INDRASHIL UNIVERSITY

(Established by an Act under the Gujarat Private Universities Act, 2009)

A Life Sciences University

Sustained Excellence with Relevance

योगः कर्मसु कौशलम्

INDRASHIL UNIVERSITY

INDRASHIL UNIVERSITY

DEPARTMENT OF BIOSCIENCES

PROGRAM STRUCTURE & DETAILED SYLLABUS

M.Sc. MICROBIOLOGY 2019-2021

SEMESTER – I			
Subject code	**Subject Name**	**L-T-P**	**Credits**
BIO 401	Cell Biology	3-1-0	4
BIO 402	Genetics	3-1-0	4
BIO 403	Macromolecular Structure & Function	3-1-0	4
BIO 404	Ecology & Evolution	3-1-0	4
BIO 405	Analytical Tools & Techniques (Lab)	0-0-12	6
	Total	12L+4T+12P	**22**
SEMESTER – II			
Subject code	**Subject Name**	**L-T-P**	**Credits**
BIO 406	Microbiology (Diversity and Systematics)	3-1-0	4
BIO 407	Molecular Biology	3-1-0	4
BIO 408	Enzymology	3-1-0	4
BIO 409	Metabolic Pathways	3-1-0	4
BIO 410	Analytical Tools & Techniques (Lab)	0-0-12	6
IU M 000	Basic Communication and Soft Skills	1-0-0	0
	Total	12L+4T+12P	**22**

SEMESTER – III			
Subject code	**Subject Name**	**L-T-P**	**Credits**
BIO MB 801	Microbial Physiology	3-1-0	4
BIO MB 802	Metabolic Diversity and Metabolic Engineering	3-1-0	4
BIO MB 803	Microbial Genetics	3-1-0	4
BIO M 503	Genetic Engineering	3-1-0	4
BIO M 504	Bioinformatics (Lab)	0-0-4	2
BIO MB 804	Biology Laboratory Techniques (Lab)	0-0-8	4
	Total	12L+4T+12P	**22**
SEMESTER – IV			
Subject code	**Subject Name**	**L-T-P**	**Credits**
BIO MB 805	Environmental Microbiology	3-1-0	4
BIO MB 806	Food and Industrial Microbiology	3-1-0	4
BIO MB 807	Research or Industrial Project/Viva	-	14
	Total	6L+ 2T	**22**

Credit to Hours calculation:
Lecture: 1h = 1C
Practicals: 2h = 1C
Total Credits: 88

SEMESTER - I

BIO 401 Cell Biology (L-T-P-C: 3-1-0-4)

Unit 1:

- Comparison of prokaryotic and eukaryotic cells
- General methods in cell biology
- Ultrastructure of plasma membrane
- Plant cell membrane-structure and function
- Cytoskeletal elements

Unit 2:

- Mitochondria- structure, biogenesis and evolution
- Mitochondria and male sterility
- Chloroplast –structure, organization, Function, Protein Import, Biogenesis, Genome and genetic manipulation
- Chloroplast mitochondrial interaction

Unit 3:

- Lysosomes- biogenesis, pathophysiology
- Peroxisomes, glyoxysomes
- Plant vacuoles
- Plant cell wall, Plasmodesmata
- Cell growth and division (mitosis, meiosis and cell differentiation)

Unit 4:

- Biosynthetic process in ER and Golgi Apparatus
- Vesicular Traffic from ER through Golgi Apparatus
- Trans Golgi Network, endocytosis and exocytosis
- Programmed Cell Death

Text Books:

1. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th Ed. Lippincott Williams and Wilkins, Philadelphia.

Reference Books:

1. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. "Molecular Biology of the Cell". Garland Science
2. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA
3. Latest review articles from Peer reviewed journals

BIO 402 Genetics (L-T-P-C: 3-1-0-4)

Unit 1:
Mendelian Genetics and analysis: Extension of Mendelian analysis. Chromosomal basis of Inheritance. Chromosome characteristics: Chromosome structure, Euchromatin and heterochromatin, Coding and Non-coding sequences, transposons

Unit 2:
Genetic Recombination in Eukaryotes. Linkage and Crossing Over, Chromosome mapping, Tetrad analysis and Gene Conversion. Mutations and mutagenesis. Detection, Molecular basis and Applications. Chromosomal Changes: Number variation – Euploidy (auto and allo polyploidy), aneuploidy. Structural variations – Deficiences, duplications, Inversions, translocations. Interaction of Genotype and Environment, Twin studies, genetic environment, non-genetic environment, phenocopies, penetrance and expressivity

Unit 3:
Gene expression regulation during differentiation and growth
Heterochromatization in human beings and other mammals, dosage compensation, mechanism, sex chromatin, position effect

Unit 4:
Quantitative inheritance
Continuous traits – multigenic variability, dominance – additivity, norms of reaction
Non-Mendelian Inheritance; Plastid mutations – nature and mode of transmission
Mitochondrial traits – nature and mode of transmission; Applications

Unit 5:
Population Genetics: Genotype and allelic frequencies, the Hardy-Weinberg equilibrium, non-random mating, consequences of homozygosity, factors affecting gene frequencies, heterosis, mutation – effect on allele frequencies, migration and genetic drift
Developmental Genetics: Model system *Drosophila*, Genetic screen, Pattern formation, Maternal effect, Homoetic transformations.

Reference Books:

1. Griffiths, A. J. F., Miller, J. H., Suzuki, D. T., Lewontin, R. C., Gelbart, W. M. An "Introduction to Genetic Analysis", W. H. Freeman & Company, New York.
2. Strickberger, M. W. "Genetics", latest Edition, Macmillan Publishing co., New York.
3. Gardner, E. J., Simmons, M. J. and Snustad, D. P. "Principles of Genetics", 8th Edition, John Wiley & Sons, New York.
4. "An Introduction to genetic analysis". Anthony A. J. F. Griffiths; Susan R. Wessler; Sean B. Carroll; John Deebly. 11th Edition
5. "Genetics: A Conceptual approach". Benjamin A. Pierce. latest Edition
6. "Genetics: analysis of genes and genomes". Daniel L Hartl; Maryellen Ruvolo. latest Edition.

BIO 403 Macromolecular Structure and Function (L-T-P-C: 3-1-0-4)

Unit 1: Introduction

The molecular logic of life: The chemical unity of diverse living organisms, Miller and Urey experiments on origin of life, composition of living matter. Macromolecules and their monomeric subunits. Evolutionary aspects of stereo specificity and structural interplay between biomolecules (RNA, DNA, Amino acids and sugars). Methods for the determination of macromolecular structure.

Unit 2: Proteins

Classification, structure and properties of amino acids, zwitter ion, rare amino acids, D-amino acids. Classification and properties of proteins, – Peptide synthesis: reactive ester method and Merrifield synthesis,sequencing of proteins,

Primary structure: Peptide conformation, N- and C- terminal, peptide cleavage

Secondary structure: α-helix, β-sheet, random coil, Ramachandran plot

Tertiary structure: Forces stabilizing, unfolding/ refolding experimentation.

Quaternary structures: Structure and function of hemoglobin.

Structure, coagulation and denaturation of proteins. Concepts of iso electric point and salting in and salting out. Structural and functional significance of Prions and viroids. Biologically active peptides, Oligomer formations -role in neurodegenerative diseases e.g., β -Amyloid etc.

Unit 3: Carbohydrates

Occurrence, classification, basic chemical structure, monosaccharides, aldoses, and ketoses, cyclic structure of monosaccharides, steroisomerism, anomers and epimers. general properties and functions of polysaccharides and complex carbohydrates; amino sugars, proteoglycans and glycoproteins. Mucopolysaccharides, deoxy sugars, amino sugars, and sugar acids.

Unit 4: Lipids

Structure, distribution and biological importance of fats and fatty acids- essential (ω-3 and ω-6) and derived essential fatty acids- eicosanoids-prostaglandins, leukotrienes and lipoxins. Chemical properties and characterization of fats. Different dietary types of fatty acids, requirements, utilization and functions. Waxes, cerebrosides, gangliosides, phospholipids and proteolipids. Steroids and bile salts. Circulating lipids, Lipoproteins, chylomicrons, LDL, HDL, and VLDL. Pathological changes in lipid levels. Formation of micelles, monolayers, bilayer, liposomes and emulsions. Vitamins.

Unit 5: Nucleic acids

Nucleic acids as genetic information carriers, experimental evidence e.g., genetic transformation, Hershey-Chase experiments, action spectrum, etc. Structure and function of nucleotides. Primary, secondary and tertiary structure of nucleic acids, DNA forms and conformations, Denaturation of DNA. Unusual nucleic acid structures, Melting curves. Role of contemporary RNA enzymes: Ribozyme. Types of Synthesis methods of RNA and DNA. Sequencing methods. Diversity in RNAs-coding and non-coding RNAs, micro RNA etc

Suggested Books:

1. "Principles of Biochemistry", Lehninger C Recent Edition.
2. "Biochemistry", L. Stryer, W.H. Freeman, San Francisco.
3. Schaum's "Outline Series of Theory and Problems of Biochemistry", Philip W. Kuchel and G.B. Ralston. Int. Ed., McGraw-Hill Book Co.
4. "Problem Approaches in Biochemistry". Wood and Hood
5. "DNA: The Secret of Life" by James D. Watson, Andrew Berry
6. "Review of Physiological Chemistry" by Harold A Harper, Lange Medical Publications Latest Edition.

BIO 404 Ecology & Evolution (L-T-P-C: 3-1-0-4)

Unit 1:
Basic concepts of ecology and environment. Introduction to ecology - Ecosystems and allied concepts. The abiotic environment: Water, temperature, radiation, nutrient cycles. The biotic environment: producers, consumers and decomposers.

Unit 2:
Adaptations to the environment – Ecological niche and adaptation to variations and stress. Community and Population ecology. Biomes of the world. Natural resources – degradation and conservation. Human impacts on Natural Resources. Tools for natural resource degradation assessment and monitoring. Conservation- concepts and measures. Climate change.

Unit 3:
Origin of Life on Earth. Experiments of Miller. Chemical Evolution. What is Life? Biodiversity-definition and Measurement. Evolutionary ideas of Cuvier, Lamarck and Darwin. Contribution of RA Fisher, Haldane, Sewall Wright, Ernst Mayr. Modern synthesis. Evolution as an Emergent property. Concept of population, gene pool, gene frequency-conservation, allele frequency (Hardy-Weinberg equilibrium), Change in gene frequencies. Genetic drift, gene flow, genetic load. Adaptations and extinction. Osmotic regulation and excretion of nitrogenous waste, protective coloration, mimicry. Periodic and mass scale extinctions- possible causes.

Unit 4:
A brief and consensus account of Organic evolution of major groups of plants and animals on Earth. Geological eras and fossil evidence for Darwinian evolution. Human Evolution. Theory of Organic Evolution by Natural Selection. Adaptive significance of variations. Operative details of Natural Selection.. Concept of Species and Speciation. Isolation mechanisms, modes of speciation (allopatric, sympatric, peripatric), anagenesis&cladogenesis, levels of evolutionary change (micro & macroevolution). A brief account of Mendelian Genetics, Mutations, Statistical analysis of Genotype and Gene (allele) frequency in Populations. Sex selection and Kin selection. Morphological and Biochemical Adaptation- selected examples. Homology, Analogy and Homoplasy. Divergent and Convergent evolution. Comparative Physiology of any one function.

Unit 5:
Basic ideas structure of bio macromolecules. Self-replicating molecules. RNA world. Cellular form of life. Prokaryote, Eukaryote and evolution of multi-cellular organisms. Comparison of primary structure of nucleic acids and proteins across members of a population, across species, genera, families, orders and classes. Dendrograms and Phylogenetic trees. Principles of construction. Concept of Molecular Clock. Evolution of enzymes and metabolic pathways towards Functional efficacy or adaptation.

Suggested Readings:

1. Odum, "Fundamentals of Ecology" (WB Saunders)
2. Ricklefy, "Fundamentals of Ecology" (WH Freeman)
3. Turk and Turk, "Environmental Science" (WB Saunders)
4. Clegg, CJ and DG Mackean (2000) "*Advanced Biology-Principles and Applications*", 2nd Edition, Hodder Education, UK
5. Mark Ridley (2004) "*Evolution*", 3rd Edition, Blackwell Publishing, UK Fritz of Capra and PL Luisi (2015) "The Systems View of Life- A unifying Vision", Cambridge University Press, Chapters 7, 8, 9 and 10.

BIO 405 Analytical Tools and Techniques (Lab) (L-T-P-C: 0-0-12-6)

1. Preparation of Various buffers 0.1 M Nacl, NaOH, Tris-HCL Phosphate and EDTA
2. Determination of pKa of amino Acids (Glycine)
3. Separation of Sugars (Glucose/Fructose/Starch/Cyclodextrin) by TLC
4. Quantitative estimation of protein by spectroscopic/Barford/BCA
5. To verify and validate Beer's Law and determine the molar extinction coefficient of NADH or Protein (Pure)
6. Determination of PI of amino acids by titration method
7. Isolation of Chloroplast by Sucrose gradient method from Spinach leaf
8. Study of Karyotyping in human normal/abnormal
9. Study of mitosis by using onion root tip
10. Problem on a) law of segregation, b) Independent assortment, c) Sex linked inheritance, d) population genetics
11. Working with Microscope and preparation of Slide.
12. Staining of nucleus and mitochondria and observation under microscope.
13. Blood Smear Preparation and identifying different cell types
14. Cell Counting
15. Buccal smear – Identification of Barr Body

BIO 406 Microbiology (Diversity and Systematics) (L-T-P-C: 3-1-0-4)

Unit 1:

Historical developments: Discovery of microorganisms, Evolution of microbiology as a discipline Spontaneous Generation- Controversy, Germ theory of fermentation, Germ theory of disease. Whittaker's five-kingdom concept. Three-domain concept of Carl Woese, Microbiological techniques, Pure culture techniques, Enrichment, Anaerobic culturing.

Discovery of microorganisms: Bacterial and fungal diversity, Culture techniques, Bacterial systematics

Unit 2:

Different groups of Microorganisms and their general characteristics, Prokaryotic vs. Eukaryotic Organisation.

Characters used in microbial taxonomy (morphological, physiological, ecological, genetics protein content, nucleic acid sequence and base composition).

Unit 3:

Nutritional requirements of microorganisms: Nutritional types, Requirements, Uptake of nutrients, Design and types of nutrient media

Cell wall of bacteria and fungi, Gram+ve cell wall, Gram-ve cell wall, Cell wall of fungi and yeasts

Unit 4:

Micrbial Ecology, Denitrification, Phosphate solubilization, Free-living nitrogen fixation, Plant-microbe interactions, Symbiotic nitrogen fixation, Mycorrhizae and Plant pathogens

Importance of microorganisms in medicine, agriculture, environment and industry

Unit 5:

General properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions, satellite virus.

Reference Books:

1. Microbiology Ed. Prescott.
2. Microbiology Ed. Torfora.
3. Microbiology Ed. Peltzar.
4. Microbiology Ed. Stanier.
5. Biology of Microorganisms Ed. M.T. Medican, J.M. Martiniko and J. Parker.

BIO 407 Molecular Biology (L-T-P-C: 3-1-0-4)

Unit 1: Genetic material

Gene-definition-Structural differences between prokaryotic and eukayotic genes- Genome: organization of prokaryotic genome- architecture of prokaryotic chromosome. Eukaryotic genome-Complexity-LINES,SINEs, Genome organization: C-value paradox, genome complexicity; Cot value analysis, repetitive sequences, gene families

Recombination at the molecular level. Holliday model of homologous recombination – events at the molecular level; role of recA, recBC and chi sequences, Site- specific recombination – eg. bacteriophage λ; FLP/FRT and Cre/Lox recombination

Unit 2: DNA Replication

DNA replication in prokaryotes and eukaryotes; Semiconservative and discontinuous mechanism of DNA replication – leading, lagging strand, Okazaki fragments, biochemistry of replication, DNA polymerases, helicase, primase, topoisomerase, processs of replication; initiation, elongation, termination, telomerase replicates the ends of chromosomes, rolling circle replication, mitochondrial DNA replication, M13 – rolling mechanism of replication, DNA repair – Nucleotide excision repair; Mismatch correction; SOS repair; Photoreactivation

Unit 3: Transcription

Prokaryotic and eukaryotic RNA polymerases, process of transcription; initiation, elongation and termination, transcription factors, other cis-trans elements, antibiotic inhibitors of transcription, RNA processing, Intron splicing, RNA editing, mRNA degradation

Regulation of gene expression; operon models- *lac, trp* and *his*, Bacteriophage lambda: a transcriptional switch; lytic and lysogenic cycle, influence of chromatin structure on transcription, nucleosome remodeling, RNA interference: miRNA, siRNA and piRNA

Unit 4: Translation

Genetic codon, protein synthesis; riobosome assembly, activation of amino acids, initiation, elongation and termination, proofreading and energetic of translation, antibiotics and toxins inhibitor of translation, post-translational modification of proteins; O and N-linked glycosylation, splicing, molecular chaperons, ubiquitin mediated protein degradation

Suggested Readings:

1. Lewin B. “Genes”. Jones & Bartlett Publishers.
2. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. “Molecular Biology of the Cell”. Garland Science.
3. Watson J.D, Baker T.A, Bell S.P, Gann A, Levine M and Losick R.”Molecular Biology of the Gene”. . Benjamin-Cummins Publishing Co.,
4. Freifelder D. “Molecular Biology”.

BIO 408 Enzymology (L-T-P-C: 3-1-0-4)

Unit 1: Enzymes

General characteristics of enzymes, role of co-factors, nomenclature, IUB enzyme classification (specific examples), The story of James B. Sumner and Urease; active sites and induced fit theory, measurement and expression of enzyme activity, enzyme assay. Definitions of IU, Katal, enzyme turnover and specific activity. Criteria for purity of enzymes. Correlation between the rates of enzyme turnover and structure and function of enzymes. Effect of pH, Temperature on Enzyme structure and function.

Unit 2: Kinetics of Enzyme Action

Concept of ES complex, active site, specificity, derivation of Michaelis-Menten equation for uni- substrate reactions. Different plots for the determination of K_m & V_{max} and their physiological significances. Importance of K_{cat}/K_m. Kinetics of zero & first order reactions. Significance and evaluation of energy of activation. Collision & transition state theories. Michaelis – pH functions & their significance. Reversible and irreversible inhibition. Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics. Suicide inhibitors, enzyme activators.

Unit 3: Mechanism of Enzyme Action

Acid-base catalysis, covalent catalysis, proximity, orientation effect. Strain & distortion theory. Chemical modification of active site groups. Site directed mutagenesis of enzymes. Mechanism of action of chymotrypsin, lysozyme, glyceraldehyde 3-phosphate dehydrogenase, aldolase, carboxypeptidase, triose phosphate isomerase and alcohol dehydrogenase. Multienzyme system – Occurrence, isolation & their properties: Mechanism of action and regulation of pyruvate dehydrogenase & fatty acid synthase complexes. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.

Unit 4: Enzyme Regulation

General mechanisms of enzyme regulation, product inhibition. Reversible (glutamine synthase & phosphorylase) and irreversible (proteases) covalent modifications of enzymes. Mono cyclic and multi cyclic cascade systems with specific examples. Feedback inhibition and feed forward stimulation. Allosteric enzymes, qualitative description of “concerted” & “sequential” models for allosteric enzymes. Half site reactivity, Flipflop mechanism, positive and negative co-operativity with examples like aspartate transcarbamoylase& phosphofructokinase. Protein-ligand binding measurement, analysis of binding isotherms, Hill and Scatchard plots.

Unit 5: Enzyme Technology

Introduction to enzyme engineering, Large scale production of enzymes, enzyme reactors, immobilization of enzymes by chemical and physical methods. Effect of partition on kinetics and on changes in pH and hydrophobicity. Enzymatic reactions in organic solvents. Industrial applications of immobilized enzymes: other applications in synthetic organic chemistry, industry, food technology, medicines. Synzymes

Suggested Readings:

1. Fundamentals of Enzymology by Price and Stevens
2. Enzymology by Dixon and Webb
3. Enzymes by Palmer
4. Textbook of Medical Physiology by Guyton. A.C., H. Sanders
5. Physiological chemistry by HA Harper.

BIO 409 Metabolic Pathways (L-T-P-C: 3-1-0-4)

Unit 1:
Metabolism as a defining property of living state. Thermodynamic principles and steady-state condition of 'living'. Methods of metabolic investigations. Metabolic pathways-linear and cyclic. Catabolism and anabolism. Phases I, II and III of catabolism.

Unit 2:
Major pathways of carbohydrate, amino acid, lipid and nucleotide metabolism. Biosynthesis of monosaccharides, fatty acids, amino acids and nucleotides. Secondary metabolites-biosynthesis and degradation. Role of metabolism in biomass production and energy homeostasis.

Unit 3:
Metabolic profile of adipose, neural, hepatic, skeletal muscle, and steroidogenic tissues.

Unit 4:
Integration and regulation of metabolic pathways in relation to cellular and organ functions. Evolution of metabolic pathways and adaptive significance, if any. Metabolic engineering for specific product production. Metabolic regulation during embryogenesis and development.

Suggested Readings:

1. Garrett and Grisham, Biochemistry, 5th Ed. BRROKS/COLE Cengage Learning. 2013.
2. RL Foster, Nature of Enzymology.
3. Annual Review of Biochemistry.

BIO 410 Analytical Tools and Techniques (Lab) (L-T-P-C: 0-0-12-6)

1. Isolation of microorganism from soil (Serial dilution method)
2. Gram Staining method
3. Testing of water by coliform test
4. Bacterial growth assessment by trubidometry
5. Isolation of genomic/plasmid DNA and gel electrophoresis
6. DNA/RNA purity and quantification by Nanodrop
7. Restriction digestion and cloning in bacteria
8. Purification of protein/enzyme (Liopoxigenase) by ammonium sulphate precipitation and dialysis
9. Column Chromatographic purification /molecular weight determination of protein by Gel electrophoresis
10. Determination of specific activity of enzymes
11. Effect of pH and temperature on enzyme activity
12. Determination of Km and Vmax
13. Isolation and assay of acid phosphatase from sweet potato (Optional)
14. Antibacterial assay by Disk plate method

IU M 000 Basic Communication and Soft Skills (L-T-P-C: 1-0-0-0)

Unit 1: Fundamentals of Communication
- Importance of Communication
- Importance of Interpersonal Communication
- Process of Communication
- Flows and Types of Communication

Unit 2: Barriers to Communication
- Definition
- Types of Barriers

Unit 3: Listening
- Hearing & Listening
- Types of Listening
- Do's and Don'ts of Effective Listening

Unit 4: Effective Presentation
- Patterns & Methods of Presentation, Oral Presentation
- How to prepare presentation
- Effective ways to deliver the presentation
- How to prepare multi-media presentation
- Difference between C.V & Resume, types of resume

Unit 5: Corporate Etiquettes
- Non-verbal Communication
- E-mail etiquette, telephone etiquette, dining etiquette
- Office meeting etiquettes, dress etiquette

Text Books:
1. Soft Skills for Everyone by Jeff Butterfield, Cengage publication
2. Technical Communication; Principles and Practice" by Meenakshi Raman & Sangita Sharma (Oxford University Press)
3. "Communication Skills" by Dr. Sanjay Kumar and Dr. Pushp Lata, Oxford University Press

Reference Books:
1. Personality Development and Soft Skills by Barun K Mitra
2. Business Correspondence and Report writing"- R C Sharma and Krishna Mohan, Tata McGraw Hill, 8th Ed.2015

SEMESTER - III

BIO MB 801 Microbial Physiology (L-T-P-C: 3-1-0-4)

Unit 1: Growth of Bacteria

• Growth kinetics,
• Synchronous and asynchronous growth, continuous culture of bacteria & its kinetics
• Cell division cycle: Cell division cycle in yeasts, cdks and cyclins as regulators
• Bacterial sporulation and its genetics, dormancy
• Specific transport mechanisms
• Chemotaxis

Unit 2: Bioenergetics

• Entropy, enthalpy, laws of thermodynamics, free energy change, standard free energy change, equilibrium constant
• Relationship between free energy change, equilibrium constant and spontaneity of a reaction
• Microbial photosynthesis : Oxygenic and anoxygenic photosynthesis, Autotroph, Heterotroph
• Microbial cycling of sulphur, iron, hydrogen and nitrogen fixation

Unit 3: Respiratory Metabolism

• Aerobic and anaerobic
• Fermentation of carbohydrates and proteins
• Electron transport systems in bacteria and eukaryotes; ATP synthesis and its release
• Cell signaling mechanisms

Unit 4: Control of Metabolic Reactions

• Control of enzyme synthesis and activity
• *ara* operon, Transcription attenuation (*trp* operon)
• Binding efficiency of RNA polymerase, antitermination, sigma factors. • Global regulation: Two component signal transduction system
• Stringent response, ntr and pho system in response to N and P starvation
• ArcAB and fnr system
• Bioluminscense and its control

Unit 5: Stress Biology and Secondary Metabolism

• Stress biology, physiology of extremophiles and their adaptation mechanisms, stress such as pH, salt, temperature etc.
• Multiple drug resistance, biochemical function and mechanisms of drug resistance
• Bacteriocins, Microbial toxins

Reference Books:

1. Principles of Biochemistry, Lehninger. (2000). 3rd ed. Nelson and Cox (worth) publisher.
2. Biochemistry, Stryer. (2001). 5th ed. W. H. Freeman. Caldwell, D. R. 1995.
3. Microbial Physiology and Metabolism Brown Publishers. Moat and Foster, J. W. (1999).

4. Microbial physiology. Wiley. Brun, Y. N. and Shimkets, L. J. (2000).
5. Prokaryotic development. ASM press. Stainer, R. Y., Ingraham, J. L., Wheelis, M. L., Painter, P. R. (1986).
6. General Microbiology, MacMillan Education Ltd. London.
7. Microbial Physiology, 4th Edition (A. G. Moat, J. W. Foster & M. P. Spector). Indian edition.
8. The Physiology and Biochemistry of Prokaryotes. David White latest edition.
9. Bacterial Metabolism" (Springer Series in Microbiology) Hardcover – 19 Dec 1985 by Gerhard Gottschalk.

BIO MB 802 Metabolic Diversity and Metabolic Engineering (L-T-P-C: 3-1-0-4)

Unit 1:
Biosynthetic pathways, novel secondary metabolites -Antibacterials - erythromycin A, vancomycin and daptomycin- antifungals (amphotericin B), immune suppressants (FK-506), anticancer agents (doxorubicin and epoxomicin), anthelmintics (avermectin), insecticides (spinosyn A and avermectin B1a) and herbicides (e.g., phosphinothricin)- Genetics and regulation.

Unit 2:
Catabolism of glucose- Glycolysis, TCA cycle, Electron transport, Biosynthesis of ATP. Glucose catabolism in anaerobic organisms- Catabolic diversity – production of ethanol, butanol, acetone – regulation of solventogenic and acedogenic pathways, biosynthesis of amino acids and fatty acids, lipids –Regulation of fatty acid biosynthesis – strategies of accumulation lipids and fats- Light to fatty acids- Link between carbon fixation and fatty acid biosynthesis – manipulation of photosynthetic bacteria to enhance biodiesel production.

Unit 3:
The concept of metabolic pathway synthesis; KEGG, EcoCyc, Need for pathways synthesis, engineering of heterologous pathway, optimization of pathway, design and production of lycopene, fine chemicals, Taxol, Artemisinin, flavours, frangance, pigments, biofuels.

Unit 4:
Biotransformation strategies to engineer microbes for green chemistry. Degardation of haloaromatic compounds, Hexachlorohexane (HCH) degradation – degradation pathways - lin genes – metabolic engineering –generation of super bug for environmental cleanup operations.

Unit 5:
Recent technologies used in metabolic engineering: Advances in cloning methods: in-fusion cloning, Golden gate, Gibson assembly, Recombineering, Adaptive laboratory evolution, global transcription machine engineering, multiplex automated genome engineering, Transcription activator-like effectors nuclease, Zinc finger protein, CRISPR-Cas9 system.

Suggested Readings:

1. “Bacterial Metabolism” (Springer Series in Microbiology) Hardcover – 19 Dec 1985 by Gerhard Gottschalk .
2. “Metabolic Engineering - Principles and Methodologies” Paperback – 21 Nov 2005
3. by Stephanopoulos
4. “*Clostridium acetobutylicum*” Paperback – 29 Oct 2010 by Frederic P. Miller (Author)
5. “Streptomyces: Molecular Biology and Biotechnology”. David A. Hopwood, John Innes Centre, UK
6. “Metabolic Engineering”, Jens Nielsen Wri J Nielsen.

BIO MB 803 Microbial Genetics (L-T-P-C: 3-1-0-4)

Unit 1:
Genome organization, *E. coli* chromosome- coiled, supercoiled (plectonemic, solenoid), folded fiber model. *Mycoplasma genitalium, Saccharomyces* and *E. coli* genomes.

Unit 2:
Plasmid types, replication, copy number control, incompatibility, maintenance, curing & function. distribution & importance. IS elements, composite transposons, replicative and non-replicative transposons, Tn-transposons and evolution; use of transposons in genetic analysis.

Unit 3:
Mutation, molecular basis of spontaneous and induced mutations and their role in evolution; mutagens, types of mutations, Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants), transposon mutagenesis, site directed mutagenesis; environmental mutagenesis; Ames and other toxicity testing.

Unit 4:
Bacterial transformation, Discovery of transformation: Griffith's experiment., Detailed Process of transformation in Gram positive (*S. pneumoniae*) and Gram negative bacteria (*H. influenzae*)., Factors affecting transformation process; Competence, molecular weight of DNA and concentration of DNA, Discovery of transduction: Lederberg and Tatum's experiment, Generalized transduction, Specialized transduction of (mediated by lambda phage – Lambda d gal, Lambda Bio, helper phage, double-lysogen), Discovery of conjugation, Properties of F plasmid, "tra" operon function, Conjugation between F+ and F- cells, Formation of Hfr strains, Cross between Hfr and F- cells, Formation of F-Prime strains, Cross between F prime and F cells, Principles of mapping, recombination frequency and map unit.

Unit 5:
Gene analysis, Genetic Complementation: Cis-trans test of genetic function, Genetic Complementation: Inter cistronic (Tryptophan synthase of *E. coli*) and Genetic Complementation: Intra cistronic complementation (rII locus of T4 phage). Lysogeny and lytic cycle in bacteriophages, Life cycle and their uses in microbial genetics. Lytic phages-T7 and T4, Lysogenic phages Lamda, M13 and ΦX174.

Suggested Readings:

1. Bruce A. (2008), Molecular Biology of the Cell, 5th Ed. Publisher: Garland Science, New York.
2. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, (2013), Molecular Biology of the Gene, 7th Ed. Pearson Publishers.
3. Microbial Physiology (2014), Albert G. Moat, Wiley-Blackwell; 5th Edition edition.
4. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, (2012) Lewin's GENES XI, 11th Ed. Jones & Bartlett Learning.

5. Lodish H. et al. (2012), Molecular Cell Biology, 7th Ed. W. H. Freeman & Company. New York.
6. William Gardner, Simmons, Snustad. (2006), Principles of Genetics, 8th Ed. John Wiley & Sons. Inc. New York.
7. Russel Peter. (2009), iGenetics: A Molecular Approach, 3rd Ed. Publisher Benjamin Cummings.

BIO M 503 Genetic Engineering (L-T-P-C: 3-1-0-4)

Unit 1:
Overview of genetic engineering, Generation of DNA fragments: Mechanical shearing, restriction endonucleases (REs), use of REs in molecular cloning, PCR technology and its application in recombinant DNA technology, cDNA synthesis – strategies for isolation of full length cDNAs, chemical synthesis of a DNA fragment.

Unit 2:
Vectors used in molecular cloning. a) Plasmids – general concepts, eg.pUC, pBlueScript, pGEM vectors; Expression vectors; pMal, GST-based, pET vectors; b) Bacteriophage λ vectors – λgt10, λgt11, λ ZAP and replacement vectors - EMBL c) Phagemids - M13-derived vectors, d) cosmids - Artificial chromosome vectors (YACs; BACs); d) Other viral vectors: SV-40, vaccinia, baculovirus& retroviral vectors.

Unit 3:
Cloning strategies & Introduction of recombinant DNA into hosts: a) Other enzymes used in cloning - DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase b) cloning strategies – basic concepts of cohesive and blunt end ligation; directional cloning, use of linkers and adaptors; c) Homopolymer tailing, d) T-vectors and cloning of PCR products, e) Introduction of recombinant DNA into suitable hosts - transformation, conjugation, transduction, transfection, particle bombardment techniques, f) Ti plasmids and *Agrobacterium*-mediated transformation.

Unit 4:
Construction and screening of genomic libraries: a) Construction of genomic and cDNA libraries using for eg. λgt11, λ ZAP vectors, b) Screening: DNA probe based screening - molecular hybridization techniques: Preparation of nucleic acid probes by nick translation, random primer labeling and end labeling, hybridization techniques for identification of clones with gene of interest, c) Screening by antibody-based methods: induction of protein expression, immune-detection, radioactive and chemiluminescent methods of detection. Characterization of cloned genes: a) Sequencing of DNA- Sanger's enzymatic method and Gilbert's chemical sequencing method; automated DNA sequencing; next generation sequencing b) Identification of promoters and regulatory elements – promoter reporter fusions c) Site directed mutagenesis.

Unit 5:
Expression of recombinant proteins. a) Protein expression in *E. coli* as a host - Factors influencing the expression of recombinant proteins. Purification of recombinant proteins - His-tag, GST-tag, MBP-tag etc. Commercially available *E. coli* hosts for expression of recombinant proteins. b) Examples of alternate expression systems – yeast, *Baculovirus*, mammalian systems and plants. Genome editing, Zinc fingers, TALEN's, CRISPR/Cas9. Ethics and patentability.

Suggested Readings:

1. Primrose, Twymand and Old. "Principles of Gene Manipulation". Blackwell Science.
2. Sambrook J and Russell D. "Molecular Cloning: A laboratory Manual". Cold Spring Harbor Laboratory Press.
3. Lewin B. "Genes". Jones & Bartlett Publishers.
4. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. "Molecular Biology of the Cell". Garland Science.
5. Watson J.D, Baker T.A, Bell S.P, Gann A, Levine M and Losick R. "Molecular Biology of the Gene". . Benjamin-Cummins Publishing Co.,
6. Freifelder D. "Molecular Biology". Narosa Publishing House.

BIO M 504 Bioinformatics (Lab) (L-T-P-C: 0-0-4-2)

1. Nucleic acid sequence databases: DDBJ, GenBank, NCBI
2. Protein Sequence Databases: PIR, UNIPROT
3. Protein Structure Database: PDB, MMDB
4. Specialized genomic resources- ENTREZ – genome, gramene, SRA
5. Sequence Alignment: BLAST variants and FASTA variants
6. Gene prediction: PFAM, GENESCAN, FGENESH, GLIMMER
7. Tools for primer designing – Primer3, Genefisher, FastPCR
8. Multiple Sequence Alignment: Clustal X, Clustal W
9. Phylogenetic Analysis: MEGA
10. Protein Modelling- SWISS Model, Modeller, I TASSER
11. Docking: Auto Dock, Swiss Docking
12. Test of significance – t-test – F-test and2-test – correlation and regression analysis – ANOVA – data transformation, RSM
13. Factorial experiments – split-plot design – strip plot design
14. Statistical analysis using MS Excel, SYSTAT/SPSS, SAS/IRRISTAT.

Suggested Readings:

1. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
3. Pevsner, J. (2009). Bioinformatics & Functional Genomics. Wiley- Blackwell, New Jersey.
4. Janus, M. Bujnicki. (2004). Practical Bioinformatics. Springer.
5. Durbin, R., Eddy .S.R, Krough A and Mitchison, G. (2004). Biological Sequence Analysis. Cambridge University Press.
6. Sharma. K.V.S. (2010). Statistics Made Simple: Do it Yourself on PC, Prentice Hall of India, New Delhi.
7. Darren George and Paul Mallery, (2007), SPSS for Windows Step by Step – A Simple Guide and Reference, Pearson Education in South Asia.
8. SYSTAT/SPSS User's Guide and User's Manual.
9. SAS/ IRRISTAT User's Guide and User's Manual.

BIO MB 804 Biology Laboratory Techniques (Lab) (L-T-P-C: 0-0-8-4)

1. Isolation of heavy metals tolerance microorganisms by serial dilution methods from sewage water samples.
2. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.
3. Determination of metals and antibiotics sensitivity tests.
4. Determination of Minimum Inhibitory Concentration (MIC).
5. Study the effect of chemical (HNO2) and physical (UV) mutagens on bacterial cells
6. Study survival curve of bacteria after exposure to ultraviolet (UV) light
7. Demonstration of Bacterial Conjugation
   Demonstration of bacterial transformation and transduction
8. Demonstration of AMES test
9. Purification of protein/enzyme and protein estimation using BSA standard
10. Preparation PCR reaction and amplification.
11. Purification of PCR product from agarose gel.
12. Isolation, restriction digestion and ligation
13. Competent cell preparation, transformation and calculation of transformation efficiency
14. Screening of recombinant DNA using antibiotics marker and blue/while.
15. Analysis of recombinant DNA using restriction digestion
16. Southern/Northern blotting techniques
17. Metabolism of iron
18. Bioactive molecules identification and characterization using HPLC
19. Bioactive molecules identification and characterization using GC

SEMESTER – IV

BIO MB 805 Environmental Microbiology (L-T-P-C: 3-1-0-4)

Unit 1: Air and Water Microbiology

Air spora in different layers of atmosphere, bioaerosol, assessment of air quality using principles of sedimentation, impaction, impingement, suction and filtration. Brief introduction to transmission of airborne microbes; Microbiology of indoor and outdoor. Fresh and marine ecosystem. Zonation of water ecosystem; upwelling, eutrophication; food chain in aquatic ecosystems. Role of methanotrophs in ecosystem. Potability of water, microbial assessment of water.

Unit 2: Soil Microbiology

Biotic and abiotic interactions, concepts of habitat and niche. Microbial communities; nature, structure and attributes, Biodiversity management and conservation. Role of microbes in organic solid waste treatment matter. Biogeochemical cycles of carbon, nitrogen, phosphorous and sulphur.

Unit 3: Pollution and Waste Treatment

Environmental pollutions, type of pollutions, sources of pollution and its adverse effects.

- Environmental pollutants, types and sources,
- Environmental pollution, Eutrophication and its control,
- Types and characteristic of waste, waste water characterization
- Principles and aims of biological waste treatment
- Waste treatment processes
- Anaerobic waste water treatment

Unit 4: Biodegradation

Role of microbes in degradation, Biodegradation of Xenobiotics hydrocarbons, pesticides and plastics. Biodeterioration of wood, pulp and paper; Biosorption/bioaccumulation of heavy metals. Bioremediation of soil, air and water: various methods, advantages and disadvantages. Bioleaching of iron, copper, gold and uranium, Biosurfactants and their applications, Co-metabolism and recalcitrant, Bioremediation of oil spills and MEOR.

Unit 5: Fungi

Classification, General characteristics of fungi; range of thallus organization and reproduction, important genera of Fungi, application of fungi in bioremediation,

Characteristics of genera important in industry, biodegradation and diseases of animals and humans

Economics Importance of Fungi. Introduction and general characteristics of cyanobacteria and algae.

Suggested Readings:

1. Textbook of fungi H. C Dube
2. Microbial Ecology: Fundamentals & Applications. Atlas RM and Bartha R. (2000), 4th edition. Benjamin/Cummings Science Publishing, USA

3. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/ Benjamin Cummings
4. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press 4. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York
5. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
7. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
8. Lynch JM &Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
9. Martin A. (1977). An Introduction to Soil Microbiology. 2nd edition. John Wiley & Sons Inc. New York & London.
10. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
11. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
12. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
13. Levy JA, Conrat HF, Owens RA. (2000). Virology. 3rd edition. Prentice Hall publication, New Jersey.
14. Wagner EK, Hewlett MJ. (2004). Basic Virology. 2nd edition. Blackwell Publishing.

BIO MB 806 Food and Industrial Microbiology (L-T-P-C: 3-1-0-4)

Unit 1:

Food Microbiology, Overview of Govt. guidelines and safety, classification of Foods based on stability, Perishable, Semi-perishable & stable. Food spoilage: Chemical and physical properties of food affecting microbial growth. Sources of food spoilage microorganisms, Spoilage of meat and poultry products, bread, fruits and vegetables, eggs and canned foods. Fermented food products: Indian fermented food products: Pickles, idli, Khaman and bread, Microbes as food: Mushrooms, spirulina and yeasts, Introduction to probiotics, prebiotics and synbiotics, Fermented beverage, Food preservation: Principles of food preservation, Thermal destruction of bacteria: use of low temperature and high temperature.

Unit 2:

Industrial microbiology and its scope, general property, primary and secondary metabolites, strains, screening and testing system, strain improvement, Basic concept, principle, mutation, selection of mutants, recombination, regulation, genetic engineering, fermentation media, Growth kinetics, Batch, Fed-batch and continuous fermentation, bioreactor, parts, and type of bioreactor fluidized bed reactors, Continuously stirred tank flow reactors etc.

Unit 3:

Upstream and downstream processing: basic introduction to upstream processing, isolation, identification, fermentation, separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

Unit 4:

Microbial production**,** biosynthesis of ethanol, ethanol production process, acetone/ butanol, biosynthesis, production process, and glycerol, basic concept, strain, biosynthesis and, production, yield, production, nutrients, optimization and product recovery for citric acid, lactic acid, L-glutamic acid, L-lysine, amylases, glucose isomerase, L-asparginases, Vitamin B12, beta-carotene, penicillin, polysaccharides, Microbial transformation,Basic, types of biotransformation, principle and procedure for biotransformation, bioconversion, transformation of steroids and sterols, biotransformation of antibiotics.

Unit 5:

Biosafety and Biosecurity: Biological Risk Assessment, Laboratory Biosafety Level 1 to 4, biosecurity, development of biosecurity program, Containment for biohazards.

Suggested Readings:

1. Wulf Crueger and Anneliese Crueger. Biotechnology: A Textbook of Industrial Microbiology by Editor of the English edition: Thomas D Brock. pp 357. Sinauer Associates, Sunderland, MA. 1990 ISBN 0-87893-131-7.

2. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
3. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
4. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.
5. Bailey, J. E., &Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
6. Banwart G. J. (1989). Basic Food microbiology, 2nd Edn. Chapman and Hall. International Thompson Publishing.
7. James M. Jay, Martin J. Loessner, David A. Golden (2005). Modern food microbiology, 7th Edn. Springer Science & Business.
8. Frazier W C and Westhoff D C (1988), Food Microbiology, 4th Edn. McGraw-Hill Book Company, NY.
9. J. M. Willey, L. Sherwood, C.J. Woolverton, L.M. Prescott, (2011), Prescott's Microbiology, McGraw Hill, New York.
10. A.L. Demain and J. Davies, (2004), Manual of Industrial Microbiology and Biotechnology, 2nd Ed. ASM Press.

BIO MB 807 Research or Industrial Project/Viva (L-T-P-C: 0-0-0-14)