritional Types: phototrophs, chemotrophs & their subgroups. Autotrophs and heterotrophs. Facultative types, fastidious groups (definition) eg Mycobacterium, Streptococcus. Basic nutritional requirements; Sources of C, N, S, P, O, H, micro nutrients, growth factors, organic/ inorganic electron donors

Physico-chemical conditions

pH: acidophiles, alkalophiles, neutrophiles, buffers & their use in culture media;
Temperature: psychrophiles, thermophiles, mesophiles; Oxygen tension: aerobic, microaerophilic, anaerobic; use of pre-reduced media (Thioglycolate, Robertson's cooked meat), Anaerobic jar; Other conditions: osmotic pressure (osmophiles, halophiles), hydrostatic pressure (barophiles)

Cultivation

Types of culture media: synthetic, complex, enriched, enrichment, selective, differential, dehydrated solid and liquid.

Isolation

Concept & methods of pure culture technique; Methods: enrichment, streak plate, surface spread, pour plate, colony characters, pigmentation

Enumeration

Physical methods: Direct counting - microscopic counts (Breed's count, Haemocytometer count); Indirect counting - turbidometry (use of colorimeter), Dry-weight, wet-weight, PCV (packed Cell Volume)

Biological methods: Direct counting - SPC (serial dilution, viable counts, colony counts), membrane filter method; Indirect counting - MPN.

Preservation:

General principles of preservation. Methods - periodic transfer, overlaying with mineral oil, soil stock, preservation in liquid nitrogen, lyophilisation; Culture collection centers (culture banks) & their role.

II) Principles and methods of light microscopy (10)

Principles of optics, magnification, resolution, angular aperture, focal length, mechanical tube length.

Types of optical microscopes - simple, compound, binocular.

Lens systems: Objectives: low power, high power, oil immersion, function & importance,

Eyepiece: Huygenian, Ramsden, Hyperplane, compensating ocular;

Condensers: Abbe, Aplanatic, achromatic, differences & applications.

Micrometry & its use

III) Stains and Principles of staining procedures

(13)

1. Definition and classification of dyes, chromogen, Chromophore and auxochrome group, acidic/basic dyes, compound dyes , Leuco dyes, metachromatism, fluorochromes.
2. Agents associated with staining and mechanism of action: mordants, fixatives, decolourisers.
3. Types of staining : Simple- monochrome, vital staining ; Differential- Gram staining & Acid –fast staining (physicochemical basis), significance in bacteriology; other stainings – DNA(Feulgen reaction), cell wall, capsule, flagella, lipids, endospores, metachromatic granules.

Practical (102)

Pure culture techniques: Aseptic pipetting and pouring Culture media in Petri dishes, streak plate (T, parallel line, quadrant, Zigzag method).

Preservation: stab culture, periodic transfer and mineral oil overlaying.

Cell wall staining; Capsule staining; Lipid staining, volutin granules; Endospore staining;

Cultivation of aerobic and anaerobic spore bearers Bacillus and Clostridium;

Enumeration of microorganisms – McFarland's tubes, Breeds Smear, Hemocytometer

Viable counts by serial dilution (pour plate, spread plate)

Micrometry

List of Books

1. Fundamental Principles of Bacteriology by A.J. Salle
2. Essentials of Microbiology by Frobisher
3. Microbiology by Pelczar
4. Microbiology by Modi
5. Microbiology by Prescott, Harley & Klein
6. Textbook of Microbiology by Ananthanarayan
7. Medical Microbiology Vol.I by Cruickshank

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SEMESTER II

103 : Introduction to Microbiology and Biochemistry II

1. General characters, Morphology and salient Features of Groups of Microorganisms; economic importance: (23)

Rickettsias: Coxiella, Rickettsia

Actinomycetes: Nocardia, Streptomyces

Cyanobacteria: Oscillatoria

Algae: distinguishing characters of major algal groups, Reproduction

Yeasts: reproduction- sexual/asexual, budding, binary fission, pseudomycelium.

Molds: nutrition, reproduction, sexual/asexual spores, distinguishing features of major groups with eggs Lichens

Protozoa: nutrition, reproduction, distinguishing features of major groups with eggs

Viruses: structure with eggs ; Criteria of viral classification: Morphology, nucleic acid, host; Viral replication (lytic and lysogeny), Cultivation.

II. Chemical Basis of Life (22)

Introduction: Chemical composition of cell important elements, types of organic/ inorganic molecules & polymers present in the cell structure, properties, biological functions.

Carbohydrates: Trioses, tetroses, pentoses, hexoses optical isomerism, pyranose and furanose forms, alpha/beta forms, reducing sugars, disaccharides, glycosidic bonds, lactose, maltose, sucrose, polysaccharides - storage: glycogen, starch; structural: cellulose. Principles of carbohydrate determination: Total carbohydrates by phenol sulphuric acid method, reducing sugars by DNSA method.

Amino acids: L & D forms, zwitterion, amphoteric nature, R groups, naturally occurring amino acids. Detection of amino acids by Ninhydrin method.

Proteins: peptide bond, peptides, primary, secondary, tertiary, quaternary structure. Protein determination: UV absorption, Colorimetrically by Biuret & Folin Lowry method.

Lipids: Principles of lipid determination, Fatty acids & triglycerides: unsaturated fatty acids.

Nucleic acid: purines & pyrimidines, nucleosides & nucleotides; principle of determination of DNA by diphenyl amine and RNA by Orcinol methods.

Practical (103)

Study of Actinomycetes- Nocardia and Streptomyces

Study of yeasts, budding

Study of fungi

Permanent slides of algae, protozoa, cyanobacteria

Chemical tests for starch, sugars, protein & fatty acids

List of books

1. Microbiology by Prescott, Harley & Klein
2. Essentials of Microbiology by Frobisher.
3. Microbiology by Pelczar
4. Biochemistry by A.L. Lehninger.
5. Outlines of Biochemistry by Cohn & Stumpf.
6. An Introduction to Practical Biochemistry by David T. Plummer.
7. Lab Manual in Biochemistry by Jayaraman

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Semester II
104: Basic Techniques in Microbiology II

I. Microbial growth

(12)

Definition of cell growth/population growth; generation time -definition & formulae, Bacterial growth curve, characteristics of growth phases; diauxic growth Synchronous growth Batch/Continuous cultures: principles, steady state, chemostat/Turbidostat.

II. Effect of Physical and chemical agents on bacteria

(10)

A. Physical agents: Low and high temperature - cardinal points of temperature; Osmotic pressure - plasmolysis, plasmoptysis, hypotonic, hypertonic, isotonic solutions; pressure; Dessication; pH; Surface tension; Ultrasonic waves; Radiations - UV, Ionising, α , β , γ , x-rays.

B. Chemical agents: Acids and alkalis, reducing/oxidizing agents (Phenols, cresols, alcohols, halogens, heavy metals, mercury compounds, aldehydes, quarternary ammonium compounds); Gases -- formaldehyde, ethylene oxide, β -propiolactone.

III Sterilization and disinfection

(10)

Definition of important terms: sterilization, disinfection, antiseptic, sanitizer, germicide

A. Sterilization methods:

Physical methods:

Heat: dry / moist heat, mechanism of sterilization. Instruments used and their operation; Pasteurization, Autoclaving, Inspissation, Tyndallization; TDP, TDT, Factors affecting sterilization, sterility checks & standards.

Radiations: ionising and UV radiations; mechanisms of sterilization

Filtration: Bacteria-proof filters for sterilizing liquid (Asbestos, Sintered, glass, membrane) and air (glass wool and HEPA)

B) Disinfection - Properties of an Ideal Disinfectant, evaluation of disinfectants' - inhibition coefficient, phenol coefficient

IV. Principle, working & applications of pH meter, colorimeter

(3)

V: Modification and advancement in microscopy

(10)

Principles underlying the construction, working and ray diagram of

Dark field microscope

Fluorescence microscope

Phase contrast microscope

Electron microscope - SEM & TEM

Practical (104)

Working of the pH meter, preparation of buffer

Effects of environment on bacteria: temperature, pH, UV -light, Dessication, Osmotic pressure, Surface tension.

Oligodynamic action of heavy metals.

Efficacy of Sterilization.

Growth curve of E.coli.

Working of the colorimeter: Demonstration of Beer - Lambert's Law

List of books

1. Microbiology by Modi,
2. Essentials of Microbiology by Frobisher.
3. Fundamental Principles of Bacteriology by A.J. Salle.
4. Microbiology by Pelczar.
5. An Introduction to Practical Biochemistry by David T. Plummer.
6. Microbiology by Prescott, Harley and Klein.
7. Lab Manual in Biochemistry by Jayaraman.

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**GOA UNIVERSITY
GOA**

**B. Sc. MICROBIOLOGY
COURSE CONTENT**

SEMESTER III

201 Microbial physiology – I

202 Microbial genetics - I

SEMESTER IV

203 Microbial physiology – II

204 Microbial genetics - II

201 Microbial Physiology - I
Semester III (45 lectures)

- I. **Thermodynamics:** (3)
Heat changes in chemical reactions, Entropy, Free energy,
1st and 2nd laws of thermodynamics, Equilibrium constant, Open and closed systems.
- II. **Bioenergetics:** (12)
ATP as a high energy system, Structure of ATP, Hydrolysis of ATP & other high energy phosphate compounds, Utilization of ATP energy in chemical work, ATP cycle: The linkage of energy-yielding oxidation to energy-requiring biosynthetic reaction, ETC and Oxidative phosphorylation
- III. **Enzymes:** (10)
Definition; protein nature, active site, specificity, Holoenzyme, Apoenzyme, Coenzyme, Cofactors, Prosthetic group, monomeric, oligomeric and allosteric enzymes.
Classification and nomenclature of enzymes with examples;
- IV. **Metabolism:** (20)
Concept of Metabolism: Anabolism, Catabolism; Energetics
Carbohydrates: Major pathways in heterotrophs & regulation: EMP, HMP, ED pathway, TCA pathway (Amphibolic pathway, Anaplerotic reactions), Glyoxylate cycle, Alcohol fermentation, Mixed Acid Fermentations - Homo & Heterofermentative pathways
Lipids: Beta and omega-oxidation
Proteins: Digestion of proteins and peptides; Flow sheet of amino acid oxidation, Transamination, Deamination, Decarboxylation; Stickland reaction

Practical (201)

- I Detection of bacterial enzyme activity: amylase, caseinase, catalase, dehydrogenase, nitratase, urease, gelatinase, lipase, desulfurase, pectinase, cellulase
II IMViC tests
III Fermentation - sugars, HL test
IV Estimation of lactic acid, alcohol (dichromate method)

List of books

1. Biochemistry by Lehninger
2. Outlines of Biochemistry by Conn and Stumpf.
3. Biochemistry by Stryer.
4. Biochemistry by S.C. Rastogi.
5. Textbook of Biochemistry by AV.S. S. Ramarao.
6. General Microbiology Volume I by Pawar and Daginawala.
7. Microbial physiology - Moat, Foster et al.
8. Harper's Biochemistry 22nd edition by Murray, Mayer, Granner and Rodwell.
9. Laboratory Manual in Biochemistry by Jayaraman.
10. An Introduction to Practical Biochemistry by David T. Plummer
11. Microbiology by Stanier.

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202 Microbial Genetics - I
Semester III (Lectures 45)

- I. Concept of gene; Chromosome, chromosome/DNA as carrier of gene (12)
Structure of DNA : purines / pyrimidines, nucleosides / nucleotides, Watson -Crick model; Prokaryotic DNA (Circular DNA, Supercoiling Palindromic); Eukaryotic DNA (Repetitive sequences, split genes, nucleosomes), mitochondrial and chloroplast DNA; RNA: mRNA, rRNA, tRNA;
- II. Microbial tools to study genetics: (6)
E.coli, yeast, *Neurospora*. Melting point of DNA (T_m) $[(G+C)\%]$, DNA/DNA homology & its significance in classification.
- III. Central dogma in molecular biology; reverse transcriptase & its implication (2)
- IV. Replication of DNA (17)
(i) Modes of replication - Conservative, semi conservative (Meselson- Stahl experiment) and dispersive.
Processes and enzymes involved in replication
Models of replication in prokaryotes & eukaryotes - Rolling circle model, linear, sigma and theta.
- V. Gene expression and regulation (8)
Induction and repression; catabolite repression; Lac operon - structural and regulatory genes, positive and negative regulation, trp operon.

Practical (202)

- II Estimations: DNA by Diphenylamine method
RNA by Orcinol method
Protein by Biuret method
Reducing Sugar by DNSA method
Sugar by Coles ferricyanide method

List of books

1. Microbiology by Frobisher.
2. Microbiology by Pelczar.
3. Microbiology by Prescott, Harley and Klein.
4. Microbiology by Stanier.
5. Biochemistry by Stryer.
6. Biochemistry by Lehninger.
7. Genetics by Goodenough.
8. Genetics by Gardner.
9. Microbial Genetics by David Freifelder.
10. Microbial Genetics by Strickberger.
11. Genes by Lewin.

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203 Microbial Physiology - II
SEMESTER IV (45 lectures)

- I. Nutrient Transport:** (8)
(a) Types of mechanisms of solute transport: passive diffusion, facilitated diffusion, active transport, group translocation
(b) Endocytosis: Phagocytosis, Pinocytosis
- II. Enzymes:** (17)
Specific activity of enzymes; factors affecting enzyme action (Substrate concentration, Enzyme concentration, Temperature, pH, Activators, Inhibitors (Competitive and non-competitive);

Enzyme Kinetics: Michaelis-Menten equation (derivation), Lineweaver- Burke plot (derivation);
Regulation of enzyme activity (Feedback inhibition, isofunctional enzymes, concerted, sequential);

Isolation and purification: Homogenization, salting-in & salting-out, Dialysis, Chromatography (Paper, TLC, Column- gel filtration), Ultracentrifugation & Electrophoresis.
- III. Coenzymes:** (3)
Definition, Coenzymes derived from vitamins: TPP (Thiamine), FMN, FAD (Riboflavin), Pyridoxal phosphate (Pyridoxine), cobamide coenzyme (Cyanocobalamin), NAD, NADP (Niacin), THFA (Folic acid), CoA (Pantothenic acid), Biotin; Functional role with examples in metabolism.
- IV. Anabolism:** (14)
(a) Biosynthesis of carbohydrates: Glycogen, Peptidoglycan
(b) Biosynthesis of Lipids: Poly beta-hydroxybutyric acid.
(c) Biosynthesis of saturated fatty acids: reactions of fatty acid synthetase system –palmitic acid.
- IV Bacterial bioluminescence:** (3)
Definition, mechanisms, significance & applications.

Practical (203)

- I Production of invertase using *Saccharomyces*
II Purification of enzymes: ammonium sulphate precipitation, dialysis, specific activity
III Determination of optimum enzyme concentration, pH, temperature for invertase/ amylase.
IV Determination of K_m ; and V_{max} of the enzyme; Michaelis-Menten and Lineweaver Burke curve
V Isolation of bioluminescent bacteria
VI. Chromatographic separation of sugars/ aminoacids by paper.
VII Chromatographic separation of sugars/ aminoacids by TLC.

List of books

1. Biochemistry by Lehninger
2. Outlines of Biochemistry by Conn and Stumpf,
3. Biochemistry by Stryer.
4. Biochemistry by S.c. Rastogi.
5. Textbook of Biochemistry by A.V.S. S. Ramarao.
6. General Microbiology Volume I by Pawar and Daginawala.
7. Microbial physiology - Moat, Foster and Spector
8. Harper's Biochemistry 22nd edition by Murray, Mayer et al.
9. Laboratory Manual in Biochemistry by Jayaraman.
10. An Introduction to Practical Biochemistry by David T. Plummer.
11. Microbiology by Stanier.

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**T.Y. B.Sc.
Microbiology**

**Course content
Third Year**

	Semester V
301	Environmental microbiology*
302	Medical microbiology *
303	Practical (301 + 302)*
304	Molecular biology
305	Industrial microbiology
306	Practical (304 + 305)
	Semester VI
307	Ecology and Agricultural microbiology*
308	Medical microbiology and Basic Immunology*
309	Practical (307 + 308)*
310	Genetic engineering
311	Food microbiology
312	Practical (310 + 311)

***Papers will be offered for both Six and Three units**

T.Y. B.Sc
301 Environmental Microbiology
Semester V (Lectures 45)

I	Microbiology of Air Numbers and types of microbes, Importance of state of suspension, aerosols, air samplers (Lemon, Andersen/ Hollander and Dalla Valle), Contamination hazards of lab techniques, significance of air flora in human health, hospitals, industries, and agriculture.	9
II	Microbiology of water: Different types of aquatic environments, Normal and contaminant microflora, Indicators of fecal pollution. Bacteriological techniques for examination of water – water sampling and processing techniques, routine analysis, detection of coliforms, potability of water. Purification of water for potability – rapid and slow sand filters, coagulation, flocculation, sedimentation, diatomaceous earth filters, chlorination, reverse osmosis;	18
III	Microbiology of sewage: Definitions and types of sewage, Objectives of sewage disposal, Chemical and microbiological composition of sewage, BOD (five days), COD Stages in sewage treatment: Physical: screening, settling tanks; Biological: Aerobic: Biofilms, activated sludge, oxidation pond; Anaerobic: sludge digestion, Imhoff tank and microorganisms involved; Chemical: Chlorination. Disposal of treated effluent: Dilution, Irrigation, Sludge as fertilizer, Waste recycling, Composting, Biogas	13
IV	Microbial degradation of pollutants: oil, pesticides; concept of bioremediation	5

List of Books

1. Fundamentals of Bacteriology by A.V. Salle.
2. Microbiology by Pelczar, Chan and Kreig.
3. General Microbiology by Roger Stanier.
4. Essentials of Microbiology by Frobisher.
5. Microbiology by Prescott, Harley and Klein

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T.Y. B.Sc
302 Medical Microbiology
Semester V (Lectures 45)

I	Normal microbiota of the human body: skin, eye, ear, oral cavity, respiratory-, digestive-, genito-urinary- tract, Significance of normal flora, Gnotobiotic maintenance and germ free animals	5
II	Communicability of Diseases: General principles of communicability, sources, spread and its control, epidemiology (endemic, epidemic and pandemic), nosocomial infection; acute and chronic diseases, sources of infection, Route of infection, Koch's Postulates and River's postulates, Methods of prophylaxis	10
III	Host Parasite interaction in relation to disease: Physiological basis of pathogenesis, chemoperception, Host defense mechanisms, Virulence and invasive factors, Opportunistic pathogens	10
IV	Pathogenesis, epidemiology, lab diagnosis, chemotherapy, prophylaxis in relation to the study of diseases caused by: a) Parasites – malaria, amoebiasis, filariasis b) Bacteria – tuberculosis, syphilis, diphtheria, Proteus infections, cholera, typhoid, dysentery, staphylococcal infections, streptococcal infections, <i>Helicobacter pylori</i> infection. Coliform infections: <i>E.coli</i> , <i>Klebsiella</i>	20

List of Books

1. Textbook of microbiology by Ananthanarayan.
2. Medical Microbiology by Curikshank.
3. Medical Microbiology by Zinscr.
4. Medical Microbiology by Jawetz.
5. Practical Medical Microbiology by Mackie and McCartney.
6. Microbiology by Prescott, Harley and Klein.
7. Medical Microbiology by Greenwood, Slack and Peutherer.

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T.Y. B.Sc
303 Practical
Semester V

- 1 Microbiology of air (qualitative studies)
- 2 Microbiology of water: MPN, SPC, Isolation of microflora of water, Routine analysis of potable water (Presumptive test, Confirmed test, Complete test), Na- azide test, Test for clostridia, Isolation and detection of agar digesters from marine water
- 3 Microbiology of sewage: SPC, Isolation of microflora of sewage, BOD test
- 4 Medical Microbiology: Isolation and study of *Staphylococcus aureus* (sputum), *Streptococcus* (sputum), and *Corynebacterium diphtheriae* (throat swab); acid fast staining of sputum (*Mycobacterium*), Isolation and study of enteric bacteria from stools (*E.coli*, *Aerobacter*, *Klebsiella*, *Salmonella*, *Shigella*, *Proteus*); Spirochaete staining from tooth tartar
- 5 Demonstration of malarial parasite

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T.Y. B.Sc
304 Molecular Biology
Semester V (Lectures 45)

I	Extrachromosomal DNA: Plasmids, Types of plasmids, Transposons, Types of transposons, Mechanism of transposition, episome	5
II	Gene expression and regulation: Induction and Repression; catabolite repression. Lac operon – structural and regulatory genes positive and negative regulation; Trp operon	12
III	Protein analysis: 1D/2D gel analysis, western blot and protein sequencing	4
III	Mutations Spontaneous mutations: principle, methodology; and significance of replica plating and fluctuation test. Types of mutations: Transitions and transversions, Point mutations: base pair substitution, frame shift (tautomerism; slippage); Missense, nonsense, silent. suppressor, auxotrophs, mutations caused by transposable elements Induction of mutations – physical and chemical mutagens Teratogenicity testing – Ames test DNA damage and repair mechanisms	12
IV	Genetic Recombination – General features, mechanism Models of recombination – reciprocal and non- reciprocal Rec genes – rec A and rec BCD complex	10
V	Concept of bacterial evolution - rRNA studies and molecular taxonomy	2

List of Books

1. Microbiology by Pelczar, Chan and Kreig.
2. Essentials of Microbiology by Frobisher.
3. General Microbiology by Stanier.
4. Microbiology by Prescott, Harley and Klein
5. Genes by Lewer.
6. Genetics by Ursula Goodenough.
7. Biochemistry by Stiyer.
8. Microbial Genetics by David Friedferder.
9. Microbial Genetics by Gardner.

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T.Y.B.Sc
305 Industrial Microbiology
Semester V (Lectures 45)

1	Batch fermentation Design and accessories of typical fermentor. Maintenance of sterility: Principles of sterilization; Sterilization of equipment, production media, and air. pH: Change of pH as a result of microbial activity, Control of pH by buffer action, <i>in situ</i> measurement and pH control Dissolved oxygen (aeration and agitation): Definition/Concept of K_{La} , Factors affecting K_{La} values in fermentation, determination of K_{La} by Sulfite oxidation technique and using Clark's oxygen electrode. Foam: Definition, cause, implication of foam in a fermentation process, Foam breakers: Chemical foam breakers – Properties of a good antifoam agent; Inert antifoams, crude antifoams, mechanism of addition, effect of antifoam agents on aeration of agitation. Mechanical foam breakers – Internal and external foam breakers. Advantages and disadvantages of both.	18
2	Continuous fermentation - Definition, advantages and disadvantages, Batch vs continuous fermentation	2
4	Fermentation media Types of raw materials – Saccharine material, starchy materials, hydrocarbon and vegetable oils, nitrogenous materials.	1
5	Screening for Industrial strains Introduction, Screening techniques: Primary screening – Crowded plate technique, Auxanography, Enrichment culture technique, Use of indicator dyes, Secondary screening	4
6	Preparation of inoculum or seed culture – Factors to be considered	2
7	Quality control (case study: pharmaceutical products) Concept of Good Manufacturing Practice, Factors affecting GMP, assessment of microbial contamination and spoilage; LAL assay. Microbiological assays based on Diffusion, Turbidometry, Metabolic response, Enzyme. Quality control (Example – vaccines): In-process control Final product control – general tests, Identity tests, Potency assays, Safety tests.	8
8	Industrial production: Upstream and down stream concepts, production, Harvest and purification of Penicillin, Vitamin B ₁₂ , Lysine, Beer, recombinant protein (Insulin)	10

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T.Y. B.Sc
306 Practical

- 1 Batch fermentation for production of vinegar
- 2 Production and extraction of Penicillin; Bioassay of penicillin (agar well method); Chemical assay of Penicillin;
- 3 Bioassay of vitamin B₁₂ (agar well method);
- 4 UV survival curve (*E.coli*)
- 5 Mutagenesis using chemical mutagen
- 6 SDS-PAGE for separation of proteins
- 7 AMES test

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T.Y. B.Sc
307 Ecology and Agricultural Microbiology
Semester VI (Lectures 45)

I	Ecology and ecosystems: Ecosystems, Community structure, functioning of ecosystems, trophic levels Soil as an ecosystem; Microorganisms in soil and their significance – bacteria, actinomycetes, fungi, algae, and protozoa; Rhizosphere biota; Winogradsky’s column – principle, set-up and significance; Biogeochemical cycles – nitrogen, carbon, sulphur and phosphorus, role of microorganisms Mangrove ecosystem: Pneumatophores, formation of detritus, mangrove as nutrient sink, ecological importance of mangroves.	21
II	Biopesticides: Definition, Bacteria eg. <i>B.popillae</i> , <i>B.thuringiensis</i> , Other microbes: fungi, viruses and protozoa; Advantages and disadvantages.	7
III	Biological Nitrogen Fixation: Symbiotic and non symbiotic modes of nitrogen fixation, Heterocyst, Mechanism of nodule formation and leghemoglobin, role of nif genes. Biofertilizers eg. Non-symbiotic: <i>Azospirillum</i> , <i>Azotobacter</i> , <i>Nostoc</i> ; Symbiotic: <i>Rhizobium</i> , <i>Azolla</i> – <i>Anabaena</i>	13
IV	Plant pathogenic microorganisms: introduction to bacterial, fungal and viral pathogens	4

List of Books

1. Soil Microbiology by Mark Coyne
2. Microbiology By Prescott, Harley and Klein
3. Fundamentals of Ecology by E. Odum
4. Soil Microbiology by Subba Rao
5. Soil Microbiology by M. Alexander.

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T.Y. B.Sc
308 Medical Microbiology and Basic Immunology
Semester VI (Lectures 45)

I	Pathogenesis, epidemiology, lab diagnosis, chemotherapy, prophylaxis in relation to the study of diseases caused by: c) Fungi – ringworm, candidiasis, d) Viruses – hepatitis, poliomyelitis	05
II	Chemotherapy Antibiotics affecting cell-wall synthesis (Penicillin, Cephalosporins), membrane function (Polymyxin, Nystatin), DNA (Nalidixic acid, Novobiocin), ribosome function (Streptomycin, Tetracycline, Chloramphenicol); Metabolic inhibitors: sulphonamides; Development of resistance to antimicrobial drugs (Causes, mechanisms, prevention)	10
III	Immunology Immunity classification – innate and acquired immunity. Cells and organs of immune system Cell mediated and humoral immunity Antigens: definition, haptens, antigenic determinants, polysaccharides, lipids, nucleic acids Antibodies: immunoglobulins (structure, classes and properties); antibody dependent cell cytotoxicity (ADCC); Types and functions of T Cells; macrophage activation; phagocytosis; complement cascade and fixation; Hypersensitivity reaction and autoimmune disorders: definitions Antigen – antibody reactions: in vitro precipitation, flocculation, agglutination, haemagglutination, passive haemagglutination, immunofluorescence, immunodiffusion, immunoprecipitation, immunoelectrophoresis, ELISA, RIA. Immunohaematology: ABO blood group system, hemolytic disease of new born	30

List of Books

1. Microbiology By Prescott
2. Medical Microbiology by Jawetz
3. Medical Microbiology By Sinzer
4. Medical Microbiology by Crikshank
5. Essential Immunology by Ivan Roitt
6. Immunology by Eissen and David
7. Immunology by James T. Barrett.
8. Text Book of Microbiology by Ananthanarayan
9. Immunology by Richard Goldshy, Thomas Kindt, Barbara Osbourne, Janis Kuby.
10. Immunology – A Short Course by Richard Coico, Geoffrey Sunshine and Eli Bengamini.

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T.Y. B.Sc
309 Practical
Semester VI

- 1 Microbiology of soil: Isolation of different groups of organisms from soil, set-up of Winogradsky's column, Isolation of cellulose and pectin degraders, Nitrification, Symbiotic N₂ fixation (microscopic examination of bacteroids from root nodules, Isolation of *Rhizobium*), non-symbiotic nitrogen fixers (*Azotobacter*, Cyanobacteria), isolation of P-solubilisers, demonstration of biocontrol activity of soil microorganisms
- 2 Microbiology of mangrove sediment and water
- 3 Immunology: Hemagglutination (Blood grouping – ABO and Rh), Staining of blood (Leishman's / Giemsa's) and differential WBC counts, preparation of plasma and serum, VDRL test (qualitative), Widal test (Qualitative)
- 4 Antibiotic sensitivity tests (paper disc, agar cup and ditch plate)
- 5 Determination of MIC of Penicillin

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T.Y. B.Sc
310 Genetic Engineering
Semester VI (Lectures 45)

I	Genetic Engineering – Introduction and tools Enzymes – restriction endonucleases, host controlled restriction and modification; ligases, lyases; terminal DNA transferase; alkaline phosphatase, DNA polymerase I, II, and III, S1 nuclease, RNase H, Reverse transcriptase, Vectors – Types of vectors with examples, plasmids (pBR322), cosmids (pJB8, pHc79), bacteriophage vectors (lambda, M13); shuttle vectors (YePs); expression vectors (pUC); Ti plasmid based vectors (___, ___), YAC/BAC Characteristics of ideal host: <i>E.coli</i> Linkers, adapters and Nucleic acid probes – synthesis of probe and labeling - radioactive and non-radioactive	20
II	Techniques in genetic engineering – principles, methodology and application of agarose gel electrophoresis; autoradiography; southern and northern blotting.	5
III	Gene cloning – isolation of DNA/plasmid, synthesis of cDNA, Construction of rDNA / Chimera, shot gun method for cloning. Identification of recombinant clones – colony and plaque gene library	5
IV	Polymerase chain reaction – principle, method, applications	5
V	DNA sequencing – chemical degradation and chain termination; Significance of rRNA homology and its role in taxonomic placement.	5
VI	Applications of genetic engineering – Medical, industrial, agricultural	5

List of Books

1. Foundation in Microbiology by Tauro and Talaro
2. Basic and Practical Microbiology by Allas
3. Microbiology by Daniel Lim.
4. Biotechnology by Purohit and Mathur
5. Principles and Applications of Recombinant DNA Technology by Bernard Glick; J. Pasternak.
6. Microbiology by Pelizar, Chan and Kreig.
7. Microbiology by Prescott, Harley and Klein.
8. Essentials of Microbiology by Frobisher.
9. General Microbiology by Roger Stancer.
10. Genes by Lewin.
11. Genetus by Ursula Gooderough.
12. Biochemistry by Stryer.
13. Microbial Genetics by David Friedfelder
14. Microbial Genetics by Gardner.

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T.Y.B.Sc
311 Food Microbiology
Semester VI (Lectures 45)

1	MICROBIOLOGY OF MILK AND MILK PRODUCTS	15
	Sources and types of microorganisms in milk - sources of contamination, different microorganisms implicated in spoilage and milk borne diseases of human and animal origin. Microbiological examination of milk – SPC, Breed’s Smear – advantages / disadvantages; Grading of milk by dye reduction test – MBRT and Resazurin – principle, techniques and applications. Preservation of milk – Pasteurization – LTHT, HTST, UHT processes, efficiency of pasteurization – phosphatase test; dehydration by roller, spray processes; Manufacture of milk products – fermented milks, butter, cheese – stages in manufacture (flow charts), microorganisms involved in souring and curing processes, spoilage, flavor and color defects.	
2	MICROBIOLOGY OF FOOD	15
	General principles of food spoilage, intrinsic and extrinsic factors responsible for food spoilage, microorganisms in spoilage; food borne pathogens, food poisoning and toxicity Principles and methods of food preservation: dehydration, freezing, salting, pickling, wood smoking, canning, pasteurization and irradiations. Microbiological examination: general and specific methods, identification of specific organisms by using selective and differential media. Spoilage of canned foods, determination of TDP/TDT and its significance in canning industry.	
3	MICROORGANISMS AS SOURCE OF FOOD AND ENZYMES	12
	SCP – microorganisms, nutritive value and use; Mushroom cultivation Enzymes-amylases and pectinases, their application in food industry	
4	Fermented foods: yoghurt, Sauerkraut	3

List of Books

1. Fundamental Principles of Bacteriology by An. Salle
2. Microbiology By Peligar, Chan and Kreig.
3. Microbiology by Prescott, Harley and Klein
4. Food Microbiology by Frazier and Westhoff
5. Modern Food Microbiology by James A. Jay
6. Basic Food Microbiology by George Banwart
7. Milk Microbiology by Mahanta
8. Essentials of Microbiology by Frobisher.

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T.Y. B.Sc
312 Practical
Semester VI

- 1 Milk Microbiology: Grading of milk – dye reduction tests (MBRT, resazurin); SPC, Breed's smear, plating on selective media, Efficiency of pasteurization by phosphatase test
- 2 Microbiology of canned food, spoiled food and fresh food; TDP; TDT; MIC of food preservatives (Sugar, NaCl, Na-benzoate and K-metabisulfite)
- 3 Solid state fermentation (cultivation of mushrooms)
- 4 Preparation and analysis of fermented foods: Curd, Idli, Sauerkraut
- 5 Restriction mapping of plasmid and electrophoretic analysis
- 6 Ligation of restriction digested plasmid and electrophoretic analysis
- 7 Demonstration of PCR

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