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**