M.Sc. Biotechnology

DRAFT

Scheme & Syllabus
For Affiliated Colleges
(Revised)
2020

University of Kerala
Thiruvananthapuram
M Sc Biotechnology

(Course Outcomes, Programme Outcomes and Programme Specific Outcomes)

Course Outcomes (CO):

After successfully completing this course, the student will be able to

**CO1:** Understand the basic knowledge and concepts of biotechnology and other related areas.

**CO2:** Understand the ability to apply their knowledge for practical which they can conduct independently.

**CO3:** Apply their knowledge in other advanced subject area like Nano-biotechnology, immuno-technology and animal and plant biotechnology for the betterment and advancement of their professional career.

**CO4:** Learn the theoretical and practical exposure to the basic and the advanced fields of biotechnology.

Programme Outcome (PO):

**PO1:** The major outcome of our MSc programme is to introduce competent biotechnologist's who can implement their knowledge base in advanced processes and applications in Biotechnology in the various fields of agriculture, industry, healthcare and environment.

**PO2:** An ability will be developed for the students to apply knowledge of Biotechnology (including other areas of life sciences like Biochemistry, Biophysics, Cell biology, Molecular Biology, rDNA technology, Immunology and Immuno-technology, Pharmaceutical Biotechnology, Nano-biotechnology etc.), for understanding its basic concepts.

**PO3:** Students also attain an ability to standardize and to conduct experiments, as well as to analyze and interpret data accordingly. They will gain an individual and team work ability to function on multi-disciplinary teams.

Programme Specific Outcomes (PSO):

**PSO1:** Design and execute industry oriented experiments in biotechnology using modern biotechnological tools and techniques.

**PSO2:** Apply the knowledge of Biotechnology to demonstrate research skills and develop technology for industrial applications such as development of new biotech products, process and clinical practices and methodologies.
## SUMMARY OF THE SYLLABUS AND SCHEME

### Semester I

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title of the Course</th>
<th>Teaching Hours/week</th>
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<th>Total</th>
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<tr>
<td>BT 101</td>
<td>Cell Biology and Genetics</td>
<td>L T P</td>
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### Semester II

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<td>Molecular Biology</td>
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<td>Plant BT/ Animal BT Lab</td>
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<td>BT 305</td>
<td>Genetic Engineering Lab</td>
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### Semester IV

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<td>Immunology</td>
<td>L T P</td>
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<td>Environmental Biotechnology</td>
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L – Lecture, T - Tutorial, P - Practical Total Number of Hours /week-25 hrs.  
90 working days, 450 hours / semester. 5 months including exams. One seminar

II. MARK DISTRIBUTION

1. PAPER/SEMESTER

<table>
<thead>
<tr>
<th>Semester</th>
<th>Papers</th>
<th>CA</th>
<th>ESA</th>
<th>Total Marks</th>
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<td>BT-201-205</td>
<td>25 x 5</td>
<td>75 x 5</td>
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<td>III</td>
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<td>Grand Total (From S-1 to S-IV) 2000</td>
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CA- Continuous Assessment  
ESA- End Semester Assessment

Total Marks for a semester 500  
Total Maximum marks at the end of IV semester 500 x 4=2000

2. DISTRIBUTION OF MARKS FOR PROJECT EVALUATION

<table>
<thead>
<tr>
<th>A. CA</th>
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<td>Attendance</td>
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<td>Work progress</td>
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<td>Discussion</td>
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<tr>
<th>B. ESA</th>
<th>Marks</th>
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<td>Project Content</td>
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<tr>
<td>Project presentation OR Viva Voce on Project</td>
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<tr>
<td>Total Marks for Project (CA + ESA)</td>
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### III. SCHEME OF EXAMINATION PATTERN OF THE COURSE

<table>
<thead>
<tr>
<th>Total Number of Hours /Week</th>
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<tbody>
<tr>
<td>One hour (period) for each subject and keep one hour for tutorial, seminar, discussions etc.</td>
<td></td>
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<tr>
<td>Number of theory papers/semester and duration</td>
<td>3 (5 hrs each)</td>
</tr>
<tr>
<td>Number of Lab /Practicals</td>
<td>2 (5 hrs each)</td>
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<tr>
<td>Project</td>
<td>10 hours</td>
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### EXAMINATION AND EVALUATION

<table>
<thead>
<tr>
<th>Examination</th>
<th>CA</th>
<th>ESA</th>
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<th>Components of CA</th>
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<td>Assignments 5</td>
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<td>Test 10</td>
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<tr>
<td>Lab/ Practical</td>
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<td>75</td>
<td>100</td>
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<td>Test 10</td>
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<td></td>
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<td>Viva 5</td>
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No. of seminars: One seminar/paper/student/semester
No. of assignments: One assignment/paper/student/semester
Tutorial hour: May be utilized for seminar and discussion

### PROJECT

Project work shall be assigned individually and must be carried out under the guidance of a faculty from the same college with or without an external guide OR in an external institution under the combined guidance of internal and external guides. The student has to submit the dissertation before the examiner for evaluation and may give a presentation on the project work, if asked for.

### PROJECT EVALUATION

The evaluation of the project (Both CA and ESA) through oral presentation or Viva-voce as decided by the Chairman, Board of examinations.

<table>
<thead>
<tr>
<th>Marks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>Project Content</td>
</tr>
<tr>
<td>50</td>
<td>Project presentation OR Viva Voce on Project</td>
</tr>
<tr>
<td>150</td>
<td>Maximum marks (including CA)</td>
</tr>
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</table>
4. DETAILED SYLLABUS
SEMESTER I
BT 101 Cell Biology and Genetics

Aim
- To give a detailed and comprehensive knowledge on the various aspects of cell biology and genetics including cell structure and its functions, Mendelian genetics, and population genetics in detail.

Course Objectives
- The course gives the life activities at cellular and molecular level and basic functions of the various cellular compartments and organelles.
- It also gives the structural-functional and biochemical details of all cellular activities.
- This explains the basic principles of Mendelian, population genetics and heredity and gives an overview on the classical genetics- Linkage & Crossing over.

Course Outcome
On completion of the course, students shall be able to,
- Identify and present relevant information from research publications dealing with issues of cell biology and genetics.
- They will be able to assess and relate the information to the context of cell biology.
- Plan and carry out simple experiments on the basis of cell.
- The course enables students to analyse hereditary data and apply fundamental coupling analyses and genetic calculations.

Course Content

Cell Biology

Module 1
2. Cell membrane - structure and function, transport of nutrients and ions across the membranes, Mechanism of vesicle transport and vesicle fusion. Functional diversity of cellular membranes. Plasmodesmata, Tight junctions, Gap junctions – Structure and role in movement of molecules

Module 2
3. Tissues- major types of plant tissues- simple tissue, complex tissues and tissue systems. Animal tissues- major types of tissues. Organs and organ systems

Module 3
5. Cell cycle- Mitosis and meiosis, chromosomes- structure and organization,
nucleosomes organization karyotypes and ideograms. Cytological, genetical and evolutionary significance of Mitosis and Meiosis. Molecular events and regulation of cell cycle in eukaryotes. Check points, Cyclins and protein kinases, MPF (maturation promoting factor).


**Genetics**

Module 4


Module 5


Module 6


**References**

1. Genetics
   AVSS Sambamoorthy
   Narosa, New Delhi

2. Principles of genetics
   DP Snustad, MJ Simmons, JB Jenkins
   John Wiley

3. Genetics
   PK Gupta
   Rastogi, Meerut

4. Cell & Molecular Biology
   PK Gupta
   Rastogi, Meerut

5. Genetics
   PJ Russell
   Benjamin Cummings

6. The science of genetics
   AG Atherly, JR Girton, JF Mc Donald
   Harcourt Brace College Publishers
   New York

7. Basic Human Genetics
   EJ Mange, AP Mange
   Sinauer Associates Inc, Massachusetts

8. The cell –A molecular approach
   GM cooper
   Sinauer Associates Inc, Massachusetts

9. Essential Cell Biology
   Alberts, Bray, Johnson
   Garland Pbl. NY

10. Concepts of genetics
    Klug and Cummings
    Person education N. Delhi

**Online resources:**

Authentic Web based resources like NCBI, PubMed, Science direct etc.
Semester I
BT 102 Biochemistry

Aim
- To give an introduction about the basic biochemistry related to the biological molecules, their diversity and biosynthesis, degradation and role in the biological systems.
- This also aims to develop a thorough knowledge among the students about the the various biochemical reactions- metabolic pathways- responsible for the manifestation of life disease and metabolic errors.

Course Objectives
- The overall objective of the course is for the student to gain a basic working knowledge of biochemical concepts and techniques which will be necessary for future scientific endeavors.
- This course gives an idea on different biological molecules, their origin, biological role and its degradation according to the needs and demand of the system under various conditions.
- The interrelation of each of these metabolic pathways and their contribution in various metabolic disorders are also explained in detail.
- The application of the knowledge generated in the practical aspects of Biotechnology.

Course Outcome
On completion of the course, the student should achieve an understanding of the following:

- The structures of amino acids, their chemical properties and their organization into polypeptides and proteins.
- Methods for isolating and characterizing proteins the basic elements of protein structure key principles of protein function.
- Enzymes and how they catalyze reactions as well as enzyme kinetics
- Structure of fundamental monosaccharides and polysaccharides structure
- Basic function of nucleotides structure of different classes of lipids and their roles in biological systems

Course Content
Module 1
   Carbohydrates- Monosaccharides-classification and structure, Isomerism in monosaccharides, Disaccharides- mclassification and types of disaccharides, its biological significance and functions, Oligosaccharides-hetero-oligosaccharides and homo-oligosaccharides, Polysaccharides- classification- hetero-polysaccharides, and homo-polysaccharides, storage polysaccharides and structural polysaccharides.

Module 2
Proteins- classification of proteins, building units of proteins- Amino acids- structure, properties and function, classification of Amino acids, peptide bonds, ramachandran plot, oligo peptides polypeptides, Structure of proteins- primary, secondary and tertiary
structures, quaternary structures, supra-secondary structures - motifs and domains,

Module 3

Lipids - structure and classification, various types of lipids – Oils and fats, Triglycerides - structure and function, Phospholipids - structure, classification and functions, Biological significance of various types of Phospholipids, Glycolipids and lipoproteins, serum lipids and its significance, Cholesterol and its derivatives,

Module 4


3. ETS and bioenergetics of cellular respiration. Redox reactions, standard oxidation reduction potential, mitochondrial electron transport chain, Oxidative phosphorylation, structure of ATP synthase, chemiosmotic hypothesis

4. Metabolism of Lipids - Oxidation of lipids. Beta-oxidation, Biosynthesis of lipids, Ketone bodies

Module 5


6. Metabolism of Nucleotides –biosynthesis, degradation and regulation of nucleotides and related molecules. Energy compounds and its biosynthesis- ATP, NAD, NADP, FAD, Creatin phosphates

7. Secondary metabolism- classification and role of secondary metabolites of plants and microbes - Role of secondary metabolites

8. Metabolic network - Interrelationship of metabolisms Krebs cycle, amino acid synthesis,

Module 6

# References

<table>
<thead>
<tr>
<th>Reference Description</th>
<th>Author(s)</th>
<th>Publisher/Location</th>
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<tbody>
<tr>
<td>1. Harpers Biochemistry</td>
<td>RK Murray, DK Grammer, PA Mayes</td>
<td>MC Graw Hill USA</td>
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<tr>
<td>2. Text Book of Biochemistry</td>
<td>DM Vasudevan and Sreekumari</td>
<td>Jaypee Brothers Medical Publishers New Delhi</td>
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<td>3. Biochemistry</td>
<td>U Satyanaryana</td>
<td>Becks &amp; Allied Kolkotta</td>
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<td>4. A text book of plant Physiology and Biochemistry</td>
<td>SK Verma</td>
<td>S Chand New Delhi</td>
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<td>5. Instant notes Biochemistry</td>
<td>Hames, Hooper &amp; Houghton</td>
<td>VIVA books Pvt ltd, N. Delhi</td>
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<td>6. Biochemistry</td>
<td>Stryer, Jermy, Berg</td>
<td>Freeman Newyork</td>
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<td>7. Biochemistry</td>
<td>Voet &amp; Voet</td>
<td>Wiely &amp; Sons</td>
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<td>9. Bioorganic chemistry</td>
<td>HR Hortan, LA Moran, RS Ochs</td>
<td>Prentice Hall USA</td>
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<td>10. Environmental Biochemistry</td>
<td>CP Jrasa</td>
<td>Saup &amp; Sons N Delhi</td>
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<td>11. Biochemistry of Green plants</td>
<td>DW Krogman</td>
<td>Prentice Hall USA</td>
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<td>13. Principles of Biochemistry</td>
<td>AL LEHINGER, DL NELSON &amp; COX</td>
<td>Worth publishers NY</td>
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</table>

**Online resources:**
Authentic Web based resources like NCBI, PubMed, Science direct etc.
SEMESTER I

BT 103 BIOPHYSICS AND STATISTICS

Aim

- To equip the students with knowledge of thermodynamics of biological system and bioenergetics. Also to give an introduction to the biophysical aspects of various biological physiological activities at cellular and molecular level.
- To get introduced to the fields of various instruments used in biotechnology- including the basic principle - application and working.
- To help students to have an idea on basic mathematical problems and calculations needed in Biotechnology aspects

Course Objective

- The course is designed to train the students in biophysics and bioinstrumentation techniques essential for the understanding of life sciences and biotechnology, for which basic knowledge in physics or Biophysics at graduate level is expected and is necessary for the proper understanding of this topic at postgraduate level.
- This course consists of basics of thermodynamics as applicable in the field of Biological systems- bio energetics- energy trapping and its transactions methods- biophysics of various biological activities.
- The course helps to attain knowledge on mathematical calculations and problems helping in competitive exams.

Course outcome

On completion of the course,
- The students will develop the capability to demonstrate a multiscale nature of biophysics by exploring macroscopic and microscopic applications.
- The students will learn to approach a research problem logically and will be able to do statistical analyses in research.

Course Content

BIOPHYSICS

Module 1
1. Structure of atoms, molecule, Physico-chemical forces- ions, ionic bonds, covalent bonds, Hydrogen bonds, vander Wals forces, hydrophobic interactions, polar and non-polar molecules

Module 2
3. Concept of Energy- matter and energy, thermodynamics- entropy, enthalpy
Bioenergetics- life as an energy system- major energy transformations mediated by life-
Photochemical reaction of photosynthesis- Oxidative photophosphorylation, ATP, GTP, Creatin phosphate, muscle contraction, generation and transmission of nerve impulse.
4. Biophysics of Muscle movement, Impulse generation and impulse transmission

Module 3

Module 4
8. Centrifugation - Principle and application of various types of centrifugation-sedimentation coefficient, Svedberg unit.
9. Chromatography- Principle and application, Classification of Chromatography Adsorption and Partition chromatography, Paper Chromatography, TLC, Liquid Chromatography - ion exchange chromatography, Gel permeation chromatography, affinity chromatography, HPLC and GC.

Module 5
10. Electrochemical instruments - pH meter and Mass spectrometry.
12. Molecular hybridization Techniques- southern blotting, Northern blotting and Western blotting, Electro blotting
13. Principle and applications of tracer technique in biology: Radioactive Isotopes and half life of isotopes; Effect of radiation on biological system; autoradiography; radiation dosimetry; scintillation counting, safety aspects

BIOSTATISTICS

Module 6
1. General principles, sampling, sampling errors
2. Mean, Median, Mode, standard deviation and standard error
5. Graphs and diagrams - Bar diagrams, pie chart. Histograms and frequency curves
## References

1. **Principles of Biochemistry**
   - AL LEHINGER, DL NELSON & COX
   - Worh publishers NY

2. **A text book of Biophysics**
   - RN Roy
   - New Central book Agency Kolkotta

3. **Biophysics**
   - Dr. S Thiravia Raj
   - Saras Publications Tamil Nadu

4. **Principles of Biostatistics**
   - M Paggana & Gaurveeau
   - Duxbery Australia

5. **Essentials of Biophysics**
   - P Naryananan
   - New age International PVt ltdN. Delhi

6. **Biochemistry**
   - Stryer, Jermy, Berg
   - Freeman Newyork

7. **Principles of Biochemistry**
   - GL Zubay, WW Parson & DE Vance
   - Wm C Brown Publishers Australia

8. **Harpers Biochemistry**
   - RK Murray, DK Grammer, PA Mayes VW Rodwell
   - MC Graw Hill USA

9. **Basic Evaluation methods**
   - Breakwell and L Millwart
   - Uty. Press Hyderabad

10. **Biophysics An Introduction**
    - RMJ Cotterill
    - John Wiely and Sons NYork

11. **Basic Biophysics for Biotechnologist**
    - M Daniel
    - Agrobios Jodhpur

### Online resources:

Authentic Web based resources like NCBI, PubMed, Science direct etc.
Aim

- To train students on the basic techniques of biochemistry

Course Objectives

- The course gives an idea for the maintenance of laboratory and the practices that should be accomplished in a laboratory.
- The course explains how to prepare buffers and reagents, various methods of estimation of proteins, enzyme extraction and purification

Course Outcomes

At the end of this course,

- The students will equip themselves with the basic biochemistry techniques which can later applied for their laboratory research and also for many other industrial researches.

Course Content

Laboratory techniques

1. Titration curve of acetic acid and Glycine
2. Titration of acetic acid to determine the pKa value.
3. Preparation of buffer of a known pH (phosphate buffer, acetate buffer)
4. Determination of isoelectric pH of a given amino acid.
6. Enzyme extraction and purification - ammonium sulphate precipitation, protein purification by Gel permeation chromatography, ion exchange chromatography
SEMESTER I
BT 105 CELL BIOLOGY, GENETICS AND BIOSTATISTICS LAB

Aim

- To train students on the basic techniques of cell biology and Genetics
- To make aware of the students a basic knowledges on computing biological problems statistically.

Course Objectives

- The course gives an idea for the maintenance of laboratory and the practices that should be accomplished in a laboratory.
- The course explains how to make slides for cytological examinations, other histochemical analysis, solving problems based on genetics and statistical analysis.

Course Outcomes

At the end of this course,

- The students will equip themselves with the basic cytology aspects to be performed in the laboratory.
- The students will be able to analyze genetic problems and will be able to approach a research problem statistically.

Course Content

Laboratory techniques

1. Cytological and Histological techniques- determination of number of viable cells in a cell population
4. Microtomy and histochemical techniques - Preparation of thin sections of tissues and developing embryos and staining with tissue specific stains
5. Isolation and estimation of chloroplasts
6. Solving the problems of genetics
7. Calculation of mean, standard deviation, standard error and student's t-test Preparation of histograms, frequency polygon and pie diagram.
SEMESTER II

BT 201  BASIC MICROBIOLOGY

Aim
- To give an introduction about the microbial world- their distribution- morphology and reproduction and about the role of microorganism in various fields of human life and Industry.

Course Objectives
- Imparts advanced training in Microbiology for the students
- Makes the student aware the role of microbes in the daily life as well as in the various fields of science. How it can be controlled is also dealt with.

Course outcome
At the end of this course,
- The students get trained in all aspects of microbiology as it is required for Biotechnology.

Course Content

Module 1
1. Ultra structure of bacteria, fungi, algae, protozoa and viruses.
2. Classification of microbes, molecular taxonomy, Artificial and Natural systems of classification, Traditional characters used for the classification of Microorganisms.

Module 2
4. Morphology and Fine structure of bacteria, cultivation of Bacteria, growth of bacteria – growth curve, Reproduction and growth, Pure culture and cultural characteristics. Microbial techniques, Staining techniques

Module 3
5. Characteristic features of eubacteria, archae, fungi- Molds and Yeasts, algae, protozoa and viruses- Viruses of bacteria, Viruses of plants and animals.

Module 4
7. Microbial nutrition. Growth, Microbial metabolism and energy production, bacterial photosynthesis and chemosynthesis
8. Microbial interaction (human microbe interaction, normal biota of the human body, plant microbe interaction).
Module 5

9. Control of Microorganisms- Physical chemical methods, Disinfectants, Antibiotics and mechanisms of antibiosis.
10. Microbial physiology and microbial genetics.

Module 6

11. Microbial ecology and Biogeochemical cycles
13. Industrial microbiology- Microbes used in industrial processes- bioengineering of microbes for industrial purposes-

References

1. A text book of Microbiology
   P Chakraborty
   New central Book agency
   culcutta
2. Modern Concepts of Microbiology
   H.D. Kumar, S. Kumar
   Vikas Publishing House, Pvt. Ltd.
   New Delhi
3. Advances in Microbial Biotechnology
   J.P. Tewari, T.N. Lakhanpal,
   J. Singh, R. Gupta, B.P. chamola
   A.P.H. Publishing Corporation,
   New Delhi
4. Instant notes in Microbiology
   J. Nicklin, K. Graeme- cook,
   T. Paget & R. Killington
   Viva books Pvt. Ltd., New Delhi
5. Principles of Microbiology
   R.M. Atlas
   Mc Giraw Hill, NY
6. Introductory Microbiology
   J. Heritage, E.G.V. Evans,
   R.A. Killington
   Cambridge University Press
7. Human Parasitology
   B.J. Bogitsh, T.C. Cheng
   Academic Press, NY
8. Microbiology
   Pelczar, Chan, Krieg, Tala
   Mc. GrawHill
9. Microbiology- An Introduction
   G.J. Tortora, B.R. Funke,
   C.L. Case
   Wesley Longman, NY
10. Microbiology
    L.M. Prescott, J.P. Harley,
        D.A. Klein.
    Wm. C. Brown Publishers,
        Australia
11. Environmental Microbiology
    Academic Press
    Ian Pepper Charles Gerba Terry
    3rd Edition
    Gentry

Online resources:
Authentic Web based resources like NCBI, PubMed, Science direct etc.
BT 202 MOLECULAR BIOLOGY

Aim
- To understand biological activities and metabolism at DNA and protein level

Course Objectives
- The course gives an in-depth insight into the molecular aspects of life - the central dogma.

Course Outcome
At the end of the course,
- The student will get an idea about the principles behind molecular biology which makes students to understand the basic molecular tools and its application in basic research and applied research in various fields of life sciences.

Course Content

Module 1
1. **Nucleic acids** - DNA and RNA structure and functions, DNA as genetic material. Griffith, Avery- McCarty-MCLEod, Hershy- Chase, Franklin Conrat Experiments

2. **DNA Structure**: Chemistry of DNA, Forces stabilizing DNA structure, Helix parameters, Forms of DNA (A,B,C,D,T and Z), Watson – Crick and Hoogsteen base pairing, Physical Properties of ds DNA (UV absorption spectra Denaturation and renaturation), Chemical that react with DNA.

Module 2

4. **Organization of DNA into chromosomes**: Packaging of DNA and organization of chromosome in bacteria and eukaryotic cells; packaging of DNA in eukaryotic nucleosome and chromatin condensation assembly of nucleosomes upon replication. Chromatin modification and genome expression.
Module 3


6. **DNA – Protein Interactions**: General features interaction of Helix- turn Helix motif, B sheet, Zn- DNA binding domain etc with DNA.

Module 4


Module 5

8. **Transcription**: RNA polymerases, features of prokaryotic and eukaryotic promoters. Strong and weak promoters. Assembly of transcription initiation complex in prokaryotes and eukaryotes and its regulation; synthesis and processing of prokaryotic and eukaryotic transcripts. Transport of RNA within eukaryotic cell. Regulatory elements of genes-promoters. Fate of mRNA.

9. **Translation- Synthesis and Processing of Proteome**: Structure and role of tRNA in protein synthesis, ribosome structure, basic feature of genetic code and its deciphering, translation (initiation, elongation and termination in detail in prokaryotes as well as eukaryotes), Post translational processing of protein (protein folding, processing by proteolytic cleavage, processing by chemical modification, inteins). Protein degradation.

Module 6

10. **Regulation of Gene expression in prokaryotes and eukaryotes**: Positive and negative regulation. lac-, ara-, his- and trp- operon regulation; antitermination, global regulatory responses; Regulation of gene expression in eukaryotes: Transcriptional, translational and processing level control mechanisms.

11. **DNA- transposable elements**- types of transposable elements, its importance in variation and evolution. Possible origin of virus, Oncogenes.

References
1. Advanced Molecular Biology  
H.S. Bramrah  
Viva Books, Pvt. Ltd., New Delhi
2. Plant Biochemistry and Molecular Biology  
Hans, Walter Held  
Oxford, NY
3. Molecular Cell Biology  
H.S. Bramrah  
Anmol Publications Pvt. Ltd., New Delhi
4. Molecular Biology of the Gene  
Watson, Baker, Bell, Gann, Levine, Losick  
Pearson Education Pvt. Ltd., New Delhi
5. Apoptosis and Cancer chemotherapy  
John A. Hickman & Caroline Dive  
Humana Press, NJ
6. Molecular Modelling  
Principles and Application, Andrew R. Leach  
Longmann, England
7. PCR 3  
Practical Approach, C. Simon Herrington & John O’Leary  
Oxford, NY
8. Essential Molecular Biology  
A Practical Approach, T.A. Brown  
Oxford, NY
9. Cell & Molecular Biology  
Concepts & Experiments, Gerald Karp, John Wiley & Sons  
NY
10. Gene VIII  
Benjamin Lemin  
Oxford University Press

**Online resources:**
Authentic Web based resources like NCBI, PubMed, Science direct etc.

**SEMESTER II**
BT 203  MATHEMATICS, COMPUTER SCIENCE, BIOINFORMATICS & RESEARCH METHODOLOGY

Aim

- To give an introduction to basic computational analysis and its applications
- To make the students understand what is Bioinformatics and Computational Biology.
- To make them aware the application of various computational tools in Bioinformatics and related subjects.
- To introduce to the world of various databases and its importance in biological research.
- Enable students to conduct scientific research and also to analyze data and communicate the results in an appropriate fashion

Course Objectives

- The course explains the applications of computer in biotechnology and statistical analysis of experimental data and also basic research methodology adopted.
- The course gives an introduction on the origin and evolution of Bioinformatics and its importance in Biotechnology, Genomics and Proteomics.
- Various methods of genome analysis and proteome analysis is also described.
- It gives an outline on the various bioinformatics and computational tools used in analyzing protein, gene and genome data bases.

Course outcome

At the end of the course,

- The student will be aware with a basic knowledge of modern molecular biology and genomics.
- The student will understand how theoretical approaches can be used to model and analyze complex biological systems.
- The students will also be able to understand the basics of how to perform scientific researches and also how to analyze and interpret a research problem

Course Content

MATHEMATICS

Module 1

1. Algebra
   Complex numbers; algebra of complex numbers; geometrical representation; real and imaginary parts; modulus and arguments of a complex number; conjugate of a complex number- triangle inequality; club roots of unity.

2. Logarithms
   Properties of logarithms- Common and Natural logarithms- Characteristics and Mantissa
3. **Progression** - arithmetic progression- Geometrical progression- harmonic progression.

4. **Quadratic equations and Expressions**
Theory of quadratic equations- relationship between their roots and coefficients; quadratic expressions; linear and quadratic inequations in one variable;

5. **Binomial Theorem**
Binomial expressions- Permutations and Combinations.

6. **Calculus**
Functions- into- onto and one-to-one functions; sum- difference- product and quotient of two functions; composite functions- inverse of a function- constant absolute value- greatest integer- polynomial - rational- trigonometric- exponential and logarithmic functions.

6. **Analytical Solid Geometry**
Analytical geometry of two dimensions and three dimensions, Central coincides, Paraboloids, Transformation of rectangular axes.

**COMPUTER SCIENCE**

Module 2
1. Computers- its application in biology- Basics
2. Basics of computer- Parts of a computer- hardware and software, operating systems-standard operating systems- MS DOS, Windows- Linux, Unix

Module 3
3. Programming - algorithms, binary language. Elements of programming languages- C++ and Perl
4. Standard software packages- Sigmaplot etc
5. Databases, Internet, Searching databases. Portals

**BIOINFORMATICS**

Module 4
1. **Information theory and biology**: Entropy, Shannon’s formula, Divergence from equiprobability and independence, mark of chains, ergodic processes, redundancy.

2. **History and development of Bioinformatics, Database**: Various types of databases and its importance Use of databases in biology, - sequence databases, structural databases. Sequence Analysis- proteins and nucleic acids, structural comparisons, genome projects.
3. Sequence alignment-various methods, DNA sequence annotation and various programmes for sequence comparison and analysis.

Module 5

4. **Proteomics**: Sequence analysis of proteins, and nucleic acids, tools and techniques in proteomics, protein-protein interactions; post translational modification, methods of 2D structure predictions.

5. **Genomics**: Structural genomics- sequence analysis software like GCG etc, Functional genomics- Gene finder, genetic mapping, and linkage analysis, application of genetic maps, human genome project.

RESEARCH METHODOLOGY

Module 6

1. Introduction to research – The role of research, type of researches
2. Understanding research Concepts, Constructs, Variables, and Definitions
3. Problems and Hypotheses – Defining the research problem, Formulation of the research hypotheses, The importance of problems and hypotheses
4. Research design – Experimental and Non-experimental research design, Field research, and Survey research
5. Methods of data collection – Secondary data collection methods, qualitative methods of data collection, and Survey methods of data collection
6. Sampling techniques – The nature of sampling, Probability sampling design, Nonprobability, sampling design, Determination of sample size
7. Processing and analysis of data
8. Ethical issues in conducting research
9. Report generation, report writing

References

1. Bioinformatics- Concepts, skills and Application
   S.C. Rastogi, N. Mendiratta, P. Rastogi
   CBS Publishers and Distributors, New Delhi
2. Bioinformatics
   M.M. Ranga
   Agrobios, Jodhpur
3. A Handbook of Bioinformatics
   N. Yadav
   Anmol Publication Pvt. Ltd, New Delhi
4. Fundamentals of Bioinformatics
   I.A. Khan and A. Khanum
   Ukaaz Publications, Andhra Pradesh
5. Bioinformatics
   The Machine Learning Approach
   I.A. Khan and A. Khanum
   The MIT Press, USA
6. Proteomics
   S.R. Pennington, M.J. Dunn
   Viva Books Pvt. Ltd., New Delhi
7. Microarray Bioinformatics
   Dov Stekel
   Cambridge University Press
8. Aloagarithms on strings, trees, and sequences- Computer Science and Computational Biology
   Dan Gusfield
   Cambridge University Press
9. Analysis of DNA Microarray data
   Steen Knudsen
   Wiley Liss NY
10. Mathematical models in
    E.S. Allman, J.A. Rhodes
    Cambridge University Press
<table>
<thead>
<tr>
<th>Course</th>
<th>Author(s)</th>
<th>Publisher</th>
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</thead>
<tbody>
<tr>
<td>13. Experimental Design and Data Analysis for Biologist</td>
<td>C. R. Kothari</td>
<td>Cambridge University Press</td>
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BT 204 MICROBIOLOGY LAB

Aim

- To train students on the basic techniques of microbiology

Course Objectives

- The course gives an idea for the maintenance of laboratory and the practices that should be accomplished in a laboratory.
- The course explains the isolation and screening techniques of microbes and quality analysis of water.

Course outcome

On completion of the course candidates will achieve the following objectives,

- A detailed knowledge of structure, function and application of microorganisms.
- Skills in handling microorganisms in the laboratory.
- An understanding of applications of microorganisms in the industry, health-care, environmental protection, food agriculture and research.

Course Content

1. Isolation of bacteria from soil, water and air
2. Gram staining of bacteria
3. Methods of streaking of bacterial culture
4. Microbial analysis of drinking water by MPN
5. Microbial analysis of solid and liquid food items
6. Determination of dissolved oxygen of water
7. Estimation of Biological Oxygen demand (BOD) of wastewater or factory effluents, Determination of chemical oxygen demand (COD) of waste water
8. Estimation of nitrates in drinking water.
9. Study of bacterial flora of environment – Laboratories, soil, water, fermented foods and spoiled foods, commercial samples of water and drinks etc,
10. Bacterial growth - growth curve
BT 205 MOLECULAR BIOLOGY LAB

Aim
- To train students on the basic techniques of Molecular biology

Course Objectives
- The course gives hands on training on the practical experiments and techniques in molecular biology

Course outcome
At the end of the course,
- The students will be made proficient in basic molecular biology skills and molecular biology laboratory techniques

Course Content

Laboratory techniques

1. Preparation of Buffers and solution for Molecular biology - TE buffer
2. Isolation of genomic DNA Preparation of Plasmid from known bacteria by alkaline lysis method - Preparation of solutions needed for the experiment
3. Estimation of DNA and purity checking by UV spectrophotometer
4. Agarose gel electrophoresis of plasmid and genomic DNA
5. Restriction analysis of plasmid DNA and evaluation of restriction sites
BT 301 PLANT BIOTECHNOLOGY

Aim
- To give an idea of plant tissue culture
- To introduce the various plant genetic engineering and transformations and its applications in various fields.

Course Objectives
- It gives introduction to the various transformation techniques employed in plant systems.
- It also describes the application of genetically modified plants in the various fields of science.

Course Outcome
At the end of the course,
- The students will gain an insight into the concepts and techniques of plant biotechnology and its application to crop plants
- They can also go for further research works during M.Phil and PhD courses

Course Content
Module 1
1. Plant cell - Plant cell and tissue and organ culture, principle - historical background
2. Plant tissue culture practical application and conventional plant breeding
3. Tissue culture media - composition and preparation- solid media and liquid media
4. Micro propagation of plants- initiation and maintenance of callus and suspension cultures- single cell clones.

Module 2
5. Organogenesis and somatic embryogenesis in plant tissue culture- development of whole -plants - Root formation, transfer of plant lets to the soil, hardening
6. Advantages of micropropagation in agriculture and horticulture
7. Shoot-tip meristem culture - raising virus free plants for rapid clonal multiplication of agricultural and horticultural plants

Module 3
8. Cell suspension cultures and its application in the production of secondary metabolites and single cell clones
9. Embryo culture and embryo rescue
10. Protoplast technology - protoplast isolation, fusion, protoplast culture, somatic hybridization, selection of somatic hybrid cells, culturing and development of somatic hybrid plants, symmetric and asymmetric hybrids, cybrids - Application of somatic hybridization plant improvement and breeding

Module 4
11. Somaclonal variation- significance in plant breeding
12. Production of haploid plants - anther and pollen culture, homozygous plants and its importance in genetics and plant breeding
13. Cryopreservation of plant cells, tissues and organs for germplasm conservation

**Module 5**

15. *Agrobacterium* mediated genetic engineering of plants, *Agrobacterium tumifaciens*, infection and molecular mechanism of tumor formation, Ti plasmids and RI plasmids, binary vectors, genetic markers, reporter genes and its application in genetic engineering,
16. Other methods of plant genetic transformation

**Module 6**

17. Metabolic engineering, Molecular plant breeding
18. Application of plant genetic engineering in agriculture, forestry and horticulture and industry, industrial application of transgenic plants, transgenic plants as bioreactors Chloroplast transformation.

**References**

1. Modern Concepts of Biotechnology  
   H.D. Kumar  
   Vikas Publishing House Pvt. Ltd., New Delhi
2. Role of Biotechnology in Medicinal and Aromatic Plants  
   Irfan A. Khan and Atiya Khanum  
   Ukaaz Publications, Hyderabad
3. Plant Tissue Culture  
   Kalyan Kumar D.  
   New Central Book Agency (P) Ltd, Calcutta
4. An introduction to Plant tissue Culture  
   M.K. Razdan  
5. Biotechnology  
   B.D. Sigh  
   Kalyan Publishers New Delhi
6. Introduction to Plant Biotechnology  
   H.S. Chawla  
7. Plant Biotechnology Recent Advances  
   P.C. Trivedi  
   Panima Publishing Corporation, New Delhi
8. Biotechnology  
   J.E. Smith  
   Cambridge University Press
9. Plant Biochemistry and Molecular Biology  
   Hans, Walter Held  
   Oxford, NY
10. Plant Cell, Tissue, and Organ Culture- Fundamental Methods  
    O.L. Gamborg, G.C. Philips  
    Narasa Publishing House, New Delhi

**Online resources**

Authentic Web based resources like NCBI, PubMed, Science direct etc.
BT 302 ANIMAL BIOTECHNOLOGY

Aim
- To give an idea of animal tissue culture
- To introduce the various genetic and transformation techniques in animals and and its applications in various fields.

Course Objectives
- It gives introduction to the various transformation techniques employed in animal systems.
- It also describes the application of genetically modified animals in the various fields of science.
- The techniques of animal cell culture and its industrial and medical applications are described.

Course Outcome
At the end of the course,
- The students will gain an insight into the concepts and techniques of animal biotechnology and its wide industrial and medicinal applications.
- They can also go for further research works during M.Phil and PhD courses

Course Content
Module 1
1. Animal cell - structure and organization, animal physiology.

Module 2
3. Types of animal cell culture- primary and secondary cell culture, development cell lines or established cultures.
4. Biological characterization of cell cultures, contact inhibition, cell transformation, cancer cells, indefinite cell lines.
6. Screening of cytotoxic compounds and its importance.

Module 3
7. Basic techniques of mammalian cell culture, methods of sub culturing.
8. Scaling up of cell cultures, bioreactors for animal cell cultures.

Module 4
9. Application of animal cell culture- industrial application, and clinical application-production. Stem cell research- types of stem cells, application of stem cells.
10. Somatic cell genetics, animal cloning and micromanipulation, apoptosis.
Module 5

11. Genetic engineering of farm animals - cloning vectors, viral vectors.
13. Transgenic animals and its uses.

Module 6

14. Gene therapy- methods of gene therapy
15. Ethical issues in animal biotechnology.

References

2. Biotechnology- Fundamentals and Applications | S.S. Purohit & S.K.Mathur | Agrobotanica, India
3. Agricultural Biotechnology | S.S Purohit | Agrobotanica, India
4. Fungi in Biotechnology | Anil Prakash | CBS Publishers, New Delhi

Online resources
Authentic Web based resources like NCBI, PubMed, Science direct etc.
BT 303 GENETIC ENGINEERING

Aim

- To acquaint the students to the versatile tools and techniques employed in genetic engineering and recombinant DNA technology.

Course objectives

- To illustrate creative use of modern tools and techniques for manipulation and analysis of genomic sequences.
- To expose students to application of recombinant DNA technology in biotechnological research.
- To train students in strategizing research methodologies employing genetic engineering techniques.

Course outcome

At the end of the course,

- The student will achieve a sound knowledge on methodological repertoire which allows them to innovatively apply these techniques in basic and applied fields of life science researches.

Course content

Module 1

1. Genetic engineering as tool in biotechnology.
4. DNA ligase, acid phosphatase and other DNA modifying enzymes.
5. Restriction enzymes - restriction analysis of genomes- restriction sites- cloning of blunt end DNA, adapters.

Module 2

8. DNA analysis: labeling of DNA and RNA probes. Southern and fluorescence in situ hybridization, DNA fingerprinting, chromosome walking.

Module 3

9. Techniques for gene expression: Northern and Western blotting, Gel retardation technique, DNA footprinting, Primer extension, S1 mapping, Reporter assays.
10. DNA sequencing and sequence assembly. Maxam-Gilbert’s and Sanger’s methods, techniques of in vitro mutagenesis, Site-directed mutagenesis, gene replacement and gene targeting, Shot gun sequencing, chemical synthesis of oligonucleotides; sequencing strategies for large genomes.
11. PCR- Principle and applications, Various types PCR.

Module 4

12. DNA mapping and DNA fingerprinting: Physical and molecular mapping, Hybridization and PCR based methods of fingerprinting.

Module 5

15. Genetic engineering of eukaryotes- genetic engineering of plants and animals- vectors used for transformations - shuttle vectors.
16. Protein engineering Metabolic Engineering, site directed mutagenesis.
18. Transgenic and gene knockout technologies to study molecular biology, chromosome engineering.

Module 6

19. Molecular markers. DNA based and PCR - based markers, RFLP, RAPD,RLGS, AFLP STS, EST, SSCP, VNTR, Multi locus probes, Microsatellites and minisatellites, STMS, DAF, AP-PCR.
20. Gene therapy.

References

1. Biotechnology - Fundamentals and Applications S.S. Purohit & S.K Mathur Agrobotanica , India
2. Agricultural Biotechnology S.S. Purohit Agrobotanica , India
5. Text Book of Biotechnology C.R. Chhatwal Anmol Publications pvt Ltd, New Delhi

Online resources
Authentic Web based resources like NCBI, PubMed, Science direct etc.
BT 304 PLANT BIOTECHNOLOGY/ANIMAL BIOTECHNOLOGY LAB

Aim
- To train students on basic and plant and animal cell and tissue culture techniques.

Course Objectives
- The course gives hands-on experience in the tissue culture of plant and animal cells.

Course outcome
At the end of the course,
- The student will be well versed with the theoretical as well as practical background knowledge in plant and animal sciences need for understanding plant and animal biotechnology.
- The student will gain working knowledge of laboratory techniques used in plant biotechnology.

Course Content
Laboratory techniques
1. Preparation tissue culture Media, methods surface sterilization of explants
2. Stock preparation and calculations
3. Organ culture. Induction of callus, callus propagation, Organogenesis and transfer of plantlets to soil
4. Protoplast isolation, cell counting viability studies
5. Culturing of protoplast and regeneration of plants/tissues from protoplasts
6. Production of haploids by anther culture, cytological examination of chromosomes in regenerated plants
7. Estimation of phenols from callus cultures
8. Preparation media for animal cell culture, sterilization by membrane filtration
9. Cell counting and viability checking by vital staining Sub culturing
10. Cytological examination of cultured cells
Practicals

**BT 305 GENETIC ENGINEERING LAB**

**Aim**
To introduce the students to the concepts and practice of genetic engineering.

**Course Objectives**
- To understand the basics of genetic engineering.
- To learn different methodologies in genetic engineering.
- To enable students to design a cloning experiment.

**Course Outcome**
At the end of the course,
- Students obtain a thorough knowledge in basic Molecular biology and genetic engineering methods practiced in research.

**Course content**

**Laboratory techniques**

1. Isolation of plasmids and purification
2. Electrophoretic separation of plasmid by agarose gel electrophoresis
3. Quantification and quality checking by UV spectrophometry and electrophoresis
4. Restriction analysis and construction of restriction map of plasmid
5. Preparation of competent *E.coli* cells, Construction of recombinant plasmid
6. Genetic Transformation of *E.coli* with a recombinant plasmid
7. Screening transformed cells for the presence of recombinant plasmid and gene
8. Transformation frequency and cloning efficiency
BT 401 IMMUNOLOGY

Aim

- To get introduced to the principles of immune systems of animals.
- To introduce to the world of molecular and diagnostic techniques of immunology, immunotechniques and its application.

Course Objectives

- This course is designed to impart the students the importance of immunology and its theoretical aspects and on the principles of immunology and immunotechnology.
- The application of immunology in medicines is also dealt with.
- It also explains the various antigen-antibody reactions involved in diseases, stem cell technology and vaccine development.

Course Outcome

At the end of the course the students will,
- Get a deep foundation in the immunological processes.
- Students will gain knowledge on how the immune system works and also on the immune system network and interactions during a disease or pathogen invasion.

Course Content

Module 1
2. Immunoglobulins- structure, distribution and function.

Module 2
3. Lymphoid tissues- ontogeny and physiology of immune system- origin and development, differentiation of lymphocytes.

Module 3

Module 4
8. Cytokines in immunity, Interleukines and their role.

Module 5

9. Genetic Immuno regulations. Introduction to tumour immunology, autoimmune disorders.
10. Use of transgenic animals in immunology, experimental immunology, vaccine, development, stem cell technology. Immunodiagnostics.

Module 6

11. Hybridoma technology and monoclonal antibody production, application and their uses. Cloning for vaccine development

References

1. Immunology Joshi. Osma Agro Botanica N.Delhi
2. Instant notes in Immunology Lydyard, helean, Fanger Viva Books N.Delhi
3. An introduction to Immunology CV Rao Narosa N.Delhi
4. Immunology Janus Kuby Freeman NY
5. Principles of cellular and molecular Immunology Jonathan Austin, Kathryn Wood Oxford NY
6. Immunology Goldsby, Kindt, Osborne, Janus Kuby Freeman NY
7. Medical Immunology Parslow, Stites, Tera, Imboden Mc Graw Hill NY

Online resources
Authentic Web based resources like NCBI, PubMed, Science direct etc.
Aim
- To give an introduction to the various aspects of environmental biotechnology to students.

Course Objectives
- The course explains the application of biotechnology in environment.

Course outcome
At the end of the course the students will,
- Obtain knowledge on basic principles and technologies of decontamination of persistent organic pollutants (dangerous contaminants of the environment) mainly by means of the biological approaches i.e. using bioremediation etc.
- The students will know about the principles and techniques underpinning the application of biosciences to the environment

Course Content

Module 1
1. Issues and scopes of environmental biotechnology.

Module 2
3. Biological wastewater treatment- Waste water characterization: COD, BOD,
4. Inorganic constituents, solids, biological components.
5. Principles and aims of biological wastewater treatment processes,

Module 3
7. Suspended growth technologies: Activated sludge, oxidation ditches, waste stabilization ponds etc. Fixed film technologies: Trickling filters, rotating biological contactors, fluidized bed etc.

Module 4
9. Environmental problems and treatment of industrial waste waters: Distillery, tannery, paper pulp etc.
10. Toxicity testing in waste water treatment plants.

Module 5
12. Biodegradation of organic pollutants:
Mechanisms and factors affecting biodegradation. Pollution problems and biodegradation of simple aliphatic, aromatic, polycyclic aromatic hydrocarbons, halogenated hydrocarbons, azo dyes, lignin and pesticides.


**Module 6**


15. Microbes in the environment- Biofilms and its relevance in microbial survival, its effect in the environment.

16. Microbial Insecticides: Biopesticides. Bacterial, fungal and viral insecticides

**References**

1. Biotechnology – Fundamentals and application  
   SS Purohit, SK Mathur  
   Agrobotanica, India

2. Agricultural Biotechnology  
   SS Purohit  
   Agrobotanica, India

3. Concepts in Biotechnology  
   Balasubraminan, Bryce, Dhamalingam, Jayraman  
   UTY Press. Hyderabad

4. Fungi In Biotechnology  
   Anil Praksah  
   CBS N. Delhi

5. Biotechnology  
   BD Singh  
   Kalyani Publishers

6. Environmental Biotechnology  
   Alan Scrugg  
   Longman England

7. Biotechnology Unzipped  
   EricS grace  
   UTY Press. Hyderabad

8. Biotechnology  
   JE Smith  
   Cambridge UTY Press

**Online resources**

Authentic Web based resources like NCBI, PubMed, Science direct etc.
TECHNOLOGY

Aim

- To introduce Food and Dairy biotechnology to non-biotechnology students
- To introduce the subject of bioprocess technology in details
- To explain the industrial aspects of Biotechnology for the production of various of industrial products of biological origin.

Course Objectives

- The course explains the role of biotechnology in food and dairy technology.
- It gives details about the conversion of a small scale laboratory process in to a large scale industrial process.
- It also deals with the various important products produced by the bioprocess techniques.

Course Outcome

At the end of the course the students will,

- Get a detailed insight into the industrial processes carrying out in the food and dairy sector as well as how to transfer a small scale laboratory process to a large scale industrial process.

Basics of Bioprocess Technology

Module 1

1. Introduction to Bioprocess Technology – Scaling up of a Bioprocess , Upstream Processing , Downstream Processing,
2. Fermentation- Types of Fermentation, Its significance in Industry, Submerged Fermentation and Solid state fermentation, batch fermentation and continuous fermentation, Chemo stat Fermentation.

Module 2

3. Upstream Processing – Sterilization, Media Components, Cell cultures, its isolation and maintenance, strain improvements –methods of strain improvements, inoculation of microorganisms
4. Upstream Processing – Importance of downstream processing and methods of downstream processing , centrifugation, filtration, precipitation, dialysis,, Chromatographic techniques- gel filtration, ion exchange chromatography and affinity chromatography, electrophoresis, capillary electrophoresis, Quality assurance techniques and its importance in marketing.

Module 3
5. Bioreactors - types of bioreactors, factors affecting the design of bioreactors
6. Industrial microorganisms and cultivation of microorganisms in bioreactors, Kinetics of microbial growth.
7. Culture media sterilization for industrial application. Air in Bioreactors, pH maintenance in bioreactors

Module 4
8. Downstream processing and purification of products
9. Industrial bio-production of chemicals - and antibiotics

Module 5
Food and Dairy Biotechnology

10. Introduction to Food Technology - application of biotechnology in food processing use of food modifying enzymes - amylase, proteases, lipases etc.
11. Elementary idea of canning and packing - sterilization and pasteurization of food products

Module 6
12. Introduction to Food microbiology, Dairy microbiology, Microbial processing of milk and milk products. Sterilization and Pasteurization of milk and dairy products, Fermentation of milk, biochemical and physical changes associated with the process-Industrial processing of milk and production of food products - bread, cheese, butter, ghee and other value added products.

References
1. Modern Concepts in Biotechnology  HD Kumar Vikas N. Delhi
2. Food Science  Potter & Hotchkins CBS N. Delhi
3. Food Microbiology  MR Adams and Moss Panima N. Delhi
4. Food Processing- Biotechnological applications  Marwah &Arora Asiatic Publ. N. Delhi
5. Biotechnology  JE Smith Cambridge UTY Press

Online resources
Authentic Web based resources like NCBI, PubMed, and Science direct etc.
• Project work shall be assigned individually / a group of students not exceeding 4 nos.
• It must be carried out under the guidance of a faculty from the same college with or without an external guide OR in an external institution under the combined guidance of internal and external guides.
• The student has to submit the dissertation before the external examiner appointed by the University for Evaluation and may give a presentation on the project work, if asked for.

**BT 405  GENERAL VIVA VICE EXAMINATION**

General viva voce on theoretical and practical aspects based on the courses covered from semester I to IV.