Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Department of Biotechnology

Curriculum

For the Academic Year 2019-20

Under CBCS

Two Year Degree Programme in Biotechnology

(Four Semester Programme)

(CC/DSE/SEC)

PG First Year

Semester I and II

Syllabus Approved by Board of Studies in Biotechnology with effect from June, 2019

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Biotechnology

1. Introduction:

Biotechnology is technology based on biology - biotechnology harnesses cellular and biomolecular processes to develop technologies and products that help to improve our lives and health of our planet. Taking into consideration of the importance of Biotechnology, Rajarshi Shahu Mahavidyalaya, Latur (Autonomous), have taken an initiative to introduce a new emerging field as a Post Graduate Programme in Biotechnology under the Faculty of Science. M.Sc. Biotechnology is a Two year Post Graduate degree program which is started in the academic year 2005-06.

The syllabus was designed according to employability needs in the field of biotechnology. After designing syllabus, we have taken online feedback on curriculum from the academia and Industry expert. The feedback is analyzed, recommendation is reviewed and necessary changes are made in the syllabus by members of BOS. The Board of Studies in biotechnology follows the systematic process in design and development of the curriculum. In the design and development of curriculum, the regulation and guidelines of curriculum frame work stipulated by apex bodies such as Parent University, State Government guidelines and UGC. The programme outcome is given in the curriculum and displayed on college website so that students can look for it before taking admission. The learning objectives and course outcome of course are given in the syllabus of respective course and communicated to students at the beginning of programme.

2. Title of the Programme: **M.Sc. Biotechnology**

3. Learning Objectives of the Programme:

The main objective is to create biologically and technologically skilled minds for the understanding theoretical and practical knowledge essential for implementation from LAB to LAND further it will useful to find the solutions of various interacting biological phenomenon. It helps effectively to inculcate scientific temper and social attitude to solve various problems in the field of science.

The member of Board of Studies from various organizations of repute has a strong recommendation for job oriented syllabus to be included. Accordingly, the necessary changes have been effectively implemented in Curriculum.

4. Programme Specific outcomes/ Programme Outcomes:

At the end of the program the student will be able to

- integrate basic principles of common analytical techniques of protein molecular structures to engage in hands-on practices for implementation of such techniques to facilitate the development of biopharmaceutical manufacturing.

- induce the understandings of basic principles of process units operations of industrial products with hands-on practices for implementation of such techniques to facilitate the development of biopharmaceutical manufacturing.
- gain fundamental knowledge of molecular biotechnology, protein expression, and structural biology for the development of new products having clinical application.
- plan, conduct, execute and write-up a proposal of original research Practical skills.
- integrate fundamental concepts of leadership, entrepreneurship and innovation, financial decision making and marketing to business enterprises.
- equip the students with the skills required for carrying out research in cutting edge areas of life sciences
- make the students competent for dealing with the future problems and challenges of regional and global interest in overall development of society
- promote the entrepreneurship for self-growth and sustainability with the aim of promoting lab to land practices in, clinical, agriculture, food, nano and animal biotechnology

5. Local, Regional and Global relevance of Syllabus:

Curriculum developed and implemented have relevance to the local, regional and global developmental needs which is reflected in Programme Specific Outcomes/ Programme Outcomes and Course Outcomes of the Programmes offered by the College.

Global and local focus has slowly shifted to using knowledge of life Science for innovative technology development that is being used for betterment of human life. Many fundamental and advanced research fields come under the umbrella of Biotechnology e.g. Biochemistry, Animal Biotechnology and Immunology and Immuno-techniques etc.

6. Duration of the Course: **Two years**

7. Eligibility of the Course: **B.Sc. Science**

8. Strength of the Students: **90**

9. Fees for Course: **As per University/College rules.**

10. Admission / Selection procedure: **Admission by merit through Registration**

11. Teacher's qualifications: As per UGC/University/College rules

12. Standard of Passing: As per UGC/University/College rules

13. Nature of question paper with scheme of marking:

As per UGC/University/College rules

14. List of books recommended: Included in syllabus

15. Laboratory Equipment's, Instruments, and Measurements etc.:

The department of biotechnology has well equipped laboratories with all necessary and advance instrumentation facility.

16.Rules and regulations and ordinance if any: As per UGC/University/College rules

17. **Course duration:** Each theory course is of 60 Contact hours

18. **Medium of the language:** English

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Biotechnology
Choice Based Credit System
Course Structure of M.Sc. Biotechnology First Year

M. Sc. I [Biotechnology] Semester I

Code No.	Course Title	Hours/ Week	Marks (100)		Credits	Marks
			In Sem	End Sem		
P-CCB-134	Cell and Cancer Biology	04	40	60	04	100
P-BIO-135	Biochemistry	04	40	60	04	100
P-MIP-136	Microbial Physiology	04	40	60	04	100
P-BIB-137	Bioinstrumentation and Biostatistics	04	40	60	04	100
P-LAC-138	Lab Course I	04	20	30	02	50
P-LAC-139	Lab Course II	04	20	30	02	50
P-LAC-140	Lab Course III	04	20	30	02	50
P-LAC-141	Lab Course IV	04	20	30	02	50
	Total Credits/Marks	**32**			**24**	**600**

M.Sc. I [Biotechnology] Semester II

Code No.	Title of the Course	Hours/ Week	Marks (100)		Credits	Marks
			In Sem	End Sem		
P-MOB-232	Molecular Biology	04	40	60	04	100
P-IMI-233	Immunology and Immunotechniques	04	40	60	04	100
P-ANB-234	Animal Biotechnology	04	40	60	04	100
P-BIE-235	Bioprocess Engineering	04	40	60	04	100
P-LAC-236	Lab Course V	04	20	30	02	50
P-LAC-237	Lab Course VI	04	20	30	02	50
P-LAC-238	Lab Course VII	04	20	30	02	50
P-LAC-239	Lab Course VIII	04	20	30	02	50
P-Sem-240	Seminar	O3	50		02	50
	Total Credits/Marks	**35**			**26**	**650**

Rajarshi Shahu Mahavidyalaya, Latur
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M.Sc. Biotechnology (Semester Pattern)
I Semester

Course Title: Cell and Cancer Biology **Course Code: P-CCB-134**
Marks: 100 **Lectures: 60** **Credit: 04**

Learning Objectives:

- To understand the structures and functions components of cell organelles.
- To know the communication between cells and related cell signaling.
- To understand the basics of cell cycle and cell division.
- To understand cellular and molecular aspects of cancer

Course Outcomes:

On the successful completion of the course, students will be able to-

- describe cell organelles and related functions of the cell.
- understand the cell signaling concepts and its significance.
- explain the process of cell division and cell cycle.
- understand and interpret the cellular and molecular aspects of cancer

Unit I: **(18 L)**

Structural and functional cell biology

Cell as the basic unit of life, History & Evolution, cell theory, Structural organization of prokaryotes and eukaryotes. Structure and function of Cell organelles, Compartmentalization of higher cells, Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. Structure& function of cytoskeleton and its role in motility, Cellular trafficking.

Unit II: **(14L)**

Cell Signaling

General principles of cell signaling, signaling by soluble extracellular molecules: Endocrine, paracrine or autocrine. Signal transduction pathways (Signaling via G-Protein-linked, protein tyrosine & developmental) second Messengers, regulation of signalling pathways. Bacterial and plant two component systems, light signaling in

plants, bacterial chemotaxis and quorum sensing. Cell-cell interactions and cell matrix interaction.

Unit III: (12L)

Cell differentiation

Cell lineages, Cell differentiation: Cortical differentiation, nuclear differentiation, differentiation of erythrocytes.

Unit IV: (16L)

Cell division and cancer biology

Mechanism of cell division mitosis, meiosis and genetic recombination; regulation of cell cycle;factors and genes regulating cell cycle.Cancer and the cell cycle, Origin and terminologies, Difference between normal and cancer cells, malignant transformation of cells, Apoptosis, Biochemistry of cancer, molecular biology of cancer, anticancer therapy.

Recommended Textbooks and References:

1. Lodishet al. (2004). Molecular Cell Biology (Scientific American Book)
2. Alberts et al. (2002). The Biology of the Cell
3. Cooper &Hausman. (2004). The Cell – A Molecular Approach
4. De Robertis, E.D.P. and Robertis, E.M.F. (1991). Cell and molecular biology. Lea and Febiger
5. David Sadava(1993): Cell and Molecular biology- Jones & Bartlett Publishers
6. Gerald Karp (1993): Cell & molecular biology -: John Wills
7. EB Wilson (1896). The Cell in Developmental and Inheritance-, MacMilan New York
8. F T logo (1987)FertilizationChapman and Hall.
9. LP Freedman (1998)Molecular Biology of Steroid and Nuclear Hormone Receptors. Springer Verlag
10. J. Sambrook (2001).Molecular Cloning: a Laboratory Manual -CSHL Press,
11. T.A.Brown (2006).Genomes – Garland Science

Rajarshi Shahu Mahavidyalaya, Latur
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M.Sc. Biotechnology (Semester Pattern)
I Semester

Course Title: Lab Course I **Course Code: P-LAC-138**
Marks: 50 **Credit: 02**

Learning Objectives:

- To understand different cells and cell diversity.
- To understand the structures and purposes of basic components of cells.
- To understand cell division in plants and animals.
- To help in understanding the basics of cell organelles with practical experience.

Course Outcomes:

On the successful completion of the course, students will be able to-

- separate and characterize subcellular components of cells.
- Use cellular techniques in research and diagnostics.
- identify and describe the cellular structure of organs and tissues from prepared slides, and outline the principles of histochemical staining.
- perform experimental techniques as instructed making accurate observations; record, analyze and interpret data.

Practicals:

1. Cellular diversity
2. Cellular permeability
3. Study of Mitosis (root tips)
4. Study of Meiosis (anthers)
5. Study of karyotypes.
6. Isolation of chloroplast.
7. Analysis of chlorophyll amount by Spectrophotometer.
8. Isolation and Vital stanning of Mitochondria.
9. Vital staining of lipid and glycogen bodies.
10. Cell types of plants- Microtomy/ maceration of various tissue explants and dentification.
11. Buccal smear- Identification of Barr body.

Rajarshi Shahu Mahavidyalaya, Latur
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M.Sc. Biotechnology
I Semester

Course Title: Biochemistry **Course Code: P-BIO-135**
Max. Marks: 100 **Lectures: 60** **Credits: 04**

Learning Objectives:

- To learn about the importance of bioenergetics, buffers and biological interactions.
- To study structure, classification and functional importance of Biomolecules.
- To study fundamentals of structures and interactions present in various biomolecules that help in functioning and organization of living cell.
- To understand biochemical pathways for synthesis and breakdown of complex biomolecules and metabolic disorders that arises out of malfunction of metabolic pathways.

Course Outcomes:

On the successful completion of the course, students will be able to-

- describe redox couples and redox potentials.
- demonstrate the structural and functional role of biomolecules essential for cellular reactions.
- know how the simple precursors give rise to large biomolecules such as proteins, carbohydrates, lipids and nucleic acids.
- explain the physiological significance of anabolic and catabolic pathways used to drive cellular functions.

Unit I:

(12L)

Carbohydrates

Introduction, biological importance. Definition, Classification, Monosaccharides other than glucose, glycosidic bond, disaccharides, polysaccharides [starch, glycogen, peptidoglycan, proteoglycan matrix.

Thermodynamics and Biological Interactions

Structure of atom, Molecules, weak interaction stabilizing biomolecules, Henderson-Hasselbach equation pH, pK, buffers. Thermodynamics principles energy rich bond.

Unit II: **(12L)**

Lipids

Lipids: Introduction, Classes, Fatty acids [Physical properties and Chemical properties- Sap value, acid value, iodine number, rancidity]. Glycerolipid, Sphingolipid, cholesterol.

Unit III: **(16 L)**

Nucleic acids and Amino Acids

Nucleic acids: Nucleosides, nucleotides, Polynucleotide, DNA and its different forms [A, B, C, D, E and Z], RNA and its types. Chargoffsrule, Forces stabilizing nucleic acid structure. Properties of nucleic acid-denaturation and renaturation, hyperchromism

Amino acids: Structure and classification. Properties of amino acids-colour reactions, Zwitterions

Unit IV **(10L)**

Protein structure

Conformation of proteins (primary, secondary, super secondary, Tertiary and quaternary domains) Peptide bond, Forces stabilizing secondary structure, Ramachandran plot, examples of quaternary structure.

Unit V **(10)**

Enzymes: Basic concept, active site, energy of activation. Transition state hypothesis, Lock and key hypothesis, induced fit hypothesis. Enzyme classification.

Co-enzymes: Thiamine, riboflavin.

Recommended Textbooks and References:

1. Jain, J.L., Jain, S. and Jain, N.,(2005), Fundamentals of Biochemistry, S. Chand and Company Ltd.
2. Nelson, D.L., Cox, M.M. Lehninger. (2004). Principles of Biochemistry 4th edition Pub.WH Freeman Co.
3. Berg JM, Tymoczko JL and Stryer L, (1995). Biochemistry 4th Edition, WH Freeman and Company.
4. Voet, D., Voet J.G. (2004). Biochemistry 2ndEdition,John Wiley & Sons, Inc.
5. Zubey, G.L. Parson, W.W., Vance, D.E. (1994). Principles of Biochemistry WmC Brown publishers. Oxford
6. Conn and Stumpf(1967). Outlines of Biochemistry, New York Wiley
7. Plummer DT (1988). An Introduction to Practical Biochemistry, Tata McGraw-Hill Publishing Company Limited.

8. Kuchel, P.W., Ralston Schaums, G.B.(2003). Outlines of Biochemistry 2nd edition Pub: Tata.
9. Elliott, W.H., Elliott, D.C. (2005). Biochemistry and Molecular Biology 3rd Indian edition, Pub.Oxford press.

Rajarshi Shahu Mahavidyalaya, Latur
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M.Sc. Biotechnology
I Semester

Course Title: Lab course II **Course Code: P-LAC-139**
Marks: 50 **Credit: 02**

Learning Objectives:

- To teach how to prepare standard solutions and Buffers.
- To make understand to analyze the given Biomolecules qualitatively and quantitatively.
- To understand how to analyze biomolecules by separation techniques.
- To understand qualitative estimation of biomolecules.

Course Outcomes:

On the successful completion of the course, students will be able to-

- prepare different solutions and buffers.
- estimate the unknown concentration of Biomolecules
- use current biochemical techniques to plan and carry out experiments.
- analyze biomolecules by separation techniques

Practicals:

1. Preparation of solutions of given normality and its standardization
2. PH meter: buffering capacity of a buffer, Indicators. To determine the pKa value and hence the dissociation constant of a given acid by using pH meter.
3. Colorimetry: To determine the dissociation constant of a given indicator colorimetrically and to prepare the buffer solutions in the pH range of 2.2 to 8.0
4. Thin layer chromatography: lipids, mixture of dyes.
5. Spectrophotometry: Double beam and recording Spectrophotometry.
6. Spectrophotometer: Estimation of protein by Lowry, Biuret and Bradford methods.

7. Enzyme assays Invertase, time, temperature, and cofactors. Km and Vmax, Various kinetic plots.
8. Polyacrylamide gel electrophoresis: Native gel.
9. SDS-PAGE of proteins.
10. column chromatography.

Rajarshi Shahu Mahavidyalaya, Latur
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M.Sc. Biotechnology (Semester Pattern)
I Semester

Course Title: Microbial Physiology **Course Code: P-MIP-136**
Marks: 100 **Lectures: 60** **Credit: 04**

Learning Objectives:

- To study and understand the microbial world and its diversity.
- To understand pure culture techniques and media required for microbial growth.
- To learn bacterial growth curves and kinetics
- To acquire knowledge on basic aspects of bacterial respiration and photosynthesis.

Course Outcomes:

On the successful completion of the course, students will be able to-

- describe basic structure and functions of microbesand relationship to the environment.
- get acquainted with pure culture techniques.
- explain microbial growth kinetics.
- describe bacterial metabolism.

Unit I: **(17 L)**

Beginning of Microbiology

Discovery of the microbial world by Antony van Leeuwenhoek; Controversy over spontaneous generation, Role of microorganisms in transformation of organic matter and in the causation of diseases; Development of pure culture methods; Enrichment culture methods, developments of microbiology in the twentieth century.

Knowing of Microbial world: Bacteria: Purple and green bacteria, cyan bacteria, Homoacetogenic bacteria. Acetic acid bacteria, Budding and appendaged bacteria, Spirilla, Spirochetes, Sheathed bacteria, Pseudomonads; Lactic and propionic acid bacteria, Endospore forming rods and cocci, Mycobacterium, Rickettsias, Chlamydias and Mycoplasma.

Archaea: Halophiles, Methanogens, Thermoplasma, Ferroplasmaand Hyperthermophilic archaea.

Eukarya: Algae, Fungi, Slime moulds and Protozoa.

Viruses: Bacterial Plant. Animal and Tumor viruses; Viroids and Prions.

Unit II : **(13 L) Pure Culture t**

Pure culture techniques, Theory and practice of sterilization, Enrichment culture techniques. New approaches to bacterial taxonomy classification including Ribotyping; Ribosomal RNA sequencing; Taxonomy, Nomenclature and Bergey's Manual.

Unit III: **(14 L)**

Microbial Growth

The definition of growth, mathematical expression of growth, growth curve, measurement of Growth and growth yields; Synchronous growth: Continuous culture; Growth as affected by Environmental factors like temperature, acidity, alkalinity, water availability and oxygen; Culture collection and maintenance of cultures.

Unit IV: **(16 L)**

Overview of Basic Metabolism and Microbial Nutrition

Metabolic Diversity among Micro-organisms Photosynthesis in microorganisms; Role of Chlorophylls, carotenoids and phycobilins; Calvin cycle; Chemolithotrophy; Hydrogen - iron - nitrite - oxidizing bacteria; Nitrate and sulfate reduction; Methanogenesis and acetogenesis: Fermentations - diversity, syntrophy

Recommended Textbooks and References:

1. Stainer, R. Y. Ingraham, E. A. Adelberg. (1999), General Microbiology, 4th Edition, The MacMillan Press Ltd.
2. M.T. Madigan, J. M. Martinko, Brock. (2010), Biology of Microorganisms, 13th Edition, Benjamin Cummings Ltd.
3. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. (2002), Microbiology, 5th Edition, Tata McGraw Hill.
4. Maloy, S.R., Cronan, J.E. Jr. and Freitelder, D. Jones. (1994), Microbial Genetics, 2nd Edition, Bartlett Publishers.
5. Cappuccino, J.G. and Sherman, N. Addison Wesley. (2014), Microbiology - A Laboratory Manual, 10th Edition,
6. Benson, H.J. WCB: Wm C. (2014), Microbiological Applications (A Laboratory Manual in General Microbiology), 13th Edition, Brown Publishers.

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
M.Sc. Biotechnology (Semester Pattern)
I Semester

Course Title: Lab Course III **Course Code: P-LAC-140**
Marks: 50 **Credit: 02**

Learning Objectives:

- To learn media preparation and sterilization
- To study isolation and maintenance of Microorganism.
- To provides hands-on pure culture and staining technique
- To study growth curve and effect of environmental factors on the growth of microorganisms.

Course Outcomes:

On the successful completion of the course, students will be able to-

- prepare solid and liquid media.
- isolate microbes by using pure culture techniques
- characterize microbes Morphologically and Biochemically
- perform growth kinetics

Practicals

1. Preparation of liquid and solid media for growth of microorganisms.
2. Isolation and maintenance of organisms by plating, streaking and serial dilution Methods. Slants and stab cultures. Storage of microorganisms.
3. Isolation of pure cultures from soil and water.
4. Bacterial Growth: Growth curve.
5. Measurement of bacterial population by turbidometry and serial dilution methods.
6. Effect of temperature, pH and carbon sources on growth.
7. Microscopic examination of microorganisms and study of organisms by Monochrome staining, Negative Staining and Gram staining.
8. Assay of Antibiotics

9. Analysis of water for portability and determination of MPN.
10. Biochemical characterization of selected microbes.

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M.Sc. Biotechnology (Semester Pattern)

I Semester

Course Title: Bioinstrumentation and Biostatistics

Course Code: P-BIB-137

Marks: 100 **Lectures: 60** **Credit: 04**

Learning Objectives:

- To understand analytical techniques and equipment used in biological sciences.
- To understand the basic principle and applications of microscopy and centrifugation.
- To acquire knowledge on the Chromatographic and electrophoretic method for the separation of biological molecules.
- To study statistical methods pertaining to life sciences

Course Outcomes:

On the successful completion of the course, students will be able to-

- apply analytical techniques in the field of biological sciences.
- acquaint the knowledge of microscopy and centrifugations techniques.
- get proficiency in chromatography and spectroscopy techniques.
- analyze the biological data using statistical tools

Unit-I **(13 L) Microscopy, Ce**

Light microscope, Fluorescence microscope, Phase contrast microscope, Electron microscope, confocal microscopy.

Centrifugation: Principle of centrifugation, small bench top centrifuges, large capacity refrigerated centrifuges, High speed refrigerated centrifuges, preparative and analytical ultra-centrifuge. **Electrochemical techniques:** Principles of electrochemical techniques, redox reactions, the pH electrode, ion-sensitive and gas-sensitive electrodes, The Clark oxygen electrode, Biosensors.

Unit-II **(15 L) Chromatograph**

Principles of chromatography, Types of Chromatography: Paper chromatography, thin layer Chromatography, size exclusion, Ion exchange, Affinity chromatography, High

performance liquid chromatography (HPLC), Gas liquid chromatography (GLC), Reverse Phase Chromatography, Mass Spectrometry, GC-MS and LC-MS.

Electrophoresis General principles, Electrophoresis of proteins: SDSPAGE, Native gels, Gradient gel, Isoelectric focusing, 2-D gel electrophoresis (2-D PAGE), cellulose acetate electrophoresis, continuous flow electrophoresis; Detection, estimation and recovery of proteins, Electrophoresis of nucleic acids: Agarose gel electrophoresis of DNA, DNA sequencing gels, Pulse field gel electrophoresis, electrophoresis of RNA, Capillary electrophoresis.

Unit-III: (11 L) Spectroscopy

Properties of electromagnetic radiation, interaction with matter. Gamma ray spectroscopy, X-ray spectroscopy, UV and Visible spectroscopy, Infrared and Raman spectroscopy, Electron spin resonance spectroscopy, Nuclear magnetic resonance spectroscopy, Circular dichorism spectroscopy, Atomic spectroscopy. Lasers, Spectrofluorimetry, Luminometry, turbidometry and nephelometry.

Unit-IV: (11 L) Radioactivity

The nature of radioactivity, detection and measurement of radioactivity: detection based on gas ionization- Geiger Muller counter- principles and applications. Detection based on excitation- Liquid Scintillation counter-principle and applications. Supply, storage and purity of radiolabelled compounds, specific activity, inherent advantages and restrictions of radiotracer experiments, safety aspects, applications- of radio isotopes in biological sciences.

Flow cytometry, ELISA, Immunoblotting

Crystallization of biomolecules: Introduction to X-ray crystallography.

Unit-V (10 L) Biostatistics

Brief description and tabulation of data and its graphical representation, Measurement of central tendency and dispersion- mean, mode, median, range, Mean deviation, standard deviation, variance. Idea of two types of errors and level of significance. Tests of significance- F-Test, and chi-square test. Linear regression and correlation.

Recommended Textbooks and References:

1. Avinash Upadhyay, Kakoli Upadhyay, Nirmalendu Nath(2009).Biophysical Chemistry,Himalaya Publishing House.
2. Keith Wilson (2005). Principles and Techniques of Biochemistry and Molecular Biology, 5thEd.s Cambridge University Press.
3. R.S. Khandpur (2004).Handbook of Biomedical Instrumentation.Tata McGraw Hill.
4. Cotrell(2002).Biophysics (Eastern Economy Edition)

5. P.Narayanan (2000).Clinical Biophysics: Principles and TechniquesBhalaniPub.,Mumbai.
6. Pattabhi and Gautham (2002).Biophysics,Narosa Publishing House.
7. R.S. Khandpur(2003).Handbook of analytical instruments Tata Mc Graw Hill.
8. Khan and Khanum (2018). Fundamentals of Biosatistics low price 3 rd. revised edition ; Ukaaz Publication.
9. S.P.Gupta (2014).Fundamental of Statistics. S. Chand publications.

Rajarshi Shahu Mahavidyalaya, Latur
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I Semester

Course Title: Lab Course IV **Course Code: P-LAC-141**
Marks: 50 **Credit: 02**

Learning Objectives:

- To Provide Hands-on Microscopy and Centrifugation techniques.
- To Provide Hands-on separation and purification of Biomolecules.
- To get expertise in Western Blotting and ELISA techniques used for analysis of proteins.
- To understand applications of statistical tools in analysis of biological data

Course Outcomes:

On the successful completion of the course, students will be able to-

- identify different specimens by using microscopy.
- separate and purify biomolecules.
- separate and identify biomolecules by using blotting techniques.
- interpret the biological data using statistical tools

Practicals

1. Practical's Based on Microscopy
2. Practicals based on centrifugation
3. Practical's Based on Electrochemical Techniques
4. TLC, Paper Chromatography
5. Separation of proteins / pigments using column/Affinity chromatography
6. Demonstration of techniques: gas chromatography high performance liquid
7. Chromatography HPLC
8. Electrophoresis Of DNA
9. Electrophoresis of proteins under native and denaturing conditions (PAGE)
10. To find out isoelectric point of amino acid
11. Western blotting
12. ELISA
13. Study of Lambert's & Beer's law
14. Absorption spectrum of protein
15. Problems based on Spectroscopy and Radioactivity
16. Problems Based on Biostatistics (Central Tendency, Dispersion, Correlation and Regression , Annova etc.)

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M.Sc. Biotechnology

II Semester

Course Title: Molecular Biology **Course Code: P-MOB-232**
Marks: 100 **Lectures: 60** **Credit: 04**

Learning Objectives:

- To understand genome organization in lower and higher organisms.
- To understand replication, mutation and repair events in both Prokaryotic and eukaryotic organisms.
- To understand central dogma of life and gene flow.
- To know gene regulation and its application.

Course Outcomes:

On the successful completion of the course, students will be able to-

- extend understanding of the molecular mechanisms via which genetic information is stored, expressed and transmitted among generations.
- understand the principles of inheritance at molecular level.
- understand the synthesis, structure, and function of nucleic acids replication in prokaryotes and eukaryotes.
- understand the flow of genetic information in populations and the relationship between genetics and evolutionary theory.

Unit I **(14 L)**

Genome organization:

Genome organization of Prokaryotes-Bacteria and virus system. Genome organization of Eukaryotes- Structure and types of chromosomes, chromatin and nucleosome, Variation in chromosome number, Concepts of ploidy, conditions and types of ploidy, variation in chromosome structure, Denaturation and Renaturation DNA, C-value paradox, Cot curve.

Unit II **(16 L)**

Genome replication:

DNA as genetic material, Genome Replication in prokaryote, various modes of DNA replication, enzymes involved, Initiation elongation and termination, Replication regulation in Eukaryotics, enzymes involved, Molecular basis of genome evolution: Mutations, causes types and effects, Hyper mutation, DNA Repair, Recombination: homologous, site specific, transposition

Unit III **(17 L)**

Transcription:

Initiation, elongation and termination, Post transcriptional processing of m-RNA, t-RNA, r-RNA.

Translation: Initiation, elongation and termination, post translational modifications of proteins- Chemical modification, intron splicing, protein folding and protein localization.

Gene regulation in prokaryotes: - Operon concept, Lactose, Tryptophan and Arabinose. Role of cAMP and CRP in lac operon, tryptophan operon, Catabolite repression

Gene regulation in eukaryotes: -Conserved mechanism, activation and repressor role in gene regulation. Gene Silencing , Signal Integration

Unit IV **(13 L)**

Basic concepts of developmental biology

Embryogenesis, organogenesis and morphogenesis. Study of molecular development of Drosophila, gene regulation. Molecular development of Arabidopsis as model organisms, Homeobox-gene expression, Role of RNAi in development.

Recommended Textbooks and References:

1. William S. Klug and Michael R. Cummins (2005) Concepts of Genetics (International Edition) Edition: Seventh Pearson.
2. T.A. Brown, (2002) Genome2 2nd EditionJohn Wiley.
3. Lodish, Berk-Freeman (2003) Molecular Biology 7th edition Pub. Molecular Biology of the Cell Macmillan publications.
4. Benjamin A. Pierce(2010) A conceptual Approach; 6th edition Genetics:
5. Albert Bruce, (2005) Molecular Biology of the Cell, Garland Science Publication.
6. T.A Brown, John Wiley (2006) Genetics a Molecular Approach,
7. Scott F. Gilbert (2003).Developmental Biology V ed Sinahauer associate Pub.
8. G.S.Miglani(2013).Developmental genetics, I.K.InternationalPub.

Rajarshi Shahu Mahavidyalaya, Latur
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M.Sc. Biotechnology
II Semester

Course Title: Lab course V **Course Code: P-LAC-236**
Marks: 50 **Credit: 02**

Learning Objectives:

- To provide Hands-on Nucleic acid isolation using various sources
- To study quantitative analysis of nucleic acids
- To provide Hands-on genome transformation.
- To study gene expression pattern

Course Outcomes:

On the successful completion of the course, students will be able to-

- develop skills in isolation and purification of genomic DNA, plasmid DNA and RNA.
- separate and purify nucleic acids based on charge.
- apply the skills of genome transformation in research.
- develop auxotroph's by using replica plating technique.

Practicals:

1. Genetic recombination (conjugation, transformation, tranduction) in bacteria.
2. Isolation of genomic DNA from bacteria, animal and plant cells.
3. Isolation of plasmid DNA by using alkaline lysis method.
4. Agarose gel electrophoresis by using DNA markers for molecular wt. determination.
5. Isolation of antibiotic resistant bacteria by gradient plate method.
6. Replica plating for transfer of bacterial colony.
7. Study of Hens embryo for developmental stage study.
8. Study of in vitro transcription and translation
9. Study of mutations: Ames test
10. Isolation of RNAs

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M.Sc. Biotechnology
II Semester

Course Title: Immunology and Immuno-techniques Course Code: P-IMI-233
Marks: 100 Lectures: 60 Credit: 04

Learning Objectives:

- To understand cells and organs of Immunology.
- To study basics of antigen, antibody and MHC molecules.
- To study clinical immunology with respect to various diseases.
- To study various immune-techniques of immunology.

Course Outcomes:

On the successful completion of the course, students will be able to-

- understand the working of cells and organs of Immunology.
- explain the properties of antigen, antibody and MHC molecules.
- discuss the clinical aspects of Immunology.
- describe various antigen-antibody reactions and their Significance.

Unit I **(14L)**

Overview of Immunology

The origin of immunology, Innate and Adaptive Immune response. Haematopoiesis, Cells of Immune system and their biological role. Humoral and cell mediated Immunity. Primary and Secondary immune responses. The Primary and secondary lymphoid organs.

Antigen Processing and Presentation: MHC molecules, Antigen processing and presentation (antigen presenting cells, endocytic, cytosolic pathway).

Cytokines and signal transduction. BCR and TCR (structure and properties), signal transduction.
Activation and Differentiation of B and T cells, Cytokines.

Unit II **(16L)**
Basics of Immunology

Antigen: Characteristics of antigen, types, Factors that Influence Immunogenicity, Epitopes, Haptens and the Study of Antigenicity, adjuvant and its types.Antigen

engineering for better immunogenicity, Antigenicity and Immunogenicity, The epitopes seen by B Cells and T Cells, Biology of superantigens.

Antibody: Discovery of antibody structure by chemical and enzymatic Methods. General Structure of antibody molecule, Function of antibody molecule. Affinity and Avidity, Valency of Antibody.Antibodies- Types, variation in structure of antibody and their biological significance. Organization and Expression of Immunoglobulin Genes, Generation of antibody diversity.

Antibody Antigen interactions: Strength of Antigen-Antibody Interactions, Cross-Reactivity.

Immunological reactions: Precipitation and Agglutination reactions, Radioimmunoassay, ELISA, Western Blotting, Flow cytometry and Fluorescence, Immunoprecipitation, Immunoelectron microscopy, chemiluminescence assay, CFT.Evolution of immune response in plants, insects and mammals.

Unit III **(15 L)**

Clinical Immunology

Lymphocyte Migration and Inflammation, Opsonization and Phagocytosis.Cell-mediated effector functions.

Complement system: Activation of Complement systems (alternative, classical & lectin pathway) and its Functions.

Hypersensitivity: Hypersensitivity reactions and its types.

Immunodeficiency Conditions: Immunodeficiency: Primary immunodeficiency (SCID), Secondary immunodeficiency (AIDS), Treatment of immunodeficiency diseases.

Autoimmunity: Organ specific autoimmune diseases andSystemic autoimmune diseases, Animal Models for Autoimmune Diseases, Treatment of Autoimmune Diseases, and Development of Immune tolerance.

Immunity to infectious diseases: Immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections.

Tumor Immunology: Tumor Antigens, Immune Response to Tumors, Cancer Immunotherapy

Unit IV **(15 L)**

Immunotechnology

Animal models and transgenic animals and their use in immunological studies.

Transplantation Technology: Types of graft (auto, Iso, Allo, and xeno graft), Specificity and memory of rejection response, Mechanisms involved in graft rejection (Bone marrow, Organ transplantation), General Immunosuppressive Therapy, Bone marrow chimera.

Vaccine Technology: Active and Passive Immunization, Live attenuated vaccines, subunit vaccines, conjugate vaccines, multivalent subunit vaccines, DNA vaccines, Recombinant vector vaccines, edible vaccines. Identifications of B and T epitopes for vaccine development.

Antibody engineering: Monoclonal antibody, Purification of antibodies, Catalytic Antibodies, Chimeric antibodies, phage display, large scale production of MAb antibodies, Applications of MAb in diagnosis and therapy.

Recommended Textbooks and References:

1. Kuby, Judy Owen, Jenni Punt, Sharon Stanford. (2007). Immunology, 8th Edition WH Freeman Publishers.
2. Kuby, Judy Owen, Jenni Punt, Sharon Stanford., (2003). Immunology, WH Freeman Publishers,5th Edition
3. Tizard, Ian R. (1995). Immunology- An Introduction, 4th edition, Saunders College Publishing, New Delhi.
4. Roitt I.(2017). Essential Immunology, 13 th edition, Blackwell Scientific Publications,
5. Abbas, Lichtman, Pillai (2017). Cellular & Molecular Immunology, Pillai. 6th ed. Elsevier publications.
6. Butterwort & Heinemann (1993). Cellular interactions & Immunobiology BIOTOL series.
7. Warren Levinson (2018). Review of Medical Microbiology & Immunology 9thed.Mac Graw Hill publications.
8. B. Hannigan.(2009).Immunology Viva books Pvt. Ltd.
9. K.R.Joshi, N.O. Osamo (2013). Immunology & Serology. Student edition.

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II Semester

Course Title: Lab course VI **Course Code: P-LAC-237**
Marks: 50 **Credit: 02**

Learning Objectives:

- To study basic immunological techniques.
- To study various antigen-antibody reactions.
- To study cells & organs of Immunology.
- To provide hands-on experiments of Hematology.

Course Outcomes:

On the successful completion of the course, students will be able to-

- deliberate diagnosis of disease with help of kit based practicals.
- describe structure of cells and organs of immunology using microscopy.
- identify the pattern of Ag – Ab interactions.
- Perform hematological experiments.

Practicals

1. Agglutination reaction
2. Latex agglutination
3. Immunoprecipitation
4. Radial immunodiffusion
5. Ouchterlony Double diffusion
6. Immunoelectrophoresis.
7. Rocket immunoelectrophoresis.
8. Crossed antigen-antibody electrophoresis.
9. Identification of thymus, spleen & lymph nodes.
10. Microscopic observation of lymphoid organs
11. Widal
12. VDRL
13. Conjugation of antibodies with Enzyme ELISA :
    i. Capture ELISA
    ii. Direct ELISA
14. Western blotting.
15. Immunofluorescence.
16. Radioimmunoassay.
17. complement fixation test
18. Purification of Immunoglobulin from serum

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Course Title: Animal Biotechnology **Course Code: P-ANB-234**
Marks: 100 **Lectures: 60** **Credit: 04**

Learning Objectives:

- To develop an understanding of current techniques used in biotechnology and their applications to animal sciences and the biomedical field.
- To understand transgenics and its application for human welfare.
- To understand basic cell culture and preservation techniques
- To understand the applications of Animal cell culture.

Course Outcomes:

On the successful completion of the course, students will be able to-

- acquaint fundamentals of Animal cell culture.
- utilize skills of cell culture for development of biomolecules of clinical importance
- describe the relevance of cell cycle regulations in reference to cellular metabolism
- understand the mechanism of cellular cytotoxicity.

Unit I: **(13 L)**

Cell Culture Laboratory Design and Equipements

Planning, construction and services; Layout; Sterile handling area; Incubation; Hot room; Air circulation; Service bench; Laminar flow; Sterilizer; Incubator; CO_2 incubator; Refrigerators and freezers; Centrifuge; Inverted stage microscope; Magnetic stirrer; Liquid nitrogen freezers; Slow cooling system for cell freezing; Water bath; Autoclaves and hot air oven; Pipette washers; Water purification system; Fluid handling systems and other equipments; Washing, packing and sterilization of different materials used in animal cell culture; Aseptic concepts; Maintenance of sterility; Cell culture vessels.

Unit II: **(15 L)**

Cell Culture Media and Reagents

Types of cell culture media; Ingredients of media; Physiochemical properties; CO2 and bicarbonates; Buffering; Oxygen; Osmolarity; Temperature; Surface tension and foaming; Balance salt solutions; Antibiotics, growth supplements; Foetal bovine serum; Serum free media; Trypsin solution; Selection of medium and serum; Conditioned media; Other cell

culture reagents; Preparation and sterilization of cell culture media, serum and other reagents.

Unit III **(12 L)**

Cell Culture Techniques

History of animal cell culture; Different tissue culture techniques; Types of primary culture;

Chicken embryo fibroblast culture; Chicken liver and kidney culture; Secondary culture; Trypsinization; Cell separation; Continuous cell lines; Suspension culture; Organ culture etc.; Behavior of cells in culture conditions: division, growth pattern, metabolism of estimation of cell number; Development of cell lines; Characterization and maintenance of cell lines, stem cells; Cryopreservation; Common cell culture contaminants.

Unit IV: **(12 L)**

Applications of Cell Culture

Cell cloning and selection; Transfection and transformation of cells; Commercial scale production of animal cells, stem cells and their application; Application of animal cell culture for in vitro testing of drugs; Testing of toxicity of environmental pollutants in cell culture; Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

Unit V: **(08 L)**

Scale up Technique

Cell culture reactors; Scale-up in suspension; Scale and complexity; Mixing and aeration; Rotating chambers; Perfused suspension cultures; Fluidized bed reactors for suspension culture; Scale-up in monolayers; Multisurface propagators; Multiarray disks, spirals and tubes; Roller culture; Microcarriers; Perfused monolayer cultures; Membrane perfusion; Hollow fiber perfusion; Matrix perfusion; Microencapsulation; Growth monitoring

Recommended Textbook and References:

1. Culture of Animal Cells(2005) 5th Edition, FreshneyWiley-Liss,

2. Animal Cell Culture - Practical Approach (2000), 3rd Edition, Ed. John R.W. Masters Oxford University Press
3. Animal Cell Culture Techniques. (1998). Ed. Martin ClynesSpringer,

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II Semester

Course Title: Lab Course VII **Course Code: P-LAC-238**
Marks: 50 **Credit: 02**

Learning Objectives:

- To develop an understanding of current techniques used in biotechnology and their applications to animal sciences and the biomedical field.
- To understand transgenics and its application for human welfare. Understand and discuss the social and ethical issues associated with biotechnology.
- To develop necessary skills in media preparation of ATC
- To learn about basics of Animal tissue culture

Course Outcomes:

On the successful completion of the course, students will be able to-

- aware about basic infrastructure and culture technique of ATC.
- learn to handle cell line History, scope, principle, merits and demerits of animal cell and tissue culture.
- learn the laboratory safety and biohazards
- apply the basic laboratory knowledge in research

Practicals:

1. Packing and sterilization of glass and plastic wares for cell culture.
2. Preparation of reagents and media for cell culture.
3. Primary culture technique for chicken embryo fibroblast.
4. Secondary culture of chicken embryo fibroblast.
5. Cultivation of continuous cell lines.
6. Quantification of cells by trepan blue exclusion dye.
7. Isolation of lymphocytes and cultivation of lymphocytes
8. Study of effect of toxic chemicals on cultured mammalian cells
9. Study of effect of virus on mammalian cells.
10. Suspension culture technique
11. Cryopreservation of cell primary cultures and cell lines.

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Course Title: Bioprocess Engineering **Course Code: P-BIE-235**
Marks: 100 **Lectures: 60** **Credit: 04**

Learning Objective:

- To understand the fluid statics and basic of bioprocess engineering.
- To understand basic idea of designing of Bioreactor, Growth and sterilization kinetics.
- To understand the measurement and control of Bioprocesses Parameters.
- To understand upstream and downstream processing techniques.

Course Outcome:

On the successful completion of the course, students will be able to-

- define a bacterium, a fungus, a virus and archaea, give examples of structurally different microbes, and list microbes by their energy metabolism and carbon sources.
- evaluate the cultivation, enrichment and growth prevention methods for microbes.
- explain the roles of microbes in elemental cycles on Earth and, the waste decontamination methods based on microbial activities.
- understand how microbes and enzymes could be applied in industry

Unit I: **(12 L)**

Basic Chemical Engineering calculations.

Material balance. Material balance with reactions. Material balance with recycle and purge. Energy balance. Enthalpy, specific heat, mean specific heat. Heat Balance. Heat of reaction and heat of solution. Material and Energy balance together.

Fluid statics: Classification of fluids, concept of Reynold's number, Rheological properties of fermentation process (Viscosity, cell concentration, product concentration etc), Fluid mechanics. Potential flow. Newtonian and non-Newtonian fluid (Bingham plastic, pseudo plastic, dilatants etc.), Heat and mass Transfer.

Unit II: **(13 L)**

Design of Fermentors and Sterilization Kinetics

Fermenters: Ideal Properties of Bioreactor, Components of the fermenters & their specifications: Body Construction, Agitator, Impeller, Baffles etc. Types of Bioreactors: (Packed-bed reactor, Air –lift, Trickle bed Photo bioreactors, Rotating Biological Reactors pneumatic) **Air & Media sterilization:**Air Sterilization Principles, Mechanisms of capture of particles in Air, Depth & Screen Filters, Sizing, Testing & validation of filters for air sterilization, Principle of Media Sterilization, Decimal reduction, Design of sterilization cycle using kinetics of thermal death of microbes and equipments used in sterilization: Batch & Continuous Quality Control, Quality assurance, Standard Operating Procedures (SOP) & Good Manufacturing Practices (GMP).

Unit III: (17L)

Media for large-scale processes & their optimization

Constituents of media, their estimation & quantification. Design of media. Costing of media. **Strain Improvement:**Isolation, Screening, Preservations and maintenance of Microorganisms, strain improvement, Mutagenesis, Genetic Engineering for Strain Improvement**. Development of inoculum** Types of Bioprocesses: Biotransformation (enzyme, whole cell), Batch, Fed-batch, Cell recycle & continuous fermentation processes. **Growth Kinetics :**Monod model & constitutive equations used for expressing growth, substrate consumption & product formation, Solid State fermentation.

Unit IV: (18L)

Measurement & Control of Bioprocesses Parameters

Measurement & Control of Bioprocesses Parameters: Cell growth. pH, temperature, Substrate consumption, product formation, Measurement of O2/CO2 uptake, evolution. Specific rates of consumption substrate & formation of product. Strategies for fermentation control. Computer controlled fermentations., Foam & its control. Scale up in Bioprocesses fermentations, Factors used in scale up.

Downstream processing: Strategy for recovery, Harvesting of Biomass and Product, Removal of microbial cells and solid matter, foam separation, filtration, centrifugation, cell disruption, Liquid -liquid extraction Ext, chromatography and membrane processes, Drying and crystallization.

Bioprocess Economics, Choice of process, process analysis, fixes & variable cost, Depreciation, Amortized costs, Selection of Pricing, Profitability, Scales of operations etc.

Recommended Textbooks and References:

1. Whittaker & Stan bury(1996),Principles of Fermentation Technology, PergamonPress.
2. Pauline Doran,(1995)Bioprocess Engineering Principles Academic Press
3. , Butter worth, Heinemann (1992)Operational Modes of Bioreactors, BIOTOL series
4. Butter worth Heinemann (1992),Bioreactor Design & Product Yield, BIOTOL series
5. B. Lydersen,N.A. Delia & K.M. Nelson(1993)Ed, Bioprocess Engineering: Systems,

Equipment & Facilities John Wiley & Sons Inc,

6. G. Subramaniam,(1998)EdBio separation & Bioprocessing Wiley –VCH,
7. Butter worth Heinemann (1992).Product Recovery in Bioprocess Technology, 'BIOTOL series
8. Paul A. Belter, E.L Cussler, Wei- Shou Hu(2000),Bioseparation: Downstream Processing for Biotechnology Academic Press
9. LarlSchuger,(1994)Solvent Extraction in Biotechnology.Spinger-Verlag,
10. Colin Ratledge (1995),Basic Biotechnology 3rd edition Cambridge Publication
11. Bailay&Ollis(1998),Fundamentals of Biochemical Engineering 2nd edition - TataMcGraw Hill Publication
12. Mooyoung (2019).Comprensive Biotechnology, Vol III Elsevier Publication
13. Cruger (2017). Introduction to Industrial Microbiology. ACS Publication

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II Semester

Course Title: Lab course VIII **Course Code: P-LAC-239**
Marks: 50 **Lecture:30** **Credit: 02**

Learning Objectives:

- The course involves a working understanding of tools of design of fermenters
- To Understand Engineering calculations, Growth kinetics and process kinetics.
- Able to understand basics of downstream processing.
- Able to explain and apply the principles of fermentation techniques in identifying, formulating and solving problems in the field of bioprocess technology.

Course Outcomes:

On the successful completion of the course, students will be able to-

- Apply the understandings of bioprocess engineering, mutagenesis, protoplast fusion techniques for strain improvement for primary and secondary metabolite production
- control the upstream and downstream processing at pilot and industrial scale.
- able to use concepts of process kinetics at industrial level
- able to explain and apply the principles of the bioprocess operation unit to produce bio-products.

Practicals:

1. Study of Growth Kinetics of Bacteria and Yeast by turbidometry & SCP
2. Screening and maintenance of Industrially important microorganism- Acids, Antibiotics, Enzymes.
3. Study of scale up of fermentation
4. Study of design of bioreactor
5. Determination of TDP
6. Determination of TDT and design of sterilizer
7. Study of types of fermentation process (Surface and submerged)
8. Downstream process of industrial products (Intra & Extra cellular)
9. Problems based on: - Growth kinetics, fluid flow, Reynold's number
10. Visit to fermentation Industry

Summary of cross cutting issues:

Biotechnology is a collective term for a group of technologies that use biological matter or processes to generate new and useful products and processes. As such, it ranges in complexity and maturity from ancient brewing and bread-making techniques to genetic modification through hybridization and interbreeding of plants and animals, as well as the manipulation of individual genes in humans, animals, plants and micro-organisms. Biotechnology is a key technology for the new millennium. It has an immense range of applications in agriculture, medicine, food processing, environmental protection, mining, and even nanoelectronics.

It is expected to cover some critical issues in the designed curriculum for the development of Students. In our syllabus we tried to include following cross cutting issues.

Cross-cutting issues relevant to Professional Ethics, Gender, Environment and Sustainability, and Human Values into the curriculum:

Sr. No.	Course Name	Code	Relevant to Professional Ethics	Description
1	Cell and Cancer Biology	P-CCB-134	Professional Ethics	Expertise in cell culture techniques will create employability in Pathology labs and Research Institutes
2	Biochemistry	P-BIO-135	Professional Ethics	Expertise in cell Biochemistry will create employability in Pathology labs
3	Microbial Physiology	P-MIP-136	Professional Ethics	Students can get jobs as technician in different labs
4	Bioinstrumentation and	P-BIB-	Professional	Student understands

	Biostatistics	137	Ethics	the Proper handling of instrument, which is essential in Research and Industry job.
5	Molecular Biology	P-MOB-232	Professional Ethics	help in getting absorb in various research organization, molecular labs and industry research and development sector
6	Immunology and immunotechniques	P-IMI-233	Professional Ethics	Expertise in immunological techniques will create employability in Pathology labs and Research Institutes
7	Animal Biotechnology	P-ANB-234	Professional Ethics	Expertise in Cell culture techniques
8	Bioprocess Engineering	P-BIE-235	Professional Ethics	Students will get job in Fermentation Industries as process design engineer.

Curricula developed and implemented have relevance to the local, national, regional and global developmental needs

Sr. No.	**Course code**	**Course Name**	**Linkage with Local/National/Regional/Global development**
1	P-CCB-134	Cell and Cancer Biology	Research and Diagnostics
2	P-BIO-135	Biochemistry	Research and Qualitative and Quantitative analysis
3	P-MIP-136	Microbial Physiology	Research
4	P-BIB-137	Bioinstrumentation and Biostatistics	Technical skills in Biology
5	P-MOB-232	Molecular Biology	Skills in Molecular Techniques
6	P-IMI-233	Immunology and Immuno Techniques	Skills in Immuno Techniques

7	P-ANB-234	Animal Biotechnology	Skills in Cell Culture Techniques, Cell line Development
8	P-BIE-235	Bioprocess Engineering	QC and QA

Courses having focus on employability/ entrepreneurship/ skill development

Sr. No.	Name of the Course	Course Code	Activities/Content with a direct bearing on Employability/ Entrepreneurship/ Skill development			Year of introduction
			Employability	**Entrepreneurship**	**Skill development**	
1	Cell and Cancer Biology	P-CCB-134	Expertise in cell culture techniques will create employability in Pathology labs and Research Institutes		Student will get idea about cell culture Technology.	2017-18
2	Biochemistry	P-BIO-135	Expertise in cell Biochemistry will create employability in Pathology labs		Students will get idea about role of biomolecules essential for cell ular reactions and physiological significance of anabolic and catabolic pathways used to drive cellular functions.	2017-18
3	Microbial Physiology	P-MIP-136	Students can get jobs as technician in different labs		Students will get thorough knowledge and understanding of core concepts of microbiology. Students will	2017-18

					also get familiar with microbe handling techniques	
4	Bioinstrumentation and Biostatistics	P-BIB-137	Student understands the Proper handling of instrument, which is essential in Research and Industry job.		Student develop the skill of instrument handling, Data analysis	2017-18
5	Molecular Biology	P-MOB-232	help in getting absorb in various research organization, molecular labs and industry research and development sector			2017-18
6	Immunology and immunotechniques	P-IMI-233	Expertise in immunological techniques will create employability in Pathology labs and Research Institutes		Student will be skilled in Immunotechniques	2017-18
7	Animal Biotechnology	P-ANB-234	Expertise in Cell line development, Vaccine Production using animal cell culture		Skills in Cell culture Techniques and its applications	2017-18

8	Bioprocess Engineering	P-BIE-235	Students will get job in Fermentation Industries as process design engineer.	Students can establish their own Industry	They learn Kinetics, Process designing etc.	2017-18