GUJARAT UNIVERSITY, AHMEDABAD 380009, GUJARAT, INDIA
B.SC. MICROBIOLOGY SYLLABUS
SEMESTER I & II
EFFECTIVE FROM JUNE 2022

A student selecting Microbiology as the core subject at First Year B. Sc. will be offeredfollowing papers in Semester-I and Semester-II

A. SEMESTER-I

- One theory paper of core course MI-101 of 100 marks
- One practical paper MI-102 of 100 marks

B. SEMESTER-II

- One theory paper of core course MI-103 of 100 marks
- One practical paper MI-104 of 100 marks

- ❖ Each theory paper at the external examination shall be of 3 hours duration and carry 70marks.
- ❖ Each external practical examination carrying total 70 marks shall be conducted for twoconsecutive days, each of four hours duration.
- ❖ Internal assessment will be of 30 marks each for theory paper and practical paper.
- ❖ For each theory paper of core course, there shall be 4 lectures of 55 minutes per week.
- ❖ For each practical paper there shall be total 4 lectures (two for each practical) each of 55minutes duration.
- ❖ Ideally one batch for practical session shall consist of 25 to maximum 30 students.
- ❖ Each theory paper is divided into four units and from each unit one question shall be setduring question paper setting for examination.
- ❖ The format of the question paper and mode of examination (online/offline) will be decidedby the Gujarat University Ahmedabad.
- ❖ The numeric on the right depicts the number of lectures allotted to a particular topic.
- ❖ EC is the abbreviation of E-Content.
- ❖ The teaching will be based on listed reference books.
- ❖ URLs/Weblinks from where E-Content [EC] is to be used are also given in references.
- ❖ Student who opts to exit after passing Semester-II examination shall be considered forawarding certificate of "Basic Microbiology".
- ❖ The syllabus of each paper is outlined as follows.

SEMESTER I

MI 101: Introduction to Microbiology

Unit 1: The Microbial World **Teaching Hours: 10**

- Introduction: Microbes in our lives
- Classification of Microorganisms
  - Binomial system of nomenclature
  - Difference between prokaryotic and eukaryotic microorganisms
  - Whittaker's five kingdom concept of classification **[EC]**
  - Carl Woese's three kingdom classification system **[EC]**
- Major Groups of Microorganism
  - Prokaryotic microbes: Eubacteria and Archaeobacteria
  - Eukaryotic microbes: Fungi (Yeasts & Molds), Protozoa, Algae **[EC]**
  - Acellular microbes: Viruses
- Distribution of Microorganisms in Nature

Unit 2: The History of Microbiology **Teaching Hours: 10**

- The Discovery of Microorganisms
  - Microbiology and the origin of life
  - Contribution of A. v. Leeuwenhoek in the discovery of microscope **[EC]**
  - Spontaneous generation vs. biogenesis
- The Golden Age of Microbiology
  - Germ theory of fermentation
  - Germ theory of disease **[EC]**
  - Pure culture technique and Koch's Postulates
  - Contribution of Joseph Lister in Antisepsis
  - Contribution of Edward Jenner & Louis Pasteur in Immunology
  - The Birth of Modern Chemotherapy: Contribution of Paul Ehrlich, Alexander Fleming and Selman A. Waksman

Unit 3: The Development of Microbiology **Teaching Hours: 10**

- Medical Microbiology: Discovery of phagocytosis, bacterial toxins and antitoxins, types of immunity and interferon
- Agricultural Microbiology
  - Soil Microbiology: Contributions of Sergei N. Winogradsky **[EC]** and Martinus W. Beijerinck and development of enrichment culture technique
  - Plant Pathology: 'Fire Blight' of pears, 'Peach Yellows', transmission of the viral diseases of plants by insects, discovery of TMV **[EC]**
- Microbial Genetics and Molecular Biology
  - One Gene - One Enzyme Hypothesis: Contributions of George Beadle and Edward Tatum **[EC]**

- DNA as Hereditary Molecule: Contributions of Frederick Griffith, Oswald Avery, Colin MacLeod and Maclyn McCarty

➢ Microbiology As a Field of Biology

➢ Microbiology As a Science: Basic and Applied Microbiology

Unit-4 The Microscopic Examination of Microorganisms Teaching Hours: 10

➢ Light Microscopy
- Principle of bright-field microscopy: resolving power, numerical aperture, limit of resolution and magnification
- Component parts of the compound light microscope **[EC]**
- Principle and applications of dark-field, fluorescence, and phase-contrast microscopy

➢ Preparation of Specimens for Light Microscopy
- The wet-mount and hanging-drop techniques **[EC]**
- Microbiological stains: acidic, basic, and neutral dyes
- Smear preparation, fixation, use of mordents, intensifiers, decolorizers
- Simple staining of the smear: positive **[EC]** and negative staining

➢ Electron Microscopy: Principle and applications of transmission & scanning electron microscopy

REFERENCE

No.	Name	Author
1.	Microbiology: An Introduction	G. J. Tortora, B. R. Funke, C. L. Case, 11th Edition (Indian Edition) (2016). Pearson India Education Services Pvt. Ltd., Noida (UP), India.
2.	Microbiology	Pelczar JR., Chan ECS, Krieg NR, 5th Edition (1993), McGraw-Hill Book Company, NY.
3.	Microbiology: An Application Based Approach	Pelczar JR., Chan ECS, Krieg NR, 3rd Reprint (2011), Tata McGraw Hill Education Private Limited, New Delhi, India
4.	Principles of Microbiology	R. M. Atlas, 2nd Edition (Indian Edition) (2015) McGraw Hill Education (India) Private Limited, New Delhi, India

URLs/Weblinks for E-content

1. Whittaker's five kingdom concept of classification https://youtu.be/hiQCCN5oisw
2. Carl Woese's three kingdom classification system https://youtu.be/ZUyK3iFptFY
3. Eukaryotic microbes:
   - Fungi https://youtu.be/VVuYGkk_I8s
   - Protozoa https://youtu.be/B1CFVuQVG2U
   - Algae https://youtu.be/j5W0apM8bxc
4. Contribution of A. v. Leeuwenhoek in the discovery of microscope https://youtu.be/qLTKU0nbzLo

5.	Germ theory of disease	https://youtu.be/97sEcWEb3Iw
6.	Contributions of Sergei N. Winogradsky	https://youtu.be/3xDexh8vJv0 https://youtu.be/9l96690AVGE https://www.sumanasinc.com/webcontent/animations/content/winogradsky.mp4
7.	Discovery of TMV	https://youtu.be/vOX1MHPw8g0
8.	One Gene - One Enzyme Hypothesis	https://youtu.be/cETqxjsB_Bw https://youtu.be/fXASTY-YoRQ
9.	Component parts of the compound light microscope	https://youtu.be/RKA8_mif6-E https://youtu.be/bdxzcoJIlyE
10.	Hanging-drop techniques	https://youtu.be/ujzSmsmg7ok
11.	Simple staining (Positive Staining)	https://youtu.be/8ODeT9DLHKI

MI 102: MICROBIOLOGY PRACTICALS

1. Microbiology Good Laboratory Practices (GLP): Rules and Safety
2. Study of principle, component parts and operation of the compound light microscope
3. Study of principles and working of laboratory instruments: Autoclave, Hot air oven, Incubator, Water bath, Bacteriological Filters, Centrifuge, Rotary shaker, pH meter, Colorimeter
4. Introduction to size, shape, labeling (if required) and uses of laboratory glass wares/plastic wares: Test tube, Pipette, Conical flask, Petri dish, Measuring cylinder, Coplin Jar, Burette, Beaker, Glass spreader
5. Cleaning and preparation of glassware for sterilization
6. pH adjustment of solution by use of pH strip and pH meter
7. Disposal of laboratory waste and cultures
8. Study of curd sample by wet mount (temporary mount)
9. Study of hay infusion by hanging drop method
10. Simple staining of bacteria: positive staining & negative staining
11. Study of permanent slides/photomicrographs of different groups of microorganisms

    a) Permanent slides of prokaryotic microbes (bacteria): *Staphylococci, Bacilli, Spirochetes, Actinomycetes*

    b) Permanent slides of eukaryotic microbes:

    - Fungi: *Yeast, Mucor, Penicillium*
    - Algae: *Diatoms, Spirogyra, Chlamydomonas*
    - Protozoa: *Amoeba, Paramecium, Euglena*

    c) Photomicrographs of acellular microbes (viruses): HIV, TMV, Bacteriophage T2

Scheme of Practical Examination

No.	Title of The Exercise	Marks
Ex-1	Microscopic study of the given sample by wet-mount or hanging drop method	**15**
Ex-2	Positive OR negative staining of the given bacterial culture	**15**
Ex-3	General exercise: Principle and operation of the given laboratory instrument	**10**
Ex-4	Spotting	**15**
Ex-5	Viva-voce	**10**
Ex-6	Journal and slides	**05**
	Total Marks	**70**

SEMESTER II

MI 103: Basic Bacteriology

Unit 1: Cellular Organization and External Structures of Bacterial cell Teaching Hours: 10

- Cellular organization: size, shape and arrangement of bacterial cells
- External structures of bacterial cell
  - Structure and chemical composition of cell wall of Gram-positive and Gram-negative bacteria **[EC]**, Archaebacteria, Acid fast bacteria
  - Mechanism of Gram stain **[EC]** and Acid-fast staining **[EC]**
  - Cell wall less bacteria, protoplast, spheroplast
  - Flagella of Gram-positive bacteria & Gram-negative bacteria **[EC]**, endo-flagella (axial filaments), bacterial motility
  - Capsules, slime layer, pili and fimbriae, sheaths, prosthecae and stalks

Unit 2: Internal Structures of Bacterial cell Teaching Hours: 10

- Cytoplasmic membrane of Eubacteria **[EC]** and Archaebacteria
- Mesosomes
- Cytoplasm and nuclear material (bacterial chromosome), bacterial plasmids
- Ribosomes of Eubacteria **[EC]** and Archaebacteria
- Inclusion bodies (Cellular reserve food materials)
- Bacterial Spores and Cyst: spore structure, types of spores, sporogenesis **[EC]** and germination of spore, bacterial cyst
- Structural differences between eubacteria and archaebacteria

Unit 3: Nutrition and Cultivation of Bacteria Teaching Hours: 10

- Nutritional and chemical requirements of bacteria: Carbon, Oxygen, Nitrogen, Sulfur, Phosphorus, Trace elements, Vitamins, Growth factors, water **[EC]**
- Nutritional diversities in bacteria
  - Based on source of energy: Phototrophs, Chemotrophs
  - Based on source of electro donor: Lithotrophs, Organotrophs
  - Based on source of carbon: Autotrophs, Heterotrophs, Mixotrophs, Obligate parasites
- Culture media: Media ingredients, Preparation of media, General cultivation media (N-broth and N-agar) **[EC]**
- Cultivation of anaerobic bacteria

Unit 4: Pure Culture Techniques Teaching Hours: 10

- Pure culture, mixed culture, Selective methods to obtain pure cultures: Chemical, Physical, and Biological Methods
- Isolation methods of pure culture: Aseptic technique **[EC]**, Streak plate **[EC]**, Spread plate and Pour plate techniques
- Cultural characteristics: Colony characteristics **[EC]**, Characteristics of broth cultures

- Maintenance and preservation of pure cultures **[EC]**
- Culture collection centers

REFERENCE

No.	Name	Author
1.	Microbiology	Pelczar JR., Chan ECS, Krieg NR, 5th Edition (1993), McGraw-Hill Book Company, NY.
2.	Principles of Microbiology	R. M. Atlas, 2nd Edition (Indian Edition) (2015) McGraw Hill Education (India) Private Limited, New Delhi, India

URLs/Weblinks for E-content

1.	Gram +ve and Gram -ve bacterial cell wall	https://youtu.be/eM-bXU1UO0Q https://youtu.be/roX0inhEdgA
2.	Gram stain	https://youtu.be/pgr-HeVNbOY https://youtu.be/sxa46xKfIOY
3.	Acid-fast staining	https://youtu.be/s1uWm6rqGpA
4.	Bacterial flagellum	https://youtu.be/B7PMf7bBczQ https://youtu.be/eKnFlbrLNOw
5.	Bacterial cell membrane	https://youtu.be/Kqa8oNDezdM
6.	Bacterial ribosomes	https://youtu.be/BEmXTs2hF-A
7.	Bacterial spores	https://youtu.be/VbDHV7j5-PQ https://youtu.be/oGSmpKUIdS8
8.	Nutritional and chemical requirements of bacteria	https://youtu.be/qMNFdmbj20Y
9.	Preparation of nutrient agar	https://youtu.be/56rl5QO1qLE
10.	Aseptic technique	https://youtu.be/bRadiLXkqoU
11.	Streak plate method	https://youtu.be/_1KP9zOtjXk https://youtu.be/pfrjpyZ-Wuw
12.	Colony characteristics	https://youtu.be/4JZAFUPckUg https://youtu.be/R0T-nplMCzo
13.	Lyophilization of bacterial culture	https://www.youtube.com/watch?v=tpoWoMtJGac

MI 104: MICROBIOLOGY PRACTICALS

1. Differential staining of bacteria: Gram stain method
2. Structural and special staining techniques
   a) Endospore staining by Dorner's method
   b) Cell wall staining by Dyar's method
   c) Capsule staining by Hiss's method
   d) Metachromatic granule staining by Albert's method
   e) *Spirochaetes* staining by Fontana's method
3. Preparation of bacteriological media: Nutrient broth and Nutrient agar
4. Cultivation and isolation of bacteria
   a) Broth culture method
   b) Agar plate methods:
      - Streak plate method
      - Pour plate method
      - Spread plate method

      [Method: Gram stain of mixed bacterial culture, Isolation of bacteria, Colony (Cultural) characteristics, Morphological characteristics (Gram stain)]
   c) Agar slant (slope) method for pure culture
5. Preservation of microbial cultures
   a) Periodic sub culturing and storage at refrigeration temperature
   b) Preservation of bacteria in soil (Nitrogen fixers)
6. Study of pigmented bacteria
   a) Staphylococcus aureus
   b) Micrococcus luteus
   c) Serratia marcescens
   d) Pseudomonas aeruginosa
7. Cultivation of anaerobic bacteria by use of:
   a) Robertson's cooked meat medium
   b) Thioglycolate broth
   c) Anaerobic jar (Demonstration)

Scheme of Practical Examination

No.	Title of The Exercise	Marks
Ex-1	Isolation of bacteria by streak plate method	**25**
Ex-2	Structural and special staining of bacteria (anyone) a) Endospore staining by Dorner's method b) Cell wall staining by Dyar's method c) Capsule staining by Hiss's method d) Metachromatic granule staining by Albert's method e) *Spirochaetes* staining by Fontana's method	**15**
Ex-3	Spotting	**15**
Ex-4	Viva voce	**10**
Ex-5	Journal and slides	**05**
	Total Marks	**70**

GUJARAT UNIVERSITY
Syllabus for Second Year Microbiology
Semester III and IV
Effective from June 2018

1. A student offering Microbiology programme will be offered four theory papers of core course MI 201, 202 and MI 204, 205; each paper of 100 marks and practical papers MI 203 and MI 206 of 100 marks each as prescribed here under
2. Each theory paper at the external examination shall be of 3 hours duration and carry 70 marks. Each practical examination shall be of three consecutive days each of four hours duration. Total marks for practicals shall be 70 each
3. Internal assessment will be of 30 marks for each theory and practical papers
4. For each theory papers there will four lectures of 55 minutes per week. For practical there will be six lectures (two/practical) each of 55 minutes per week.
5. Each theory paper is divided into four units and from each unit one question shall be set. The fifth question will be of objective type covering contents of all four units
6. Practical batch shall consist of 20 to maximum 25 students
7. **The teaching shall be based upon listed textbooks**
8. The numeric on the right depicts the number of lectures allotted

Proposed Syllabus for Microbiology Semester III and IV
Course MI- 201
Microbial Physiology **(Hours)**

Unit 1Biomolecules
Chemical structure, Properties, Classification and Biological significance of

A. Carbohydrates (03)
B. Proteins (03)
C. Lipids (02)
D. Nucleic acids (02)

Unit 2Enzymes
1. General Introduction (04)

A. Physical and chemical properties
B. Structure of enzymes: Prosthetic group, apoenzyme, coenzyme, cofactors.
C. Localization of enzymes: Extra cellular and intra cellular
D. Nomenclature and classification of enzymes, IUB system of enzyme classification.

2. Enzyme action (06)

A. Active site of enzymes
B. Mechanism of enzyme action.
C. Factors affecting enzyme activity
D. Inhibition of enzyme activity: Competitive and Non competitive

Unit 3 Microbial Nutrition and Introduction to Metabolism
1 Modes of Nutritional uptake: (04)
Entry of nutrients in cell, Passive diffusion, facilitated diffusion and active transport.
2 Classification of bacteria on the basis of growth supporting environmental factors such as oxygen, temperature, pH, osmotic pressure, salt and hydrostatic pressure. (04)
3 Introduction to microbial metabolism (02)

i) Anabolism, catabolism, primary and secondary metabolism

ii) Role of reducing power, precursor metabolites and energy rich compounds in cell metabolism

Unit 4 Microbial growth

1. Methods of reproduction in bacteria and new cell formation (02)
2. Growth (05)
   A. Introduction to growth rate, generation time
   B. Criteria for growth measurement: Cell mass and Cell number, methods of their measurement
   C. Normal growth curve of bacteria
   D. Continuous growth and synchronous growth.
3. Chemotherapeutic agents as growth inhibitors (03)
   A. Principles of chemotherapy
   B. General mode of action of various chemotherapeutic agents: Sulfonamides, Antibiotics (penicillin, streptomycin, polymyxin)

Text Books:

1. PelczarJr, M J, Chan E C S, Krieg N R, (1986) Microbiology, 5thedn, McGraw-Hill Book company, NY
2. IngrahamJ L, and Ingraham, C L, (2000) Introduction to Microbiology, 2nd edn, Brooks/Cole, Singapore
3. Black J G, (2002) Microbiology: Principles and Explorations, 5thedn, John Wiley and Sons, Inc. NY.

Semester –III
Course MI- 202
Soil and Water Microbiology

Hours

Unit 1Microbiology of Soil

1 Physicochemical characteristics of soil, soil as culture media and soil microflora (02)

2 Methods to study soil flora: (03)

Direct microscopic methods, agar plate technique, enrichment culture technique, buried slide technique and soil respiration technique

3 Microbial interactions in soil (05)

A Neutral, positive and negative associations

B Interaction between plant roots and microorganisms

I) Rhizosphere and its significance

II) Mycorrhiza

Unit 2 Microorganisms as Biogeochemical Agents

1 Introduction to biogeochemical transformations in soil: Mineralization and immobilization of elements (01)

2 Rotation of elements in nature (08)

A. Nitrogen Cycle
B. Sulphur Cycle
C. Carbon Cycle
D. Iron Cycle
E. Phosphorous Cycle

3 Soil fertility: Biofertilizers (01)

Unit 3 Microbiology of Drinking Water

1 Natural waters: Sources of contamination (03)

2 Microbial indicators of fecal pollution

A. Coliforms as indicator
B. Methods for differentiation: IMViC test and Elevated temperature test
C. Microbial indicators other than coliforms

3 Nuisance organisms in water: Slime forming bacteria, Iron and Sulphur bacteria and Algae (01)

4 Water borne diseases (01)

5 Bacteriology examination of drinking water (03)

A. Sampling
B. Quantitative analysis: Total viable count, Membrane filter technique
C. Qualitative analysis: Detection of coliforms (presumptive, confirm and completed test) Defined substrate test, P-A (Presence Absence test)

6 Purification of drinking water: sedimentation, filtration and disinfection (01)

Unit 4 Microbiology of Waste water

1 Types of waste water, Chemical and Microbiological characteristics of waste water (01)

2 BOD, COD and TOD as indicators of untreated waste water, Pollution problems due to disposal of untreated waste (03)

3 Methods of waste water treatment (06)

A. Primary treatment and secondary treatment: Principles and role of microorganisms in: Septic tank, Imhoff tank, trickling filters, activated sludge process and oxidation ponds
B. Advanced treatment and final treatment
C. Solid waste processing: Anaerobic sludge digestion and composting

Text Books:

1. PelczarJr, M J, Chan E C S, Krieg N R, (1986) Microbiology, 5thedn, McGraw-Hill Book Company,NY.
2. Alexander M, (1977), **Soil Microbiology,** 2nd Edition Krieger Publ. Co. Melbourne, FL
3. Atlas R M, (1977), **Principles of Microbiology**2nd Edition, Wm. C. Brown Publ. Iowa USA

Semester III

MI 203
Microbiology Practicals

1 Study of different types of media
   A. Selective media: Rose Bengal agar medium
   B. Differential medium: MacConkey's agar medium, EMB agar medium, Triple sugar iron agar medium
   C. Enrichment media: Selenite broth
   D. Enriched media: Blood agar medium, Glucose yeast extract agar medium
   E. Natural media: Soil extract agar medium,

2 Qualitative analysis of biomolecules
   A. Carbohydrates: Iodine test, Molisch's test, Benedict's test, Barfoed's test, Bial's test and Seliwanoff's test
   B. Protein: Biuret test, Ehrlich's test, Glyoxilic acid test and Xanthoproteic test

3 Study of effect of antimicrobial compounds on growth of bacteria
   A. Study of effect of heavy metal on growth of bacteria
   B. Study of effect of chemicals (5% phenol, 1% crystal violet and 0.001% $HgCl_2$)on growth of bacteria (Agar cup method)
   C. Study of effect of antibiotics on growth of bacteria using paper disc method
   D. Study of effect of antibiotic on growth of bacteria using agar ditch method

4 Study of Biochemical reactions
A Based on Carbon source
   i. Oxidative and fermentative breakdown of glucose
   ii. Fermentation of Sugars: Glucose, Xylose, Mannitol, Lactose, Maltose and Sucrose
   iii. Glucose break down products: Methyl red test and Voges Proskauer's test
   iv. Citrate utilization test
   v. Starch utilization test
   vi. Lipid utilization test

B Based on Nitrogen source
   i. Indole production test
   ii. H_2S production test
   iii. Urea utilization test
   iv. Casein hydrolysis test
   v. Gelatin Hydrolysis test
   vi. Deamination test
   vii. Ammonia production test
   viii. Nitrate reduction test

C Other tests
   i. Catalase test
   ii. Dehydrogenase test
   iii. Oxidase test

5 Microbiological analysis of soil
   A. Enumeration of organisms from soil (Standard plate count)
   B. Isolation and cultivation of symbiotic and non-symbiotic nitrogen fixing bacteria, Actinomycetes and Fungi (*Mucor, Rhizophus, Aspergillus* and *Penicillium*) from soil
6 Microbiological analysis of drinking water

A. Standard plate count
B. Detection of fecal pollution of water by performing presumptive, confirmed and completed test
C. Determination of MPN of coliforms in water

7 Study of skin flora

8 Study of Air flora by settling plate technique

Scheme for Practical Examination

Exercise	**Marks**
1 Microbiological Analysis of soil/water	(15)
A. Standard plate count	
B. MPN	
C. Presumptive and confirmed test	
D. Confirmed and completed test	
2 Biochemical reactions (any five)	(15)
3 General Exercise (any one)	(10)
A. Study of effect of antimicrobial agents on growth of bacteria (antibiotics, heavy metals and Chemicals)	
B. Qualitative analysis of protein/carbohydrates	
C. Study of cultural and morphological characters of Actinomycetes/Fungi	
D. Cultivation and study of nitrogen fixing bacteria from soil	
E. Study of Air flora	
F. Study of skin flora	
4 Spotting	(10)
5 Vive voce	(10)
6 Journal and slides	(05)

Semester IV

MI-204
Diversity of Bacteria

Hours

Unit 1 Archea bacteria

A. Introduction and phylogeny (01)

B. General properties (04)

1) Cell wall and cell membrane
2) Chromosome
3) Ribosome

C. Salient features of: (05)

1) Methanogens
2) Halophiles
3) Thermophillic S^0 metabolizers

Unit 2 Eubacteria I (Selected genera)

A. Photosynthetic bacteria: General properties (05)

1) Oxygenic photosynthetic bacteria: *Cyanobacteria*
2) Anoxygenic photosynthetic bacteria: Purple bacteria, Purple non sulphur bacteria, Green bacteria

B. Chemolithotrophic bacteria (05)

1) Nitrifying bacteria: *Nitrobacter*, *Nitrosomonas*
2) Colorless Sulphur bacteria: *Thiobacillus, Acidiphilium*
3) Iron, Hydrogen and Magnetotactic bacteria: *Sidero*c*occus, Hydrogenobacter, Aquaspirillum*

Unit 3 Eubacteria II (Selected genera)

A. Gram negative spiral and curved rods (03)

1) Spirocheatales
2) Spiral bacteria: *Spirillum and Azospirillum*
3) Curved rods: *Bdellovibrio, Desulfovibrio*

B. Gram negative aerobic rods and cocci (02)

1) Pseudomonadaceae: *Pseudomonas*, *Xanthomonas*
2) Neisseriaceae: *Neisseria*

C. Gram-negative anaerobic and facultative rods and cocci (03)

1) Enterobacteriaceae: *E coli, Serratia, Enterobacter, Proteus, Shigella, Salmonella*
2) Vibrionaceae: *Vibrio, Photobacterium*
3) Veillonellaceae: *Veillonella*

D. Obligatory Parasites (02)

1) Rickettsiaceae: *Rickettsia, Coxiella*
2) Chlamydiaceae: *Chlamydia*
3) Mollicutes: *Mycoplasma*

Unit 4 Eubacteria III (Selected genera)

A. Gram positive rods and cocci (02)

1) Micrococcaceae: *Staphylococcus*
2) Deinococcaceae: *Deinococcus*
3) Other genera: *Streptococcus, Leuconostoc, Peptococcus*

4) Endospore formers: *Bacillus, Clostridium*
5) Non spore forming Rods: *Lactobacillus*

B. Gram positive irregular rods (03)

1) Nonfilamentous rods: *Corynebacterium, Arthrobacter*
2) Aerobic curved rods: *Mycobacterium*
3) Nocardioforms: *Nocardia*

C. Filamentous bacteria with complex morphology: *Frankia, Streptomyces* (02)

D. Bacteria with unusual morphology (03)

1) Prosthecate budding/nonbudding bacteria: *Hyphomicrobium, Caulobacter*
2) Nonprosthecate budding/nonbudding bacteria: *Planctomyces, Gallionella*
3) Sheathed bacteria: *Spherotilus, Crenothrix, Leptothrix*
4) *G*liding fruiting/nonfruiting bacteria: *Myxobacteria, Beggiatoa*

Note: (Content of syllabus should not be beyond the prescribed text book)

Textbook: Atlas R M, (2015), **Principles of Microbiology** 2nd Edition, McGraw Hill education, Mumbai

Suggested Reading:

Garrity George M, Noel R Krieg et al (2011) Bergey's Manual of Systematic Bacteriology (Vol. I to IV) 2ndedition, Editors James T Staley and Aidan C Parte Springer

Semester IV

MI-205
Food and Dairy Microbiology

Hours

Unit I Microbes in Food Infection and Poisoning

1. Food as a substrate for microorganisms (01)
2. Microbial flora of food: fruits, vegetables, meat, eggs, biochemical, temperature and pathogenic types of milk (02)
3. Factors affecting kinds and numbers of microorganisms: intrinsic and extrinsic (02)
4. Food and milk borne infections: Microorganism involved, source of infection, Incubation period and characteristics in brief: (02)
   A. Bacterial infections: *Salmonella* sp., *Shigella* sp., *E. coli, Vibrio* sp., *Campylobacter jejuni, Listeria monocytogenes*
   B. Viral infections: RotavirusHepatitis A Poliovirus
   C. Protozoal infections: *Entamoeba*
5. Food poisoning: (03)
   A. Role of *Staphylococcus aureus, Clostridium botulinium* and *Salmonella* spp
   B. Molds as poisoning agents: Role of Mushroom, *Aspergillus, Claviceps purpurea, Fusarium moniliformis.*

Unit II Microbial Food Spoilage and Preservation

1. Microbial Spoilage of food (04)
   A. Spoilage of milk and milk products, fruits, vegetables, eggs, meat
   B. Spoilage of canned foods
2. Preservation of food and Milk (06)
   A. General principles
   B. Methods of preservation
      i. Use of aseptic handling
      ii. High temperature: Pasteurization, sterilization, canning
      iii. Low temperature: Refrigeration and freezing
      iv. Dehydration
      v. Osmotic pressure
      vi. Preservatives
      vii. Radiations: Ionizing and non-ionizing radiation

Unit IIIMicrobes as Food and Food Products

1. Fermented dairy products (05)
   A. Starter culture
   B. Cheese: Types, curdling, processing, ripening
   C. Other fermented dairy products: Yogurt, cultured buttermilk, acidophilus milk, Kefir and cultured sour milk
   D. Introduction to probiotics, prebiotics and synbiotics
2. Fermented food products: Pickles, sauerkraut and bread (02)
3. Microbes as food: Mushrooms, spirulina and yeasts (03)

Unit IV Methods in Food Microbiology

1. Biological methods: Generalized scheme for microbiological examination (05)
   A. Direct microscopic examination, colony forming units (CFU)

B. Most probable number (MPN)
C. Identification of specific group or species of microorganisms

2. Bacteriological analysis of milk (03)
   A. Grading of milk: Methylene Blue Reduction and Resazurin test
   B. Determination of efficiency of pasteurization: Phosphatase test
   C. Determination of MPN
   D. Acid-fast staining
3. Microbiological criteria of food safety: (02)
   A. Microbial standards for food
   B. FDA, BIS, Food Safety and Standard Act of India
   C. Food certification marks in India: ISI, Agmark, FPO, BIS, FSSAI

Text Books:

1. Pelczar Jr, M J, Chan E C S, Krieg N R, (1986), ***Microbiology: AnApplication Based Approach***, 5th edn. McGraw-Hill Book Company, NY
2. Frazier W C and Westhoff D C (1988), ***Food Microbiology***, 4th edn. McGraw-Hill Book Company, NY
3. Prescott L, Harley J P, and Klein D A, (2008), ***Microbiology***, 7th edn. Wm C. Brown - McGraw Hill, Dubuque, IA.
4. Indian Standards: Food Hygiene-Microbiological Criteria-Principles for Establishment and Application
5. Fssai: Manual of methods of analysis of foods- food safety and standards authority of India, Ministry of health and family welfare, Government of India, New Delhi, 2015

Semester IV

MI-206
Microbiology Practicals

1. Study of bacterial diversity in soil by using Winogradsky column (Demonstration only)
2. Study of bacterial motility
3. Measurement of bacterial yeast and fungal cell size using micrometer
4. Pure culture study: Morphological, Cultural and Biochemical Characters
   A. Gram positive bacteria: *Staphyloccus aureus*, *Bacillus subtilis*, *B megaterium and B cereus*
   B. Gram negative bacteria: *E coli*, *Enterobacter aerogenes*, *Proteus vulgaris* and *Pseudomonas aeuginosa*
5. Isolation and cultivation of yeast
6. Study of permanent slides: Amoeba, *Euglena*, *Paramecium*, Diatoms and *Spirogyra*
7. Microbiological analysis of food
   A. Standard plate count
   B. Determination of MPN of coliforms
8. Microbiological analysis of milk
   A. Standard plate count
   B. Determination of microbial load by use of MBRT and RRT of raw, boiled and pasteurized milk
   C. Detection of fecal coliforms
   D. Detection of Acid fast bacteria in milk

Scheme for Practical Examination

Exercise	**Marks**
1 Microbiological Analysis of food/milk A. Standard plate count B. MPN C. Presumptive and confirmed test D. Confirmed and completed test E. MBRT/RRT and Acid fast staining	(15)
2 Pure culture study (any one)	(20)
3 General Exercise (any one) A. Isolation and cultivation of yeast B. Study of Bacterial motility C. Micrometry	(10)
4 Spotting	(10)
5 Vive voce	(10)
6 Journal and slides	(05)

GUJARAT UNIVERSITY
Syllabus for Third Year B. Sc. Microbiology
Semester V and Semester VI
Effective from June-2019

1. A student selecting Microbiology as the special subject in Third Year B. Sc. will be offered following papers in Semester-V and Semester-VI.

   A. Semester-V

   I. Four theory papers of core course MI-301, MI-302, MI-303 and MI-304, each of 100 marks.

   II. One theory paper of subject elective course MI-305 of 100 marks.

   III. One practical paper MI-306 of 200 marks.

   B. Semester-VI

   I. Four theory papers of Core Course MI-307, MI-308, MI-309 and MI-310, each of 100 marks.

   II. One theory paper of subject elective course MI-311 of 100 marks.

   III. One practical paper MI-312 of 200 marks.

2. Each theory paper at the external examination shall be of 2½ hours duration and carry 70 marks. The external practical examination carrying 140 marks shall be conducted for three consecutive days, each of four hours duration.
3. Internal assessment will be of 30 marks for each theory paper and 60 marks for practical paper.
4. Distribution of lectures for individual paper is as follows.

   A For each theory paper of core course, there shall be 4 lectures per week, each of 55 minutes duration (4 X 4 = 16 lectures/week)

   B. For theory paper of subject elective course there shall be 3 lectures per week, each of 55 minutes duration (1 X 3 = 03 lectures/week)

   C For practical paper there shall be 4 periods each of 55 minutes duration, for three consecutive days (4 X 3 = 12 periods per week for one batch).

5. Ideally one batch for practical periods shall consist of 20 students; however maximally 25 students can be accommodated.
6. Every theory paper is divided into four units and from each unit one question shall be set for examination. The type of question/sub-question and its marks shall be set on the basis of question paper format decided by the Gujarat University from time to time.
7. The teaching shall be based upon listed reference books.
8. The numeric on the right depicts the number of lectures allotted to a particular topic.
9. The syllabus for each paper is outlined as follows

SEMESTER - V
COURSE MI-301
Molecular Biology and Genetics of Prokaryotes

Unit I Genetic material and its replication

1. Nature of Genetic material (3 hr)
   A. Understanding of terms: Chromosome, Nucleoid, Plasmid, Genome, Genetic material, Gene, Genotype, Phenotype, Replicon
   B. Experimental proof for DNA as genetic material: Work of Griffith; Avery, McCarty and MacLeod; Hershey and Chase

2. Structure of DNA (2 hr)
   A. The elucidation of DNA structure
   B. Watson-Crick's model of DNA

3. Replication of DNA (5 hr)
   A. Semi conservative nature, Meselson and Stahl's experiment
   B. Molecular mechanism: Strand separation, Synthesis of RNA primer, Formation of leading strand and lagging strands, Removal of primer, Joining of Okazaki Fragments, Proof reading activity of DNA polymerase
   C. Patterns of DNA replication: Cairn's (Ø) model and Rolling Circle Mechanism (σ model)

Unit II Gene expression and regulation

1. Fundamentals (1 hr)
   A. Central Dogma: The flow of genetic information
   B. Structure of the protein coding gene

2. Transcription (2 hr)
   A. Initiation: Role of Promoter, RNA polymerase, Sigma factor
   B. Elongation
   C. Termination: Rho independent and Rho dependent
   D. Intron, Exon, Cistron and Polycistronic mRNA

2. Genetic code: Triplet nature, Polarity, Degeneracy, Wobble phenomenon, near universality (2 hr)

3. Translation (3 hr)
   A. Initiation: role of initiation factors, 70 S initiation complex
   B. Elongation: binding of AA-tRNA to A site, peptide bond formation, translocation
   C. Termination: role of release factors.

4. Regulation of gene expression (2 hr)
   A. Negative inducible control of lactose operon
   B. Catabolite repression and positive control of lactose operon
   C. Negative repressible control of tryptophan operon

Unit III Mutation and DNA repair

1. Types of mutation (3 hr)
   A. Spontaneous mutations
   (i) Experimental proof for spontaneous nature of mutation: work of Joshua and E. Leaderberg
   (ii) Transition, Transversion, Insertion, Deletion, Development of AP sites

   B. Induced mutations
   (i) Chemical mutagenesis by 5-bromouracil, methyl-nitrosoguanidine and acridine orange
   (ii) Physical mutagenesis by UV radiations
   (iii) Biological mutagenesis by phage Mu

2. Transposable elements: Properties, Insertion Sequences (IS), Tn elements, Transposon mutagenesis (1 hr)

3. Effects of mutation in protein coding gene (2 hr)
   A. Forward mutations: silent, missense, nonsense, frame shift
   B. Reverse mutation: true reversion
   C. Suppressor mutation: intragenic and extragenic

4. Classes of bacterial mutants: (1 hr)
   Morphological, conditional, biochemical (nutritional) and resistant mutants

5. DNA repair mechanisms (3 hr)
   A. Direct: Photo-reactivation repair
   B. Indirect: Excision (base and nucleotide) repair, Mismatch repair
   C. SOS repair system.

Unit IV Gene transfer among bacteria

1. Fundamentals: Zygote, Allele, Recombination, Horizontal and Vertical gene transfer, Production and fate of merozygote (1 hr)

2. Bacterial plasmids: (2 hr)
   General properties, functional types of plasmid, maintenance of plasmids

3. Gene transfer mechanisms (7 hr)
   A. Transformation: Competent cell, natural transformation and DNA uptake system in Gm +ve and Gm -ve bacteria, artificial transformation of bacteria using plasmid

   B. Transduction:
      i. Lytic and Lysogenic life cycles of bacteriophage
      ii. Generalized and Specialized transduction

   C. Conjugation: Formation of mating pairs, F+ X F- Mating, Hfr Conjugation, F’ Conjugation

Reference Books:

1. **Prescott, Harley, and Klein's Microbiology,** J. M. Willey, L. M. Sherwood, C. J. Woolverton**,** 7th Edition (2008), McGraw Hill Higher Education- USA

2. **Principles of Microbiology,** R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited –New Delhi

SEMESTER- V
COURSE MI-302
Bacterial Metabolism

Unit I Fundamentals of metabolism

1. Energy: Its generation and conservation (2 hr)
   A. Free energy, the standard free energy change,redox potential, exothermic and endothermic reactions
   B. Energy rich compounds: Compounds with phosphoenhydride, acyl phosphate, enol phosphate, guanidine phosphate and thioester bonds. Structure and function of ATP

2. Enzyme kinetics (2 hr)
   A. Michaelis-Menten equation
   B. Lineweaver-Burk plot and its significance

3. Metabolic regulation (3 hr)
   A. Significance of metabolic regulation
   B. Types of regulatory mechanisms
      i. Metabolic channelling
      ii. Regulation of enzyme activity: Allosteric regulation, feedback inhibition, covalent modification, energy linked control, precursor activation

4. Fundamentals of biosynthesis (3 hr)
   A. Principles governing biosynthesis, strategies of biosynthesis
   B. Structure and function of NAD/NADP as reducing power
   C. Methods of studying biosynthesis: Study of enzymes, sequential induction, use of metabolic inhibitors, biochemical mutants, isotopes and pulse labelling technique

Unit II Fuelling reactions in heterotrophs

1. Catabolism of glucose: EMP, ED and PP pathways of glucose catabolism (2 hr)

2. Tricarboxylic acid (TCA) cycle: Catabolic and anabolic role of TCA cycle (1 hr)

3. Modes of ATP generation (4 hr)
   A. Substrate level phosphorylation
   B. Oxidative phosphorylation: Components of electron transport chain (ETC) in bacteria and their function, generation of proton motive force and its role, mechanism of oxidative phosphorylation and chemiosmotic coupling hypothesis, structure and function of ATP phosphohydrolase, inhibitors and uncouplers
   C. Anaerobic respiration: Types of anaerobic respiration, ETC in nitrate respiration

4. Fermentation: Overview, lactic acid, ethanol, mixed acid and butanediol fermentations (1 hr)

5. Catabolism of fatty acids and proteins (2 hr)

A. β-oxidation of fatty acids
B. Catabolism of amino acids: deamination, decarboxylation, transamination, stickland reaction

Unit III Fuelling reactions in chemolithotrophs and phototrophs

1. Fuelling reactions in chemolithotrophs (4 hr)

A. Physiological groups of chemolithotrophs
B. Generation of ATP and reducing power in chemolithotrophs, role of forward and reverse electron transport chain

2. Fuelling reactions in phototrophs (6 hr)

A. Physiological groups of phototrophs
B. Photosynthetic pigments in phototrophic eubacteria
C. Photosynthetic apparatus in phototrophic eubacteria
D. Cyclic and noncyclic photophosphorylation
E. Photophosphorylation in halobacteria

Unit IV Biosynthesis

1. Feeder pathways and their significance (2 hr)

A. Anaplerotic reactions
B. Glyoxylate cycle

2. Assimilation of ammonia, nitrate, molecular nitrogen and sulphate (2 hr)

3. Carbohydrate biosynthesis (4 hr)

A. Pathways for CO_2 fixation: Calvin cycle, reductive TCA cycle
B. Gluconeogenesis in heterotrophs
C. Biosynthesis of peptidoglycan

4. Biosynthesis of saturated & unsaturated fatty acids, polymerization of fatty acids into lipids (2 hr)

Reference Books:

1. **General Microbiology,** Stanier, R. Y., Ingrahm, J. L., Wheelis, M. L. and Painter, P. R. 5thed^{n}. (1995)**,** Mac Millan Press Ltd., Hong Kong

2. Prescott, Harley, and Klein's **Microbiology,** J. M. Willey, L. M. Sherwood, C. J. Woolverton**,** 7th Edition (2008), McGraw Hill Higher Education- USA

3. **Principles of Microbiology,** R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited –New Delhi

Suggested Reading

1. **Principles of Biochemistry,** Cox, M. M. and Nelson, D. L. Lehninger 5thed^{n} (2008), W. H. Freeman and Company, USA.

SEMESTER - V
COURSE MI-303
Principles of Immunology

Unit I Immune system, immunity and immune response

1. Cells and organs of the immune system (4 hr)
   A. Composition of the human blood: Types of white blood cells
   B. Types of lymphocyte: B-cells and T-cells
   C. Antigens presenting cells: neutrophils, macrophages and dendritic cells
   D. Differentiation of cells of immune system: MHC: Class I and II, HLA, clonal selection
   E. Primary (central) and secondary (peripheral) lymphoid organs

2. Immunity and its types (3 hr)
   A. Innate (native) and acquired (adaptive) immunity
   B. Innate immunity: species, racial and individual
   C. Acquired immunity: active and passive, natural and artificial
   D. Nonspecific and specific immunity

3. Immune response (IR) (3 hr)
   A. Concepts and basic functions
   B. Humoral and cell mediated immune response
   C. Characteristics of IR: Discrimination, diversity, specificity, memory and transferability
   D. Primary and secondary immune response

Unit II Antigens and antibodies

1. Antigens (4 hr)
   A. Concepts of antigen, immunogen, hapten, epitope
   B. Physico-chemical and biological properties of antigen
   C. Adjuvant and its types
   D. Types of antigens, bacterial antigens

2. Antibodies (4 hr)
   A. Concept of antibody, immunoglobulin, myeloma protein
   B. Basic structure of antibody
   C. Classes of antibody: Physico-chemical and biological properties
   D. Antibody diversity

3. Monoclonal antibodies: Production using hybridoma technology and its applications (2 hr)

Unit III Antigen-antibody reactions (serological reactions)

1. Mechanism of antigen-antibody reactions: zone phenomenon and lattice formation (1 hr)

2. Principles, types and applications of in vitro antigen-antibody reactions: (4 hr)
   A. Precipitation reaction
   B. Agglutination reaction
   C. Complement fixation reaction
   D. Immunofluorescence

3. Principles, types and applications of advanced antigen-antibody reactions: (5 hr)
   A. Enzyme linked immunosorbent assay (ELISA)
   B. Radio immunoassay (RIA)
   C. Radio-Allergo-Sorbent test (RAST)
   D. Western blot
   E. Skin test

Unit IV Immune disorders and haematology

1. Immune disorders: hyper and hypo functioning of immune system
   A. Hypersensitivity and its types (2 hr)
   B. Autoimmunity and autoimmune disorders (2 hr)
   C. Immunodeficiency (1 hr)
   D. Tumor immunity (1 hr)
   E. Transplantation immunity, immunosuppression (1 hr)

2. Haematology (3 hr)
   A. Various blood group antigens and human blood groups
   B. Blood transfusion
   C. Brief introduction to blood banking

Reference Books:

1. Prescott, Harley, and Klein's **Microbiology,** J. M. Willey, L. M. Sherwood, C. J. Woolverton**,** 7th Edition (2008), McGraw Hill Higher Education- USA

2. **Principles of Microbiology,** R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited –New Delhi

3. ***Baker and Silverton's Introduction to Medical Laboratory Technology,*** Baker F J, Silverton R E, Pallister C J, 7th edition (1998), Butterworths-Heinemann, Oxford, UK

SEMESTER - V
COURSE MI-304
Fermentation Technology

Unit I Introduction to fermentation technology

1. Fundamental concepts of fermentation (1 hr)
2. Chronological development in industrial microbiology (3 hr)
3. Introduction to the component parts of fermentation process (3 hr)
4. Range of fermentation processes (3 hr)

Unit II Industrially important microorganisms

1. Screening (4 hr)
   A. Characteristics of an industrially ideal organism
   B. Primary screening of amylase, organic acid, antibiotics and amino acid producers
   C. Introduction to secondary screening

2. Strain improvement (4 hr)
   A. Strategies
      i. Selection of induced mutants
      ii. Selection of recombinants
   B. Strain improvement for modifications of properties other than yield.

3. Preservation: principle, methods and quality control (2 hr)

Unit III Fermentation media and inoculum development

1. Fermentation media (4 hr)

   A. Principles of media formulation

   B. Media ingredients: water, carbon sources, nitrogen sources, minerals, growth factors, buffers, chelators, precursors, inducers, inhibitors, antifoam agents

2. Sterilization of media (3 hr)
   A. Use of high pressure steam: principle, batch and continuous sterilization process
   B. Use of filtration: principle, types of filters.

3. Inoculum development: general principles for development of seed culture for bacterial, yeast and fungal processes (3 hr)

Unit IV Fermenter design

1. Stirred tank bioreactor (6 hr)
   A. Essential features (basic functions) of a bioreactor
   B. Body construction and design

C. Devices of aeration and agitation
D. Devices for monitoring pH, temperature, foam and dissolved oxygen

2. Special purpose bioreactors (4 hr)
   A. Air-lift fermenter, Tower fermenter, Cyclone fermenter,
   B. Bio-catalyst reactors

Reference Books:

1. **Principles of Fermentation Technology,** Stanbury P F, Whitaker A and Hall SJ, (1995), 2nd edition, Pergamon Press, London, UK
2. **Industrial Microbiology: An Introduction,** Waites, M J and Morgan N L, (2002), Blackwell Science
3. **Biotechnology: A Textbook of Industrial Microbiology,** Crueger W and Crueger A, (2000), 2nd edition, Panima Publishing Corporation, New Delhi, India
4. **Fermentation Microbiology and Biotechnology,** El-Mansi E M T, Bryce CFA, Dahhou B, Sanchez S, Demain AL, Allman AR (eds), (2011), 3rd edition, CRC Press; Taylor and Francis Group, Boca Raton
5. **Industrial Microbiology,** Casida LE, Jr. (1968), Wiley Eastern Ltd, New Delhi, India

SEMESTER - V
COURSE MI-305.1
Environmental Microbiology

Unit I Microbial ecosystem and environment

1. Microbial ecosystem (4 hr)
   A. Introduction to populations, communities, ecosystems, microenvironment, ecological niche, microbial ecology and environmental microbiology
   B. Microbial consortia, biofilms and microbial mats
   C. Microorganisms and ecosystem
   D. Microorganism movement between ecosystems

2. Microbial habitat and environment (4 hr)
   A. Water as microbial habitat
   B. Soil as an environment for microorganisms
   C. Extreme environments

Unit II Microbial environmental processes

1. Microbiology of green house gases (4 hr)
   A. Soil microorganisms and atmosphere: Role of soil microorganisms in production and utilization of green house gases
   B. Methane based mutualism
   C. The rumen ecosystem

2. Role of microbes in soil fertility (3 hr)
   A. Symbiotic and non symbiotic nitrogen fixation by microorganisms
   B. Soil, Plant and Nutrients: Biodegradation of cellulose & lignin to increase soil organic matter

3. Geochemical process: Acid mine drainage (1 hr)

Unit III Pollution microbiology

1. Biological indicators of pollution (1 hr)
   Water pollution-coliforms & harmful algal blooms, Air pollution-lichens

2. Waste treatment and disposal (5 hr)
   A. Biological treatment of liquid waste: trickling filter, activated sludge process, biodisc system
   B. Biological treatment and disposal of solid waste: anaerobic sludge digestion, composting and sanitary landfills

3. Biodegradation of environmental pollutants (2 hr)
   A. Alkylbenzyl sulfonates

B. Chlorinated compounds
C. Biomagnifications of DDT & Mercury

Unit IV Environmental biotechnology

1. Microbial processes (4 hr)
   A. Microbially enhanced oil recovery
   B. Bioremediation of petroleum hydrocarbons
   C. Bioleaching of copper

2. Microbial products (4 hr)
   A. Biofuels: ethanol, hydrogen, methane and other hydrocarbons
   B. Biodegradable polymers (biodegradable plastics)
   C. Microbial pesticides

Reference Books

1. **Principles of Microbiology,** R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited –New Delhi

2. **Microbiology,** Prescott, Harley, and Klein's J. M. Willey, L. M. Sherwood, C. J. Woolverton**,** 7th Edition (2008),McGraw Hill Higher Education- USA

3. **Microbiology**, Pelczar Jr M. J., Chan E. C. S., Krieg N. R. 5th edition (1986), McGraw Hill Book Company NY

SEMESTER- V
COURSE MI-306
Microbiology Practicals
(Practicals based on the theory papers MI-301 to MI-305.1)

1. Isolation of *lac*$^{-}$ mutants of *Escherichia coli* using UV radiations as mutagen.
2. Isolation of pigmentless mutant of *Serratia marcescens* using UV radiations as mutagen.
3. Isolation of streptomycin resistant mutants of *Escherichia coli* by gradient plate method.
4. Isolation of DNA (Demonstration only).
5. Estimation of glucose by Cole's method.
6. Estimation of glucose by Nelson-Somogy's method.
7. Estimation of protein by Folin-Lawry's method.
8. Estimation of streptomycin by sodium nitroprusside method
9. Study of agglutination reaction: Widal test by slide agglutination & double dilution method.
10. Study of precipitation reaction: Rapid plasma regain (RPR) method.
11. Detection of HBsAg using ELISA test.
12. Determination of human blood group: ABO and Rh systems.
13. Estimation of hemoglobin by Sahli's acid hematin method.
14. Total count of erythrocytes and leucocytes.
15. Differential count of leucocytes by Field's method
16. Screening of industrially important organisms
    A. Primary screening of amylase producers.
    B. Primary screening of organic acid producers
    C. Primary screening of antibiotic producers by crowded plate method
17. Determination of OTR under static, sparging and shake flask condition by sulfite oxidation method.
18. Isolation, cultivation and microscopic identification of economically important fungi — Yeast, Neurospora, Fusarium, Alternaria, Curvularia and Helminthosporium

Scheme for Practical Examination

No.	Exercise	Marks
1	Bacterial Genetics OR Fermentation technology	**30**
2	Immunology / Haematology	**30**
3	Metabolism	**30**
4	Spotting	**20**
5	Viva	**20**
6	Journal and slides	**10**
	Total	**140**

SEMESTER - VI
COURSE MI-307
Genetic Engineering

Unit I Tools of rDNA technology

1. Fundamentals: rDNA technology, genetic engineering, cloning (1 hr)
2. Enzymes: Restriction endonucleases, Reverse transcriptase, Terminal transferase, Alkaline phosphatase, DNA ligases (3 hr)
3. Cloning vectors (4 hr)
   A. Criteria for selection of cloning vector
   B. Types of vector: plasmid vector (pBR322), phage vector (λ), cosmid, shuttle vector - yEP and Ti plasmid
4. Genetic probes, primers and reporter genes (Green Fluorescent Protein) (1 hr)
5. Host cell for cloning: properties of good host, prokaryotic and eukaryotic host cells (1 hr)

Unit II Techniques for genetic engineering

Principle, method and applications of following techniques

1. Gene editing: Site directed Mutagenesis (2 hr)
2. Gene amplification: Polymerase Chain Reaction (2 hr)
3. Gene detection by hybridization: Southern blotting (2 hr)
4. Gene sequencing: Sanger's dideoxy chain termination method (2 hr)
5. Gene expression: DNA microarray (2 hr)

Unit III rDNA technology

1. Obtaining desired DNA fragment: Isolation from donor cell – shot gun cloning and construction of genomic library, construction of cDNA library, chemical synthesis of DNA (4 hr)
2. Preparation of rDNA: Protocol for joining isolated DNA fragment with cloning vector (2 hr)
3. Transfer of rDNA in to suitable host cell: Transformation, Gene gun, Microinjection, Protoplast Fusion, and Electroporation. (2 hr)
4. Selection of recombinant clone: Colony hybridization technique, Use of marker genes, X- gal dye and reporter gene (2 hr)

Unit IV Applications of rDNA technology

1. Medical applications: Recombinant vaccine (Hepatitis-B), Recombinant protein (Insulin) (4 hr)
2. Agricultural applications: Transgenic plants resistant to microbial pathogens & insect pests (4 hr)
3. Environmental applications: Environmental genomics - metagenomics (1 hr)
4. Social impacts of rDNA technology (ELSI) (1 hr)

Reference Books:

1. **Prescott, Harley, and Klein's Microbiology,** J. M. Willey, L. M. Sherwood, C. J. Woolverton**,** 7th Edition (2008), McGraw Hill Higher Education- USA

2. **Principles of Microbiology,** R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited –New Delhi

3. **Biotechnology: The Biological Principles**, Trevan M. D., Boffey S., Goulding K. H. and Stanbury S. (1987) Tata – McGraw Hill, New Delhi – India.

4. **Biotechnology,** U. Satyanarayana, 1st Edition (Reprinted 2008), Books and Allied (P) Ltd. Kolkata

SEMESTER - VI
COURSE MI-308
Virology and Mycology

Unit I Introduction to viruses and sub-viral entities

1. General characteristics and structural organization of virus (3 hr)
2. Classification of viruses: ICNV and Cryptogram system of viral classification (2 hr)
3. Cultivation of viruses: (3 hr)
   A. Cultivation in animal
   B. Cultivation in embryonated eggs
   C. In vitro culture: cell lines, primary and secondary cell lines, continuous cell lines, cytopathic effects
4. Sub-viral entities: viroids, virusoids, prions, introduction to persistent, latent and slow viruses, oncogenic viruses (2 hr)

Unit II Bacteriophages, plant viruses and animal viruses

1. Lytic cycle (T4 Phage) (3 hr)
   A. One step growth curve experiment, burst size
   B. Phage adsorption and penetration, intracellular development, early and late events, replication of phage chromosome, phage morphogenesis (assembly) and release
2. Single stranded DNA and RNA phages: ΦX174 and MS2. (1 hr)
3. Lysogenic cycle (lambda phage): Mechanism of establishment, induction, and replication. (2 hr)
4. Plant Viruses: Introduction and replication of plant viruses (TMV) (1 hr)
5. Animal viruses: Introduction and replication (adsorption, penetration, uncoating, replication, synthesis and assembly, and release) of animal viruses in general (HIV) (3 hr)

Unit III Introduction to fungi

1. General characters: Somatic structure, ultra-structure of fungal cell, hyphal modifications, asexual and sexual spores (4 hr)
2. Cultivation of fungi (3 hr)
   A. Principles of fungal nutrition
   B. Cultivation media & methods, slide culture technique, prevention of bacterial contamination
3. Economic importance of fungi (3 hr)
   A. Primary and secondary metabolites of fungi and their importance
   B. Overview of plant and animal fungal diseases

Unit III Reproduction and classification of fungi

1. Fungal classification: Criteria used for classification, recent classification system (2 hr)

2. Brief outline of following classes of fungi:
   Salient features, reproduction and economic importance in general

   A. Myxomycetes (2 hr)

   B. Eumycetes (6 hr)
      i. Chytridiomycetes
      ii. Phycomycetes (Phycomycotina)
      iii. Ascomycetes (Ascomycotina)
      iv. Basidiomycetes (Basiomycotina)
      v. Deutromycetes (Deuteromycotina)

Reference Books:

1. **Introductory Mycology**, Alexopoulos C J, Mims C W, Blackwell M, (1996) 4th edition, Blackwell Publishing.

2. **Introduction to Fungi**, Webster J, R W S Weber (2007) 3rd edition, Cambridge University Press.

3. **Principles of Microbiology,** R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited –New Delhi

4. **Prescott, Harley, and Klein's Microbiology,** J. M. Willey, L. M. Sherwood, C. J. Woolverton**,** 7th Edition (2008), McGraw Hill Higher Education- USA

5. **Basic Virology**, Wagner E K, Hewlett N J, Bloom D C and Camerini D (2008) 3rd edition Blackwell Publishing Ltd UK.

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SEMESTER - VI
COURSE MI-309
Medical Microbiology

Unit I Relationship between human body and microbe

1. Normal microbiota (normal flora) of the human body (4 hr)
   A. Importance, origin and establishment
   B. Microbiota of various body parts
   C. Gnotobiotic life and gnotobiosis

2. Host-parasite relationship (6 hr)
   A. Concept of host-parasite relationship and factors affecting it
   B. Microbial pathogenicity:
   C. Overview of bacterial and viral pathogenicity
   D. Factors affecting the process of infection
   E. Pathogenicity: (a) Invasiveness: role of structures and secretions of bacteria
      (b) Toxigenicity: Protein and LPS toxins -properties and mode of action

Unit II Epidemiology of infectious disease and vaccines

1. Epidemiology (6 hr)
   A. Concepts of epidemiology
   B. Epidemiological types of infection
   C. Techniques used to study epidemiology
   D. Epidemiological markers
   E. Infectious disease cycle
   F. Nosocomial infections: sources, transmission and control

2. Vaccines (4 hr)
   A. Concept immunoprophylaxis
   B. Types of vaccine
   C. Schedule of vaccination (followed in India)
   D. Hazards of vaccination

Unit III Clinical Microbiology

1. Specimen: types of specimen, methods of collection, storage and transportation (2 hr)

2. Methods used for diagnosis and identification of pathogens (8 hr)
   A. Microscopy
   B. Growth and biochemical characteristics
   C. Clinical immunology
   D. Pathological changes in blood and body fluids and tissues
   E. Significance of computer and possible uses of biosensors

Unit IV Infectious diseases of human being

Study of following diseases with respect to etiological agent, symptoms, transmission, diagnosis and control.

1. Airborne diseases: Tuberculosis, Swine flu (2 hr)
2. Food and waterborne diseases: Typhoid, Hepatitis A (2 hr)
3. Contagious diseases: Syphilis, AIDS (2 hr)
4. Insect borne diseases: Malaria, Dengue (2 hr)
5. Zoonoses: Rabies, Anthrax (2 hr)

Reference Books:

1. **Principles of Microbiology,** R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited –New Delhi
2. **Prescott, Harley, and Klein's Microbiology,** J. M. Willey, L. M. Sherwood, C. J. Woolverton**,** 7th Edition (2008), McGraw Hill Higher Education- USA
3. **Baker and Silverton's Introduction to Medical Laboratory Technology,** Baker F J, Silverton R E, Pallister C J, (1998), 7th edition, Butterworths-Heinemann, Oxford, UK

SEMESTER - V
COURSE MI-310
Bioprocess Technology

Unit I Fermenter operation and scale up

1. Modes of operation: surface culture fermentation, submerged fermentation (batch, fed-batch and continuous fermentations), solid substrate fermentation (4 hr)

2. Operating parameters and their control: aseptic operation, mass transfer of oxygen, foam, pH, temperature (2 hr)

3. Safety procedures (2 hr)
   A. Containment
   B. Clean room environment

4. Introduction to scale up (2 hr)

Unit II Downstream processing

1. Introduction (1 hr)

2. Removal of microbial cells and suspended solids (3 hr)
   A. Foam separation
   B. Precipitation
   C. Filtration
   D. Centrifugation

3. Cell disruption methods (2 hr)
   A. Physico-mechanical methods
   B. Chemical methods

4. Product concentration and purification (2 hr)
   A. Liquid-liquid extraction
   B. Membrane processes

5. Finishing stages (1 hr)
   A. Drying
   B. Crystallization

6. Effluent treatment (1 hr)

Unit III Product analysis and fermentation economics

1. Detection and assay of fermentation products (6 hr)
   A. Physical assays: Titration and gravimetric analysis, turbidity and cell yield determination
   B. Chemical assays: Chromatography, Spectrophotometry
   C. Biological assays: Microbial assay

2. Microbial quality assurance (2 hr)
   A. Sterility testing
   B. Pyrogen testing (LAL test)

3. Introduction to fermentation economics (2 hr)

Unit IV Typical fermentation processes

1. Enzyme: Amylase (2 hr)
2. Antibiotic: Penicillin (2 hr)
3. Organic acid: Citric acid (2 hr)
4. Biofuel/solvent: Ethanol (2 hr)
5. Amino acid: Lysine (2 hr)

Reference Books:

1. **Principles of Fermentation Technology,** Stanbury P F, Whitaker A and Hall SJ, (1995) 2nd edition, Pergamon Press, London, UK.
2. **Industrial Microbiology: An Introduction,** Waites, M J and Morgan N L, (2002) Blackwell Science.
3. **Biotechnology: A Textbook of Industrial Microbiology,** Crueger W and Crueger A, (2000) 2nd edition, Panima Publishing Corporation, New Delhi, India.
4. **Fermentation Microbiology and Biotechnology,** El-Mansi E M T, Bryce CFA, Dahhou B, Sanchez S, Demain AL, Allman AR (eds), (2011) 3rd edition, CRC Press; Taylor and Francis Group, Boca Raton.
5. **Industrial Microbiology,** Casida LE, Jr. (1968), Wiley Eastern Ltd, New Delhi, India.

SEMESTER - VI
COURSE MI-311.1

Biotechnology

Unit -1 Introduction to biotechnology

1. Introduction & historical background of biotechnology (1 hr)
2. Old and new biotechnology (2 hr)
3. Biotechnology: an interdisciplinary & multidisciplinary science (2 hr)
4. Scope and importance of biotechnology (major areas of biotechnology) (2 hr)
5. Biotechnology in Gujarat & India: Education and Research (1 hr)

Unit: 2 Instrumental methods

Principle, method, and applications of following methods

1. UV-Vis spectroscopy (1 hr)
2. Centrifugation and its types in brief (2 hr)
3. Chromatography: Paper, TLC, HPLC (2 hr)
4. Electrophoresis: SDS-PAGE and Agarose gel electrophoresis (2 hr)
5. Biosensors (1 hr)

Unit: 3 Cellular & molecular techniques

Principle, method and applications of following techniques

1. Animal cell culture: primary & secondary cell culture, continuous cell lines (2 hr)
2. Plant tissue culture: Introduction to PTC, callus culture (2 hr)
3. Northern blotting (2 hr)
4. CRISPR CAS 9 (2 hr)

Unit: 4 Areas of application of biotechnology

1. Plant biotechnology: transgenic plants-herbicide resistant plants & golden rice (2 hr)
2. Animal biotechnology (2 hr)
   A. Transgenic animals- features of animal suitable for gene transfer
   B. Transgenic cow for lectoferrin production
   C. Transgenic sheep for wool production
3. Microbial biotechnology: baker's yeast production (2 hr)
4. Enzyme biotechnology: analytical, industrial and therapeutic applications (1 hr)
5. Intellectual property rights: Introduction to IPR, patents in biotechnology (1 hr)

Reference Books:

1. **Basic Biotechnology,** Colin Ratledge and Bjorn Kristiansen (2006) Cambridge University Press, 3rd edition.

2. B. Sc. Edition **Biotechnology,** B.D. Singh 5th Edition (Reprinted 2015), Kalyani Publishers, Ludhiana, Punjab

3. **Principles and Techniques of Biochemistry and Molecular Biology**, Wilson K and Walker J (2005) (6th Edn), Cambridge

4. **Biotechnology: The Biological Principles**, Trevan M. D., Boffey S., Goulding K. H. and Stanbury S. (1987) Tata – McGraw Hill, New Delhi – India.

5. **Biotechnology,** U. Satyanarayana, 1st Edition (Reprinted 2008), Books and Allied (P) Ltd. Kolkata

6. **Introduction to biotechnology,** Ashim K. Chakravarty, (2013) Higher Education Division– Oxford University Press, Oxford-UK

7. **CRISPR-Cas: A Laboratory Manual,** edited by Jennifer Doudna and Prashant Mali, (2016) Cold Spring Harbour Laboratory, NY, USA

SEMESTER-VI
COURSE MI-312
Microbiology Practicals
(Practicals based on the theory papers MI-307 to MI-311.1)

1. Separation of amino acids by paper chromatography.
2. Separation of amino acids by thin layer chromatography.
3. Immobilization of cells by calcium-alginate entrapment method and activity check by methylene blue reduction test. (Demonstration only).
4. Use of enzyme as analytical tool: Glucose estimation by GOD-POD method.
5. Isolation of bacteriophage from sewage.
6. Isolation and cultivation of yeasts.
7. Cultivation of and microscopic examination of molds by slide culture technique.
8. Study of plant diseases caused by Virus and Fungi — Mosaic, red rot, rust, smut, wilt, leaf curl, powdery mildew, downy mildew.
9. Isolation, cultivation and identification of gram-negative bacteria—*Escherichia coli, Enterobacter aerogenes, Proteus vulgaris, Pseudomonas aeruginosa, Salmonella typhi, Salmonella paratyphi* A, *Salmonella paratyphi* B.
10. Characterization of Gram-negative bacteria based on biochemical reactions using rapid identification kit. (Demonstration only).
11. Study of antibiogram (using multidisc).
12. Physical and chemical analysis of urine.
13. Estimation of blood urea by diacetyl monoxime method (DAM).
14. Study of permanent slides
    A Insect vectors: Female anopheles mosquito, head louse, tick, flea, mite.
    B. Microorganisms: Actinomycetes, yeast, bacteroids, acid-fast bacilli, spirochetes, *Streptococcus pneumoniae, Clostridium tetani* and *Plasmodium vivax*
15. Fermentative production of amylase and its activity check.
16. Bioassay of penicillin/ampicillin using *Bacillus subtilis*.
17. Sterility testing of pharmaceutical product.

Scheme for Practical Examination

No.	Exercise	Marks
1	Isolation and identification of Gram negative bacteria	**30**
2	Bioprocess technology	**30**
3	General exercise A. Separation of amino acids by paper chromatography B. Separation of amino acids by thin layer chromatography C. Estimation of glucose by GOD-POD method D. Estimation of blood urea by DAM method E. Physical and chemical analysis of urine F. Determination of antibiogram G. Isolation of bacteriophage from sewage	**30**
4	Spotting	**20**
5	Viva	**20**
6	Journal and slides	**10**
	Total	**140**