SIES College of Arts, Science & Commerce (Autonomous)

RISE WITH EDUCATION

NAAC REACCREDITED - 'A' GRADE

Sion (West), Mumbai – 400022.
(Autonomous)

Faculty: Science

Program: B.Sc.

Subject: BIOTECHNOLOGY

Academic Year: 2022 – 2023

S.Y.B.Sc. Biotechnology

Credit Based Semester and Grading Syllabi approved by Board of Studies in Biotechnology to be brought into effect from June 2022.

PREAMBLE

Biotechnology, broadly defined, includes any technique that uses living organisms, or parts of such organisms, to make or modify products, to improve plants or animals, or to develop microorganisms for specific use. The interdisciplinary nature of biotechnology integrates living systems including animal, plant and microbes and their studies from molecular biology to cell biology, from biochemistry to biophysics, from genetic engineering to stem cell research, from bioinformatics to genomics-proteomics, from environmental biology to biodiversity, from microbiology to bioprocess engineering, from bioremediation to material transformation and so on. Biotechnology is the science of today and tomorrow. It has applications in all major service sectors i.e. health, agriculture, industry, environment etc. Biotechnology as an application science has taken firm footing in many countries, abroad where a number of transgenic crops, genetically modified food and recombinant therapeutic molecules for human and animal health are available in the market. Biotechnology as a science of service to human society is yet to make inroads in India

With the advent of World Wide Web in the early nineties and its subsequent growth, the latest research trends have become accessible from drawing rooms across the globe. This acted as a positive feedback mechanism in increasing the pace of research in all fields including Chemical Engineering and Biotechnology. This was the motivation for an in depth analysis of what is actually required for today's technology. It is also important to take advantage of the freely available software to enhance the quality and quantity of material that can be covered in the classroom.

This restructured syllabus is therefore intended to combine the principles of physical, chemical and biological sciences along with developing advanced technology. The undergraduate curricula is prepared to impart primarily basic knowledge of the respective subject from all possible aspects. In addition, students will be trained to apply this knowledge particularly in day-to-day applications of biotechnology and hence get a flavor of research.

PROGRAM SPECIFIC OUTCOMES

An undergraduate student upon completion of this program is expected to gain the following attributes:

- Understand and describe the nature of the basic concepts of Cell biology, Microbiology Chemistry and Biochemistry with an interdisciplinary perspective about of other branches of Life Sciences.
- Explain the application of Biotechnology in the field of Medicine, Agriculture, Environment, and Sustainable development.
- Describe and explain the concepts of Immunology, Neurochemistry, Recombinant DNA technology and correlate them towards diagnosis and therapy of diseases and understanding how they can contribute towards the alleviation of human suffering.
- Discover and examine the causes of environmental pollution and devise methods to control the release of biohazardous waste into the environment.
- Perform practical as per laboratory standards in Chemistry, Biochemistry, Microbiology and Molecular Biology – Understand and analyze the results.
- Effectively communicate using ICT enabled tools and critically analyze and explain the data in a lucid manner.

Semester III				
Course Code	**Course Type**	**Course Title**	**Credits**	**Lectures/week**
SIUSBT31	Core Subject	Biophysics	2	3
SIUSBT32	Core Subject	Applied Chemistry-I	2	3
SIUSBT33	Core Subject	Immunology	2	3
SIUSBT34	Core Subject	Cell biology and Cytogenetics	2	3
SIUSBT35	Core Subject	Molecular Biology	2	3
SIUSBT36	Core Subject	Bioprocess Technology	2	3
SIUSBT37	Core Subject	Biosafety	2	3
SIUSBTP38, SIUSBTP39, SIUSBTP40	Core subject Practical	Practical of SIUSBT31, SIUSBT32, SIUSBT33, SIUSBT34, SIUSBT35 and SIUSBT36	6	18
Semester IV				
Course Code	**Course Type**	**Course Title**	**Credits**	**Lectures/week**
SIUSBT41	Core Subject	Biochemistry	2	3
SIUSBT42	Core Subject	Applied Chemistry-II	2	3
SIUSBT43	Core Subject	Medical Microbiology	2	3
SIUSBT44	Core Subject	Environmental Biotechnology	2	3
SIUSBT45	Core Subject	Biostatistics and Bioinformatics	2	3
SIUSBT46	Core Subject	Molecular Diagnostics	2	3
SIUSBT47	Core Subject	Entrepreneurship Development	2	3
SIUSBTP48, SIUSBTP49, SIUSBTP50	Core subject Practical	Practical of SIUSBT41, SIUSBT42, SIUSBT43, SIUSBT44, SIUSBT45 and SIUSBT46	6	18

SEMESTER III

COURSE CODE	TITLE	CREDITS	LECTURES
SIUSBT31	**BIOPHYSICS**		
Course Outcomes	On successful completion of the course the learner will be able to: • discuss electromagnetic radiations and lasers, their uses, types and applications of spectrophotometer and microscopy, • apply the concepts of heat, sound, magnetism and fluid dynamics, • describe the types of electrophoresis and specific requirements, investigate the parameters affecting electrophoresis and its applications		
Unit I Optics and Electromagnetic Radiations	**Introduction to Optics and Lasers:** **Optics:** Properties of light: Reflection, Refraction**,** Dispersion and Interference; **Lasers:** Properties of lasers, Stimulated Emissions, Laser Action, Applications of Laser; **Electromagnetic Radiation:** Introduction to Electromagnetic Radiation; **Spectroscopy:** Types and Properties of Spectra; Basic Laws of Light Absorption. **Spectrophotometer:** Principle; Instrumentation and Applications; UV-Vis Spectrophotometer, Single and Dual-beam Spectrophotometer **Microscopy:** Types of Microscopy: Electron Optics; Electron Microscopy: Preparation of Specimens, SEM TEM, Immuno-electron Microscopy, Fluorescence Microscopy and Confocal Microscopy	**2**	**15**
Unit II Heat, Sound, Magnetism and Fluid Dynamics	**Heat:** Concept of Temperature; Modes of Heat Transfer; Measuring Temperature; Platinum Resistance Thermometer, Thermocouple and Thermistors **Sound:** Types of Sound Waves - Audible, Ultrasonic and Infrasonic Waves; Doppler Effect; Applications of Ultrasonic Waves **Magnetism:** Magnetic Field; Magnetism of Earth; Para- magnetism, Diamagnetism, Ferromagnetism. Nuclear Magnetism and Biomagnetism **Fluid Dynamics:** ***Viscosity:*** Definition Flow of Liquids through Capillaries; Stokes' Law; Terminal Velocity. Determination of 'η' by Falling Sphere Method; Viscosity Estimation by Oswald's Viscometer. ***Surface Tension:*** Definition - Surface Tension and Surface Energy; Capillary Action; Angle of Contact; Wettability; Temperature Dependence of Surface Tension. Applications in Biology.		**15**

Unit III **Electrophoresis**	Migration of Ions in an applied electric field; Factors affecting Electrophoretic Mobility; Moving Boundary Electrophoresis; Principle of Electrophoresis; Supporting Matrix; Paper electrophoresis; AGE; Native and SDS PAGE (reducing and non-reducing, continuous and discontinuous); IEF and 2D PAGE. Staining and Detection methods; Gel-Documentation. Applications in Biology.		**15**

COURSE CODE	**TITLE**	**CREDITS**	**LECTURES**
SIUSBT32	**APPLIED CHEMISTRY-I**		
Course Outcomes	On successful completion of the course the learner will be able to: • outline the organic reactions and metal coordination in biological systems, • discuss the various synthesis routes for organic compounds, • enlist the importance and relevance of green chemistry		
Unit I **Organic Chemistry**	**Introduction to Types of Organic Reactions**: Addition, Elimination and Substitution Reactions. Essential and Non-essential Elements in Biological Systems. Role of Metal Ions in Biological Systems. **Metal Coordination in Biological Systems:** Enzymes, Apoenzymes and Coenzymes. Biological Role of Metalloenzymes wrt Myoglobins, Haemoglobin. Biological Role of Carboxypeptidases, Catalases and Peroxidases. **Structure and Function:** Dioxygen Binding, Transfer and Utilization; Metal Complexes in Medicines.	**2**	**15**
Unit II **Synthesis of Organic Compounds**	**Synthesis of Organic Compounds:** Criteria for Ideal Synthesis; Selectivity and Yield. Linear and Convergent Synthesis and Multicomponent Reactions. Microwave Assisted Organic Ultrasound in Synthesis and Polymer supported Synthesis. Retrosynthesis.		**15**
Unit III **Green Chemistry and Synthesis**	**Green Chemistry and Synthesis:** Introduction to Green Chemistry; Need and Relevance of Green Chemistry; Principles of Green Chemistry. Green Synthesis in Industry: Green Materials, Green Reagents, Green Solvents and Green Catalysts.		**15**

COURSE CODE	TITLE	CREDITS	LECTURES
SIUSBT33	**IMMUNOLOGY**		
Course Outcomes	On successful completion of the course the learner will be able to: • describe the role and significance complement system, MHC classes and pathways & immune cell receptors involved in immune system, • enlist the various immunotechniques & applications with respect to antigen-antibody interaction		
Unit I **Effectors of Immune Response**	**Complement System-** Classical, Alternate and Lectin; Regulation and Biological Effects of Complement System; Deficiencies of Complement System **MHC Classes** – General Organization and Inheritance; Structures and Peptide Interactions; Class I and II Diversity and Polymorphism; Antigen Presentation - Endocytic and Exocytic Pathways; MHC Restriction.	**2**	**15**
Unit II **Cell Receptors**	**T-cell Receptor Complex:** Structure, mechanism, T cell co-receptor complex **B-cell Receptor:** Structure, mechanism, B cell co-receptor complex **Toll-like receptors (TLRs)** **B-T cell interaction (B-T cell cooperation).** Introduce cell cytotoxic responses as the effector mechanism		**15**
Unit III **Immuno-Techniques**	Antigen-Antibody Interactions: Precipitation and Agglutination **Precipitation Reactions:** Immunoprecipitation, Immunoelectrophoresis, CIEP, Rocket Electrophoresis and 2-D Immunoelectrophoresis. **Agglutination Reactions:** Passive, Reverse Passive, Agglutination Inhibition. Coomb's Test; Complement Fixation Tests, RIA, ELISA, ELISPOT, Chemiluminescence, Western Blot, Immunofluorescence, Flow Cytometry. **Alternatives to Antigen-Antibody Reactions.**		**15**

COURSE CODE	TITLE	CREDITS	LECTURES
SIUSBT34	**CELL BIOLOGY AND CYTOGENETICS**		
Course Outcomes	On successful completion of the course the learner will be able to: • discuss the types of cytoskeleton, their assembly and functions in a cell, • describe cell membrane, various membrane transport mechanisms and cell junctions, • analyze the structure of chromosome, understand the dosage compensation and determine the map distance via linkage analysis		
Unit I **Cytoskeleton**	**Cytoskeleton**: Overview of the Major Cytoskeleton. **Microtubules:** Structure and Composition. **MAPs:** Functions- Role in Mitosis, Structural Support and Cytoskeleton Intracellular Motility. **Motor Proteins:** Kinesins, Dynein; MTOCs. Dynamic Properties of Microtubules. Microtubules in Cilia and Flagella. **Microfilaments:** Structure, Composition Assembly and Disassembly. **Motor Protein:** Myosin. **Muscle Contractility:** Sliding Filament Model. **Actin Binding Proteins:** Examples of Non-Muscle Motility. **Intermediate Filaments:** Structure, Composition; Assembly and Disassembly, Types and Functions.	**2**	**15**
Unit II **Cell Membrane**	**Cell Membrane:** Uptake of Nutrients by Prokaryotic Cells; Cell Permeability. Principles of Membrane Transport- Transporters and Channels; Active Transport, Passive transport; Types of Transporters, Types of ATP Driven Pumps - Na+ K+ Pump, Ca^{+2} ATPase pump, Gated Ion channels: Voltage gated ion channels: K+, Na+; Ligand gated ion channels: Acetylcholine receptor Cell Junctions;Cell Adhesion and Extracellular Material; Microvilli; Tight Junctions, Gap Junctions; Cell Coat and Cell Recognition. Cellular Interaction		**15**
Unit III **Cytogenetics**	**Cytogenetics**: Structure of Chromosome - Heterochromatin, Euchromatin, Polytene Chromosomes **Sex Determination and Sex Linkage:** Mechanisms of Sex Determination (XX-XY, ZZ-ZW, XX-XO), Dosage Compensation and Barr Body. Environmental effect on expressions of the genes **Genetic Linkage, Crossing Over and Chromosomal Mapping:** Tetrad Analysis; Two-point Cross; Three- point Cross; Linkage dihybrid cross; Pedigree Analysis.		**15**

COURSE CODE	TITLE	CREDITS	LECTURES
SIUSBT35	**MOLECULAR BIOLOGY**		
Course Outcomes	On successful completion of the course the learner will be able to describe: • transcription process in prokaryotes and eukaryotes, • translation and post-translational modifications, • regulatory mechanism of gene expression in prokaryotes and eukaryotes		
Unit I **Gene Expression-Transcription**	Gene Expression- an Overview. **Transcription Process in Prokaryotes:** RNA Synthesis; Promoters and Enhancers; Initiation of Transcription at Promoters; Elongation and Termination of an RNA Chain. **Transcription in Eukaryotes:** Eukaryotic RNA Polymerases; Eukaryotic Promoters; Transcription of Protein Coding Genes by RNA Polymerase; Eukaryotic mRNAs; Transcription of other Spliceosomes; RNA editing.	**2**	**15**
Unit II **Gene Expression-Translation**	**Nature of Genetic Code.** **Wobble Hypothesis**. **Translation:** Process of Protein Synthesis (Initiation, Elongation, Translocation, Termination); **Post Translation Modifications.** **Protein sorting.**		**15**
Unit III **Regulation of Gene Expression**	**In Bacteria:** *lac* Operon of E. coli; *trp* Operon of E. coli. **In Viruses:** Lytic / Lysogenic Regulation **In Eukaryotes:** Operons in Eukaryotes; Control of Transcriptional Initiation; Gene Silencing and Genomic Imprinting; Post-Transcriptional Control; RNA Interference.		**15**

COURSE CODE	TITLE	CREDITS	LECTURES
SIUSBT36	**BIOPROCESS TECHNOLOGY**		
Course Outcomes	On successful completion of the course the learner will be able to: • perform the screening of strains to develop inoculum, • outline the basic fermenter design, media and sterilization process, • discuss the various industrial fermentation processes and their assays		
Unit I **Microorganisms in Industrial Processes**	**Types of Microorganisms used in Industrial Processes:** Bacteria, Actinomycetes, Fungi and Algae. **Screening and maintenance of strains:** Primary Screening and Secondary Screening; Cultivation; Preservation of Industrially Important Microbial Strains. **Inoculum Development:** Introduction to Inoculum development; Bacterial and fungal inoculum development with one example each	**2**	**15**
Unit II **Fermenters**	**Design of a fermenter:** Stirred Tank Fermenter- Basic Design; Parts of a Typical Industrial Fermenter. **Fermentation Media:** Components; Design and Optimization. **Sterilization:** Sterilization of Fermenter and Fermentation Media. **Types of Fermenters:** Air Lift, Bubble, Column, Deep jet and Membrane bioreactor		**15**
Unit III **Fermentation Processes**	**Study of representative fermentation processes**: Penicillin, Ethanol, Beer, Wine, Vinegar and Citric acid **Assay of Industrial Products:** Chemical and Biological; Types and Subtypes Advantages and Disadvantages.		**15**

COURSE CODE	TITLE	CREDITS	LECTURES
SIUSBT37	**BIOSAFETY**		
Course Outcomes	On successful completion of the course the learner will be able to explain the understanding of: • Importance of GLP and assess the risk associated with biological agent and work practices • SOPs for instruments and record keeping • The risk associated with genetically engineered crops and bioethics		
Unit I **Introduction to Biosafety**	Introduction; Biological Risk Assessment, Hazardous Characteristics of an Agent; Genetically modified agent hazards; cell cultures; Hazardous Characteristics of Laboratory Procedures; Potential Hazards Associated with Work Practices; Safety Equipment and Facility Safeguards; Pathogenic risk and management	**2**	**15**
Unit II **GLP**	Concept of GLP; Practicing GLP; Guidelines to GLP; Documentation of Laboratory work; Preparation of SOPs; Calibration records; Validation of methods; Documentation of results; Audits & Audit reports Microbiological Assays for pharmaceutical products; Regulatory Microbiological testing in pharmaceuticals		**15**
Unit III **Biosafety in Biotechnology**	Concepts on biosafety in Biotechnology; Regulating rDNA technology; Regulating food and food ingredients; Genetically engineered crops, livestock Bioethics; Contemporary issues in Bioethics		**15**

SEMESTER III (PRACTICAL)

COURSE CODE	TITLE	CREDITS	NOTIONAL HOURS
SIUSBTP38	**PRACTICALS based on SIUSBT31 and SIUSBT32**	**2**	**30 Hrs**
Course Outcomes	On successful completion of the course, the leaner will be able to use electrophoretic techniques to separate protein & DNA. They will be able to elucidate the effect of protein denaturation on viscosity as well as perform various organic estimations.		

1. Extraction of Plasmid DNA and Separation by Agarose Gel Electrophoresis.
2. Determination of Purity of Plasmid DNA using UV Spectrophotometry.
3. Study of the Structure and Function of an Electron Microscope
4. Demonstration of Structure and Working of a Fluorescence Microscope (Stained Preparation).
5. Electrophoresis of Proteins by PAGE and SDS-PAGE (Demonstration)
6. Viscosity
7. Osazone test
8. Organic Estimations: Acetone, Amide, Benzoic Acid.
9. Organic Preparations: Acetylation of Primary Amine (Preparation of Acetanilide).

COURSE CODE	TITLE	CREDITS	NOTIONAL HOURS
SIUSBTP39	**PRACTICALS based on SIUSBT33 and SIUSBT34**	**2**	**30 hrs.**
Course Outcomes	On successful completion of the course, the leaner will be able to correlate and perform various antigen-antibody interactions to determine their amount or to identify a diseased condition. They will be skilled to map the genes and analyze pedigree.		

1. Complement Fixation Test (CFT)- Demonstration
2. Passive Agglutination- RA Factor Test.
3. Immunoelectrophoresis.
4. Double immunodiffusion (Ouchterlony method)
5. SRID
6. ELISA (Kit-based) - HEPALISA.
7. DOT-BLOT
8. Western Blotting - Demonstration.
9. Flow Cytometry – Lab Visit/Demonstration.
10. Study of Polytene Chromosomes.
11. Mapping based on Tetrad Analysis and Three Point Cross.
12. Pedigree Analysis- Autosomal and Sex-Linked.

COURSE CODE	TITLE	CREDITS	NOTIONAL HOURS
SIUSBTP40	**PRACTICALS based on SIUSBT35 and SIUSBT36**	**2**	**30 hrs.**
Course Outcomes	On successful completion of the course, the leaner will be able to ▪ screen soil sample for potential antibiotic producers as well as estimate a common antibiotic chemically and biologically. ▪ produce ethanol at laboratory scale and estimate its amount. identify and cultivate filamentous bacteria, and ▪ select industrially important bacterial strains on the basis of their growth rate		

1. Comparison of Growth curve and selection of industrially important strains
2. Slide culture of actinomycetes
3. Estimation of acetic acid in vinegar titrimetrically
4. Study of lac Gene Expression using Blue-White Selection (Demo).
5. Induction and screening of β-galactosidase activity
6. Screening for an Antibiotic Producing Strain of Microorganism.
7. Estimation of Penicillin by Chemical (Iodometric) Method
8. Estimation of Penicillin by Biological (Bioassay) Method
9. Lab Scale Production of Ethanol.
10. Purification of Ethanol from Broth Culture of *Saccharomyces* spp. By distillation
11. Estimation of Alcohol from Recovered Broth by Dichromate Method
12. Validation of micropipette, measuring cylinders, colorimeters
13. Calibration of pH meter & weighing balance (Problems)
14. Detection of adulterants in food
15. Sterility testing of injectables

SEMESTER IV

<table>
<tr><th>COURSE CODE</th><th>TITLE</th><th>CREDITS</th><th>LECTURES</th></tr>
<tr><td>SIUSBT41</td><td>BIOCHEMISTRY</td><td></td><td></td></tr>
<tr><td>Course Outcomes</td><td colspan="3">On successful completion of the course the learner will be able to describe and discuss:
reactions, regulation and disorders associated with carbohydrate catabolism, pathways and electron transport chain,
amino acid and nucleic acid metabolism & associated metabolic disorders,
fatty acids oxidation reactions and lipid storage disease</td></tr>
<tr><td>Unit I
Carbohydrate Metabolism, ETS and Energy Rich Compounds</td><td>Carbohydrate Metabolism:
Glycolytic Pathway and its Regulation, Homolactic Fermentation; Alcoholic Fermentation; Energetics of Fermentation; Citric Acid Cycle and its Regulation;. (Sequence of Reactions, Regulation, Energy Yield and Metabolic Disorders of the above pathways)
Electron Transport System:
Electron Transport and Oxidative Phosphorylation. Inhibitors of ETS
Energy Rich Compounds:
ATP as Energy Currency, Structure of ATP, Hydrolysis, Other Energy Rich Compounds other than ATP like PEP, Creatine Phosphate, NAD, NADP, FAD, etc.</td><td rowspan="2">2</td><td>15</td></tr>
<tr><td>Unit II
Amino Acid and Nucleotide Metabolism</td><td>Amino Acid Breakdown:
Deamination, Transamination, Urea Cycle
(Reactions and Metabolic Disorders - PKU, Maple syrup urine disease, Alkaptouria, Albinism, tyrosinemia)
Amino Acids as Biosynthetic Precursors:
Biosynthesis of Serotonin, GABA, Histamine, Glutathione.
(Sequence of Reactions, Regulation and Metabolic Disorders - Epilepsy, Allergic responses, Hemolytic anemia)
Nucleotide Metabolism:
Degradation of Purines and Pyrimidines (Sequence of Reactions and Metabolic Disorders - Gout and Lesch-Nyhan syndrome)</td><td>15</td></tr>
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Unit III **Lipid Metabolism**	**Lipid Metabolism:** Mobilization, Transport of Fatty Acids. Beta, Alpha and Omega Oxidation of Saturated Fatty Acids; Oxidation of Unsaturated Fatty Acids; Oxidation of Odd Chain Fatty Acids. Energy Yield, Ketone Body Breakdown to Yield Energy. (Sequence of Reactions, Regulation, Energy Yield and Metabolic Disorders of the above pathways) Lipid storage diseases- Tay Sachs disease, Fabry's disease, Niemann-Pik's disease and Gaucher disease		**15**

COURSE CODE	**TITLE**	**CREDITS**	**LECTURES**
SIUSBT42	**APPLIED CHEMISTRY-II**		
Course Outcomes	On successful completion of the course the learner will be able to: • discuss the principle and types of sampling and separation techniques like solvent extraction and centrifugation, • list the principle and applications of column chromatography, • classify various natural and synthetic polymers and investigate their uses, • describe the basics of nanotechnology wrt synthesis, characterization and applications		
Unit I **Sampling and Separation Techniques**	**Sampling**: Importance of Sampling and Sampling techniques, Types of Sampling - Random and Non-Random Sampling of Solids, Liquids and Gases. **Separation Techniques:** Solvent Extraction - Partition Coefficient and Distribution Ratio, Extraction Efficiency, Separation Factor, Role of Complexing Agents, Chelation, Ion pair Formation, Solvation, and Soxhlation. **Centrifugation** – Basic principles of sedimentation. Preparative: differential and density gradient, isopycnic and rate zonal gradient materials, preparation, sample application, recovery, choice of rotors. Analytical centrifuge	**2**	**15**
Unit II **Chromatographic Techniques**	**Column chromatography and its types:** Column chromatography: Principle, packing of column, matrix used, parts of column chromatography. Principle, working and application of Adsorption chromatography, partition chromatography, Affinity, Gel Permeation and Ion-Exchange chromatography, Applications		**15**

Unit III **Polymers and Nanomaterials**	**Polymers:** Introduction to Polymers, Types of Polymers: Monomers, Polymer, Homopolymer, Copolymer, Thermoplastics and thermosets, Addition and Condensation Polymers (Examples and Uses) Stereochemistry of Polymers Biodegradable Polymers **Nanomaterials:** Introduction to nanomaterials, Types of nanomaterials, Forms of Nanomaterials: Nanoparticles, Nanofilms, Nanotubes and Quantum Dots, Synthesis and characterization of Nanomaterials, Applications of Nanomaterials.		**15**

COURSE CODE	**TITLE**	**CREDITS**	**LECTURES**
SIUSBT43	**MEDICAL MICROBIOLOGY**		
Course Outcomes	On successful completion of the course the learner will be able to: • describe the host-parasite interactions and epidemiology of infectious diseases, • discuss the transmission, pathogenesis and diagnosis of skin, respiratory and urinary tract infections, • outline the pathogenesis, diagnosis and treatment of sexually transmitted diseases GI infections		
Unit I **Infectious Diseases**	**Host Parasite Relationship:** Normal Flora; Factors Affecting the Course of Infection and Disease; Mechanisms of Infection and Virulence Factors. **Infection:** Patterns of Infection; Types of Infections; Signs and Symptoms; Epidemiology and Epidemiological Markers. **Diseases:** Origin of Pathogens; Vectors; Acquisition of Infection; Koch's Postulates.	**2**	**15**
Unit II **Medical Microbiology-Causative Organisms-I**	**Skin:** *S. aureus* **Respiratory Tract Infections:** *M. tuberculosis, S. pneumoniae* (Characteristics, Transmission, Course of Infection, Lab Diagnosis, Management of TB, Prevention and Control, Immuno and Chemoprophylaxis, DOTS and MDR). **Urinary Tract Infections:** *E.coli* (Characteristics, Virulence, Clinical disease, and *E.coli* Infections)		**15**

Unit III **Medical Microbiology-Causative Organisms-II**	**GI Tract Infections:** *Salmonella and Shigella spps.* (Characteristics, Virulence - Pathogenesis and Immunity, Clinical Disease, Carriers Lab Diagnosis, Typing Prophylaxis and Treatment). **Sexually Transmitted Diseases:** *Syphilis* and *Gonorrhea*. **Nosocomial Infections:** *P. aeruginosa*		**15**

COURSE CODE	**TITLE**	**CREDITS**	**LECTURES**
SIUSBT44	**ENVIRONMENTAL BIOTECHNOLOGY**		
Course Outcomes	On successful completion of the course the learner will be able to identify and evaluate the : • causes, types and control methods of water and soil pollution, • causes, types and control methods of air pollution, • significance of bioremediation in control of environmental pollution		
Unit I **Water Microbiology & Pollution**	**Types of Pollution** **Water Pollution:** Causes, Types and Classification; Eutrophication; Assessment of Water Quality- Pollutant Monitoring and Control; **Assessment of Water Quality-** • Microbiology of potable water supplies. • Sanitation of water for domestic use- preventive treatment, Sedimentation, Coagulation and Flocculation, Filtration (Slow sand filter, Rapid sand filter, Diatomic filter, Reverse osmosis), Disinfection of potable water. • Bacteriological examination of drinking water- Indicator organisms of faecal pollution, other indicator organisms and their significance. • Bacteriological analysis of water- Test for coliforms- MPN, Presumptive, Confirmed, Completed and IMViC.	**2**	**15**

Unit II **Air Microbiology, Pollution and Monitoring**	**Air Microbiology:** Composition of air, number and kinds of microorganisms in air. **Enumeration:** Impingement in liquid- Lemon Sampler and Kluyver and Visser, Impingement on solid surfaces- Hollaender sampler, Andersen air sampler. **Air Pollution:** Types; Sources; Classification of Air Pollutants; Temperature inversion; Air Pollution Monitoring and Control; Air Sanitation- Filtration, Sedimentation, Centrifugation, Electrostatic precipitation, Wet Scrubber **GreenHouse Effect:** Factors Responsible for GreenHouse Effect; GreenHouse Gases. Global Warming; Ozone Depletion; Montreal Protocol; Kyoto Protocol; UV Radiation; Acid Rain.		**15**
UNIT III **Soil Erosion and Bioremediation**	**Soil Erosion:** Concept, Causes and Effects, Prevention and Control **Concept of Bioremediation:** Microorganisms in Bioremediation, Myco-remediation and Phytoremediation, Bioremediation Technologies, Measuring Bioremediation in the Field. Bioaugmentation and Biostimulation. Monitoring the Efficacy of Bioremediation. **Heavy metal pollution:** Sources, microbial systems for heavy metal accumulation, techniques used for heavy metal removal, biosorption by bacteria, fungi and algae, factors affecting biosorption limitations of biosorption.		**15**

COURSE CODE	TITLE	CREDITS	LECTURES
SIUSBT45	**BIOINFORMATICS AND BIOSTATISTICS**		
Course Outcomes	On successful completion of the course the learner will be able to: ▪ demonstrate the understanding of biological databases, protein classification on the basis of its structure and protein visualization software ▪ comprehend and identify various alignment matrices, decipher homology using BLAST and deduce phylogeny using multiple alignment of sequences ▪ implement various statistical tools for analysis of biological data		
Unit I **Introduction to Computers and Biological Databases**	**Computer Basics:** Organization of a Computer; I/O Units; Computer Memory; Processor; Binary Arithmetic; Logic Circuit; Architecture; Operating System. Internet Basics: Connecting to the Internet, E-mail, FTP, www, Difference between www and Internet. **Biological Databases:** Classification of Databases- Raw and Processed databases; Primary (NCBI), Secondary (PIR) and Tertiary or Composite (KEGG) databases; Structure and Sequence databases. Specialized Databases - Protein Pattern Databases; Protein Structure and Classification Databases (CATH/SCOP). **Genome Information Resources:** DNA Sequence Databases specialized Genomic Resources. Protein Databases based on Composition, Motifs and Patterns. Protein Str. Visualization Software.	**2**	**15**
Unit II **BLAST and Sequence Alignment**	**Pairwise Alignment:** Identity and Similarity; Global and Local Alignment; Pairwise Database Searching. FASTA **BLAST and Sequence Alignment**: BLAST and its Types; Retrieving Sequence using BLAST **Multiple Sequence Alignment:** Goal of Multiple Sequence Alignment; Computational Complexity; Manual Methods; Simultaneous Methods; Progressive Methods; Databases of Multiple Alignment; Secondary Database Searching; Analysis Packages; MSA and phylogenetic trees.		**15**
Unit III **Biostatistics**	Definition & Importance of Statistics in Biology, Difference between Population and sample; Types of Population Sampling; Types of Data, Normal and Frequency Distribution, Representation of Data and Graphs (Bar Diagrams, Pie Charts and Histogram, Polygon and Curve, Concept of Box Plot)		**15**

	Concept of descriptive/summary statistics, Measures of Central Tendency (For Raw, Ungroup & Group Data): Mean, Median, Mode. Advantages & disadvantages. Importance of dispersion, Measures of Dispersion: Range, Variance, Coefficient of Variation, Standard Derivation (for population and sample)		

COURSE CODE	**TITLE**	**CREDITS**	**LECTURES**
SIUSBT46	**MOLECULAR DIAGNOSTICS**		
Course Outcomes	On successful completion of the course the learner will be able to: • discuss the importance of molecular diagnostics, personalized medicine and hybridization techniques, • describe the principle and types of PCR & primer designing, • identify and evaluate the different molecular diagnostic techniques based on molecular identification		
Unit I **Basics of Molecular Diagnostics**	**Introduction to Molecular Diagnostics:** Overview of Molecular Diagnostics; History of Molecular Diagnostics; Molecular Diagnostics in post genomic era; Areas used in Molecular Diagnostics; Future prospects- Commercializing Molecular Diagnostics, Personalized medicine, Theranostic. **Characterization and analysis of Nucleic-acids and Proteins:** Extraction, Isolation and Detection of DNA, RNA and Proteins; Restriction Endonucleases and restriction enzyme mapping **Hybridization techniques:** Southern, Northern, Western Blotting technique and Markers, probes and its Clinical applications.	**2**	**15**
Unit II **Nucleic Acid Amplification Methods**	**Target amplification:** PCR - General Principle; Components of a Typical PCR reaction; Experimental Design; **PCR Types:** Reverse Transcriptase and Real Time PCR **Probe amplification:** Ligase Chain Reaction **DNA Polymorphism and Identification:** RFLP and Parentage Testing; RFLP and Sickle-Cell Anemia. **Molecular Diagnostics for infectious diseases:** Molecular testing for Neisseria, Molecular diagnosis for HIV-1		**15**

Unit III **Molecular Biology based Diagnostics**	**Variation in Chromosomal Structure and Number:** Deletion, Duplication, Inversion, Translocation, Euploidy, Aneuploidy, Polyploidy and Syndromes- Klinefelter, Turner, Cri-du-Chat, Trisomy-18 and Trisomy-13. **Cytogenetic staining :** Principle of Karyotype, G-banding, R-banding, C-banding, T-banding, Q-banding; FISH **Genetic Counselling and Molecular Diagnosis:** Genetic testing- Need and uses; genetic counselling. Case studies- Diagnostic testing for Cystic fibrosis; Fragile X diagnostic and Carrier testing, CML and Down Syndrome **Ethical, Social and legal issues to molecular genetic testing**		**15**

COURSE CODE	**TITLE**	**CREDITS**	**LECTURES**
SIUSBT47	**ENTREPRENEURSHIP DEVELOPMENT**		
Course Outcomes	On successful completion of the course the learner will be able to: • compare and contrast the types of IPR, • outline the planning, requirements and setting-up of an enterprise, • assess the strategies of sales, market research and advertisement		
Unit I **Introduction to Entrepreneurship Development and IPR**	**Entrepreneurship:** Concept of Entrepreneur; Entrepreneurship; Need and Importance; Factors Influencing Entrepreneurship; Essentials of a Successful Entrepreneur **Intellectual Property Rights (IPR):** Introduction, Types and Management of IPR.	**2**	**15**
Unit II **Setting-up of an Enterprise and Planning**	Location of Enterprise; Real Estate and Human Resource Planning, Financial Planning; Role of Government and Financial Planning Institutions in Entrepreneurship Development; Raising Money from Venture Capitalists, Government Grants, Product Selection and Ideas; Project Planning and Formulation; Project Feasibility Assessment; Regulatory Affairs, Corporate Laws, Innovation, IPR generation and Protection, Preparation of a Business Plan, Characteristics and Importance of Planning.		**15**

Unit III **Marketing, Sales, Advertising & International Market Research**.	Marketing Plan for an Entrepreneur; Strategic Alliances, Advertising and Sales Promotion; Market Assessment, Need for International, Domestic vs. International Market research Market Research, Cost and Methodology of Market Research, Desk and Field Research.		**15**
Internal evaluation	Submission and Presentation of Business Proposal for any Biotechnological Product/Enterprise.		

SEMESTER IV (Practical)

COURSE CODE	TITLE	CREDITS	NOTIONAL HOURS
SIUSBTP48	**Practical based on SIUSBT41 and SIUSBT42**	**2**	**30 hrs.**
Course Outcomes	On successful completion of the course, the student will be able to ▪ estimate cholesterol levels, assess liver function as well as detect gout using different methods ▪ isolate & demonstrate the function of mitochondria and chloroplast ▪ separate components from a mixture using various column chromatographic techniques. ▪ synthesize nanoparticles chemically & biologically as well as characterize them		

1. Gradient Plate technique
2. Determination of Cholesterol in Serum.
3. Organ Function Tests: Liver (SGPT, SGOT); Kidney (Urea from Serum)
4. Estimation of Uric acid and Creatinine in Urine
5. Qualitative Detection of Ketone Body in Urine
6. Isolation of Mitochondria by differential centrifugation and Demonstration of ETC using a Marker Enzyme.
7. Separation of Chloroplast using Sucrose Density Gradient
8. Separation of Binary (Solid-Solid) Mixtures
9. Separation of components from a mixture using Affinity chromatography (Kit may be used)
10. Separation of components from a mixture using ion exchange chromatography (Kit may be used)
11. Separation of components from a mixture using Size exclusion chromatography (Kit may be used)
12. Chemical and Biological Synthesis of Silver Nanoparticles and its characterization by UV- Vis Spectrophotometer

COURSE CODE	TITLE	CREDITS	NOTIONAL HOURS
SIUSBTP49	**Practical based on SIUSBT43 and SIUSBT44**	**2**	**30 hrs.**
Course Outcomes	▪ On successful completion of the course, the learner will be able to identify causative agents of various infections. They would exhibit the skill for determining the potability of water as well as establishing the concentration of organic matter as an index to assess the effect discharged wastewater on the receiving environment.		

1. Identification of *S.aureus*-Isolation, Catalase, Coagulase Test.
2. Identification of *E.coli*-Isolation, Sugar Fermentations, IMViC.
3. Identification of *Pseudomonas* - Isolation, Urease test, Oxidase Test, TSI Slant.
4. Identification of *Streptococcus*: Bacitracin and Optochin sensitivity test, Bile solubility test
5. RPR Test (Kit Based).

6. Acid fast staining of *Mycobacterium.*
7. Biological Oxygen Demand (BOD).
8. Chemical Oxygen Demand (COD)
9. Isolation of Bacteria from Air by Gravity Sedimentation Method
10. Most Probable Number (MPN) – Presumptive, Confirmed and Completed tests.

COURSE CODE	TITLE	CREDITS	NOTIONAL HOURS
SIUSBTP50	**Practical based on SIUSBT45 and SIUSBT46**	**2**	**30 hrs.**
Course Outcomes	On successful completion of the course, the learner will be able ▪ apply various basic computational tools like EXCEL for data analysis as well as graph generation use various biological database and implement pairwise alignment tools like BLAST to decipher homology as well as carry out multiple alignment of sequences to identify consensus region as well as construct phylogenetic tree ▪ isolate DNA from microbial source and quantify nucleic acid		

1. Familiarization with NCBI, EMBL, DDBJ, PIR, KEGG Databases.
2. Basic formatting using MS word
3. Use of MS Excel
4. Preparation of graph using MS excel
5. Use of PowerPoint
6. Use of Coral draw for posters
7. Use of NCBI BLAST Tool.
8. Pairwise and Multiple Sequence Alignment and Phylogeny.
9. Classification of Proteins using CATH/SCOP.
10. Visualization PDB Molecules using Rasmol/Raswin.
11. Isolation and visualization of Genomic DNA by AGE (Bacteria and Yeast).
12. Quantitative estimation of DNA by DPA method
13. Quantitative estimation of RNA by Orcinol method
14. Problems on Restriction Enzyme Digestion
15. Problems on PCR
16. RFLP- Kit Based.
17. Primer Designing through Open Online Source NCBI- BLAST.
18. Study of Chromosomal Aberrations-Normal male and female and Syndromes- Trisomy 21 Trisomy13 Trisomy 18, Klinefelter and Turner, Cri-du-Chat and Philadelphia chromosome
19. Induction of Polyploidy by PDB Treatment using Suitable Plant Material.

EVALUATION SCHEME

The performance of the learner shall be evaluated into TWO Parts.
The learner's performance shall be assessed by Internal Assessment of **40 Marks** and Semester End Examination (theory) of **60 Marks for each term**.
Practical examination will be conducted at end of each semester for **300 Marks**.
The allocation of marks for the Internal Assessment and Semester End Examinations are as follows:-

Internal Assessment – 40 Marks
There will be **two** internal assessment tests:

Sr. No.	Particulars	Marks
1.	Internal Assessment 1 - Centralized	20 Marks
2.	Internal Assessment 2 - Departmental	20 Marks
	TOTAL	**40 Marks**

Semester End Examination – 60 Marks

Sr. No.	Particulars	Marks
	All questions are compulsory Number of questions – 4 (Four) Each question carries 15 Marks	
1.	Q1 – Unit I a. Answer in one sentence (any three out of five) b. Short notes (any three out of five)	 3 Marks 12 Marks
2.	Q2 – Unit II a. Answer in one sentence (any three out of five) b. Short notes (any three out of five)	 3 Marks 12 Marks
3.	Q3 – Unit III a. Answer in one sentence (any three out of five) b. Short notes (any three out of five)	 3 Marks 12 Marks
4.	Q4 – Short notes based on Unit I, II and III (any three out of five)	15 Marks
	TOTAL	**60 Marks**

References

1. Ahluwalia, V. K. (2009). Green chemistry: environmentally benign reaction. Ane Books Pvt. Ltd.
2. Ahluwalia, V. K., & Aggarwal, R. (2001). Organic synthesis: special techniques. CRC Press.
3. Alberts B, Johnson A, Lewis J, et al. Molecular Biology of the Cell. 4th edition. New York: Garland Science; 2002.
4. Ananthanarayan, R. (2013). Textbook of microbiology. University Press (India).
5. Ananthanarayan, R., & Paniker, C. K. Jayaram.(2009). Textbook of Microbiology. Universities Press (India) Pvt. Ltd. Hyderabad, India. ISBN, 978(81), 7371.
6. Arora, P. N., & Malhan, P. K. (2010). Biostatistics (2010 Edition). Himalaya Publishing House.
7. Atkins, R. C., & Carey, F. A. (1997). Organic chemistry: a brief course (p. 362). New York: McGraw-Hill.
8. Attwood, T. K., & Parry-Smith, D. J. (2003). Introduction to bioinformatics. Prentice Hall.
9. Baliga, K., et. al. College Analytical Chemistry, T.Y.B.Sc (Mumbai University). Himalaya Publishing House.
10. Basotia, G. R., & Sharma, K. K. (1999). Handbook of Entrepreneurship Development: an Entrepreneur's Guide to Planning Starting Developing and Managing a New Enterprise. Mangal Deep Publications.
11. Beat, J., Elliott, E., Baur, L., & Keena, V. (2002). Scientific Writing-Easy when you know how. The BMJ Publishing Group.
12. Beiser, A. (2003). Concepts of modern physics. Tata McGraw-Hill Education.
13. Bruckner, R. (2001). Advanced organic chemistry: reaction mechanisms. Elsevier.
14. Buckingham, L. (2007). Flaws. Molecular Diagnostics (Fundamentals, Methods, Clinical Applications), FA Davis Company.
15. Carruthers, W., & Coldham, I. (2015). Modern Methods of Organic Synthesis South Asia Edition. Cambridge University Press.
16. Casida, L. E., & Casida, L. E. (2005). Industrial microbiology. New Age International (P) Limited Publishers.
17. Coleman, W. B., & Tsongalis, G. J. (Eds.). (2006). Molecular diagnostics: for the clinical laboratorian. Springer Science & Business Media.
18. Conn, E., & Stumpf, P. (2009). Outlines of biochemistry. John Wiley & Sons.
19. Corey, E. J. (1991). The logic of chemical synthesis. John Wiley & Sons.
20. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2017). Essential immunology. John Wiley & Sons.
21. Dewick, P. M. (2006). Essentials of organic chemistry: for students of pharmacy, medicinal chemistry and biological chemistry. John Wiley & Sons.
22. Dey, S. (2000). Business Communication. Reliable Publications, Mumbai.
23. Frobisher Jr, M. (1953). Fundamentals of microbiology. (Edn 5). W. B. Saunders Co.
24. Goldsby, R. A., Kindt, T. J., Osborne, B. A., & Kuby, J. (2003). Immunology. 5th. New York: WH Freeman, 23(551), 70.
25. Gowariker, V. R., Viswanathan, N. V., & Sreedhar, J. (1986). Polymer science. New Age International.
26. Habraken, J. W. (2003). Absolute beginner's guide to networking. Que Publishing.
27. Jain, J. L. (2004). Fundamentals of biochemistry. S. Chand.
28. Karp, G. (2009). Cell and molecular biology: concepts and experiments. John Wiley & Sons.
29. Khopkar, S. M. (1998). Basic concepts of analytical chemistry. New Age International.
30. Kobe, K. A. (1957). Unit operations of chemical engineering (McCabe, WL, and Smith, JL). ACS Publications.

31. Kothari, C. R. (2004). Research methodology: Methods and techniques. New Age International.
32. Kulkarni, S. K. (2015). Nanotechnology: principles and practices (p. 403). Berlin, Germany:Springer.
33. Kurup, M.R. (1990). Towards Entrepreneurship. Bombay Kelkar Edu. Trust.
34. Lehninger, A. L. (2005). Lehninger Principles of Biochemistry: David L. Nelson, Michael M. Cox. W. H. Freeman.
35. Mahajan, B. K. (2002). Methods in biostatistics. Jaypee Brothers Publishers.
36. Mendham, J. (2006). Vogel's textbook of quantitative chemical analysis. Pearson Education India.
37. Mittal, P., Anand. J. (2007). A Textbook of Sounds. Har Anand Publications.
38. Modi, H.A. (2009). Fermentation Technology, Volume-II. Pointer, Jaipur.
39. Morisson, R. N., & Boyd, R. N. (1973). Organic Chemistry, Vol. 2. Allyn and Bacon, Inc. Boston, Massachusetts, 73.
40. Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2015). Medical microbiology. Elsevier Health Sciences.
41. NCERT Physics Textbook, Class XII.
42. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). Lehninger principles of biochemistry. Macmillan.
43. Owen, J. A., Punt, J., & Stranford, S. A. (2013). Kuby immunology (p. 692). New York: WH Freeman.
44. Park, T. K., & Talaro, A. (1999). Foundations in Microbiology. McGraw-Hill.
45. Patel, A. H. (2007). Industrial microbiology. Macmillan Publishers India
46. Patrinos, G., & Ansorge, W. (2009) Molecular Diagnostics. Academic Press.
47. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (2001). Text book of microbiology. MC Graw-Hill publications, 5th edn, New York, 1193, 504-508.
48. Pierce, B. A. (2012). Genetics: A conceptual approach. Macmillan.
49. Pillai, S. O. (1994). Solid State Physics: Structure and Electron Related Properties. Wiley Eastern Limited.
50. Prieve, D. (2000). Unit Operation of Chemical Engineering. Notes.
51. Raghuraman, K., Prabhu, D.V., & Sathe, P.A. Basic Principles in Analytical Chemistry Sem-III & IV(Mumbai University), Sheth Publishers.
52. Rajaraman, V., & ADABALA, N. (2014). Fundamentals of computers. PHI Learning Pvt. Ltd.
53. Rangan, C. S., Sarma, G. R., & Mani, V. S. V. (1983). Instrumentation: devices and systems. Tata McGraw-Hill.
54. Rao, C. V. (2005). Immunology: A textbook. Alpha Science Int'l Ltd.
55. Rao, R., et. al. College Organic Chemistry, T.Y.B.Sc (Mumbai University), Himalaya Publishing House.
56. Rastogi, S. C., Rastogi, P., & Mendiratta, N. (2008). Bioinformatics Methods and Applications: Genomics Proteomics and Drug Discovery 3Rd Ed. PHI Learning Pvt. Ltd.
57. Robertis, D. (1987). Cell and molecular biology. 8th edition. B.I. Waverly, 1995.
58. Russell, P. J. (2009). IGenetics-A Molecular Approach. Pearson Education India.
59. Russell, P. J., & Gordey, K. (2002). IGenetics (No. QH430 R87). San Francisco: Benjamin Cummings.
60. Salle, A. J. (1973). Fundamental principles of bacteriology (Vol. 7). New York: McGraw-Hill.
61. Satyanarayan, U., & Chakrapani, U. (2013). Textbook of Biochemistry. Elsevier Health Sciences.
62. Scragg, A. H. (2005). Environmental biotechnology. New York: OXFORD university press.
63. Singh, V. (2011). Handbook of Science Communication. ABD Publishers.

64. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of instrumental analysis. Cengage learning.
65. Smith, M. B. (2008). Reagents for Organic Synthesis: Collective Index for (Vol. 1). John Wiley & Sons.
66. Smith, M. B., & March, J. (2007). March's advanced organic chemistry: reactions, mechanisms, and structure. John Wiley & Sons.
67. Srivastava, M.L. (2007). Bioanalytical techniques. Alpha Science International Ltd.
68. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). Principles of fermentation technology. Elsevier.
69. Stanier, Y., Adelberg, E. A., & Ingraham, J. L. (1977). General microbiology. Macmillan India.
70. Subrahmanyam, N., Lal, B., & Avadhanulu, M. N. (2015). A Text Book of Optics (me). S. Chand.
71. Thakur, I. S. (2011). Environmental biotechnology: basic concepts and applications. New Delhi: IK International.
72. Tortora, G. J., Funke, B. R., Case, C. L., & Johnson, T. R. (2007). Microbiology: an introduction (Vol. 9). San Francisco, CA: Benjamin Cummings.
73. Upadhyay, A. (2009). Biophysical chemistry. Himalaya Publishing House.
74. Verma, H. C. (1992). Concepts of Physics, Vol. I. Bharati Bhawan.
75. Verma, H. C. (1999). Concept of physics part 2. Bharati Bhawan.
76. Viswanathan, B. (2009). Nano Materials. Alpha Science.
77. Voet, D., & Voet, J. G. (2004). Biochemistry. John Wiley & Sons.
78. White, A., Handler, P., Smith, E. L., Hill, R. L., & Lehman, I. R. (1978). Principles of Biochemistry. McGraw-Hill Publications.
79. Willey, J. M., Sherwood, L., & Woolverton, C. J. (2008). Prescott, Harley, and Klein's microbiology. New York: McGraw-Hill Higher Education.
80. Wilson, K., & Walker, J. (Eds.). (2000). Principles and techniques of practical biochemistry. Cambridge University Press.

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