Meeting Educational Needs with “Course” Correction
Remodelled M.Tech. Food Biotechnology Curriculum
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with “Course” Correction
Remodelled M.Tech Food Biotechnology Curriculum

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Ministry of Science & Technology
Government of India

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Department of Biotechnology initiated Integrated Human Resource Development Programme way back in 1985-86 to cater to the requirement of quality manpower for R&D, teaching and manufacturing activities. I am very proud that India is one of the first countries in the world to initiate postgraduate teaching programme in Biotechnology. M.Sc./M.Tech. programme was initiated in 5 universities and has been expanded to over 70 universities/IITs in the country to cover general, medical, agricultural, veterinary, environmental, industrial, marine, food, pharmaceutical biotech.

Students for these programmes are selected on the basis of an All India entrance test and all selected students are paid studentships. I am very happy to know that the Department has initiated major curriculum revision exercise for specialisations offered under DBT supported teaching programme. The exercise has been coordinated by Biotech Consortium India Limited. The Department invited feedback from researchers, academic community, biotech industries and past as well as present students. Feedback has been considered by the Expert groups and areas with recent developments have been included and identified gap areas which need inclusion and updation have been taken care of. I compliment the Department for taking up this major exercise for the benefit of student community and congratulate the group for bringing out this publication.
Andy Hargreaves, a renowned educational expert, has once remarked: “Capacity building originally meant helping people to help themselves. Now it means required trainee to deliver imposed policies.” In the Indian context, the Integrated Human Resource Development Programme of the Department of Biotechnology is a flagship and dynamic programme that has done exceedingly well to meet the requirements of capacity building. The central idea should be to take enough care in the selection of quality students and provide hands-on practical training to students.

I am extremely happy to note that the Department is revising the curriculum for various PG programmes in Biotechnology at regular intervals to incorporate the latest developments in the field. While doing so, I am told that Biotech Consortium India Limited has obtained necessary feedback from different stakeholders, viz., researchers, academia, industries, and students regarding the proposed changes in curriculum. Feedback was analysed and considered by the Expert Groups vis-a-vis with the curricula followed by the best international universities. I am assured that the proposed curricula have incorporated papers on research methodology, scientific communication, prevailing regulations in the country, etc.

I am confident that this curriculum revision exercise would be very beneficial for faculty and students of not only DBT supported programmes but also other universities involved in biotechnology teaching. I compliment the Department for undertaking this valuable exercise.

(Shri Y. S. Chowdary)
Integrated Human Resource Development Programme in biotechnology is a unique, innovative initiative taken by Department of Biotechnology way back in 1985-86. Human Resource Development programmes of the Department are highly dynamic and have evolved continuously based on need, regional aspirations and feedback from different stakeholders.

Emphasis is laid on selection of institutions based on existing expertise, infrastructure, nearby institutions engaged in research in relevant areas and students are provided hands on practical training. These programmes are continuously mentored and monitored by Advisory Committee, Expert Task Force and Course Coordinators meeting. An attempt is made to conduct curriculum revision exercise at frequent intervals to incorporate feedback from stakeholders as well as inclusion of latest developments. I am confident that revised curriculum has been framed after intense deliberations and would serve as a valuable resource to experts and student community.

I thank the Biotech Consortium India Limited for assisting DBT in this important exercise and compliment my colleague Dr. Suman Govil, Adviser, DBT for bringing out this publication.
MESSAGE

As the Chairperson of the expert syllabus committee for M.Tech. Food Biotechnology, I am glad to offer this document to the academic institutes engaged in training post graduate students in applied biotechnology oriented towards industrial needs so as to have good employability of these trained manpower. Due to interdisciplinary nature of Food Biotechnology, engineering graduates from allied fields are eligible to join the program which demands extensive bridge courses - both theory and laboratories. A group of senior researchers, academicians and industry experts have worked together and spent nearly a thousand person-hours to arrive at the best possible combination of subjects, pool of electives with due emphasis on soft skills. Fulfilling demands of all stake holders was the biggest challenge. M.Tech Food Biotechnology course is highly specialized and relatively small number of students are undertaking this PG program across the nation. However, unlike other M.Sc. programs these students join industry rather than further studies and hence concept of finishing school and industrial training has been used which make this syllabus unique.

(Prof. S.S. Lele)
Preface

Promotion of Indian Biotechnology sector is high on policy agenda of Government of India. Biotechnology has also been recognized as one of the key priority sectors under ‘Make in India,’ ‘Skill India’ and ‘Startup India’ initiatives of Government of India, as it is one of sectors expected to contribute towards enterprise creation, innovation and economic growth. Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India has immensely contributed to this dynamism through various policies and initiatives, establishment of innovation clusters, academia-industry partnerships, increasing capabilities for technology development, etc. The National Biotechnology Development Strategy (2015 – 2020) released by DBT provides a strategic roadmap for India’s emergence as a global biotechnology innovation and manufacturing hub. It has also highlighted importance of human resource development and need for nurturing tailor-made human capital for advanced scientific research and entrepreneurship.

DBT has taken a number of initiatives aimed at integrated human resource development to evolve an ecosystem where scientists, innovators and future entrepreneurs can be nurtured. Keeping in mind requirement for trained manpower in various areas of Biotechnology, DBT initiated Post-Graduate Teaching Programme way back in 1985 with 5 universities which has expanded to 74 universities imparting M.Sc./M.Tech./M.V.Sc. degrees in general, agricultural, animal, food, environmental, industrial marine, medical, neuroscience and pharmaceutical biotechnology. 10 programmes are being phased out. These universities and institutes are provided liberal financial support towards strengthening of laboratory facilities, equipment, consumables, fellowships to students, dissertation grant per student etc. Post-Graduate Teaching Programme selects best students and trains them to join research or industry workforce contributing significantly to biotechnology workforce.

Taking into cognizance the changing needs of the economy and to keep abreast with latest developments in the field of biotechnology, DBT proactively initiated revision of course curricula of Post-Graduate Programmes in biotechnology. The present exercise has been undertaken by Biotech Consortium India Limited (BCIL), New Delhi. Earlier exercise was carried out in 2008. The Course Curriculum Revision Exercise has been carried out for 13 Post-Graduate programmes in Biotechnology supported by DBT.

The revision of course curriculum of M.Tech. Food Biotechnology aims to address mismatch between ‘knowledge’ gained by students and appropriate skill set required for technology development and implementation including present contemporary needs of economy.

About the Course Curriculum Revision Exercise

A meticulous and structured approach has been adopted to accomplish the Course Curriculum Revision exercise.

BCIL had initiated the exercise with a review of literature of relevant national and international documents on curriculum design and planning for biotechnology programmes of premier national as well as international universities, guidelines by University Grants Commission, recent curricular guidelines released by Indian Council of Agricultural Research, Ministry of Health and Family Welfare and Indian Institute of Science Education & Research and other relevant research papers on curriculum development in peer-reviewed journals.
The findings of the literature review were adopted to design questionnaires for eliciting feedback from stakeholders of Biotechnology community i.e. academicians, scientists, industry representatives and students. Feedback was received from 165 experts and 20 students belonging to academic institutions, research organizations and industry regarding addition of advanced topics, deletion of elementary, redundant and overlapping topics, updation of laboratory practicals, re-adjustment of credit load, incorporating ‘technology’ component in the curriculum, among others. It was also suggested that re-orientation of curricula should be done keeping in view the needs of the industry.

**Strategic Approach**

A Core Committee along with 9 subject specific subcommittees comprising of 63 academicians, scientists and industry representatives were constituted to revise and update the curricula. The constitution of subject specific subcommittee for M.Tech. Food Biotechnology is given at Annexure-1.

The salient recommendations identified from stakeholder survey were presented to the Committee. Several brainstorming discussion sessions were held for achieving the desired balance between the foundation courses, recent developments in biotechnology and updation needs identified during the stakeholder survey. Core Committee finalized broad contours for revising all the course curricula. The guidelines set by the Core Committee were taken up by the subject specific subcommittee of M.Tech. Food Biotechnology for updating the curriculum. The subject specific subcommittee incorporated latest advancements in areas of food Biotechnology in the curriculum. Separate meeting was held to discuss and deliberate the updations to be made in the curriculum. The revised curriculum was vetted and finalized by the Core Committee.

**Course Curriculum Revision**

The members of Committee agreed that revised course curriculum should provide skill and outcome based education and help the students to gain domain knowledge, ability to design and interpret research experiments and acquire effective communication skills. The course curriculum has been re-designed accordingly to promote skill-based and outcome-based education. The revised course curriculum totals to 96 credits comprising of theory, practical, technology-based topics, electives and dissertation. Each course includes learning objectives, student learning outcomes, course plan (number of lectures/unit) and reference textbooks/resources. Theory and practical courses include relevant examples, case scenarios and tutorials for inculcating critical thinking against rote learning. Several new courses have been included and content for existing courses has also been updated. Specialized courses such as Principles of Food Analysis, Biotechnology of Fermented Foods, Nutrigenomics, Bioreactor Operations, Food Process Engineering, Food Allergies and Toxicology have been incorporated to introduce industry-relevant courses. With importance of students being able to execute research projects independently, separate credits have been allotted for proposal preparation and presentation before initiating dissertation and also credits for dissertation have been increased accordingly.

We hope that model course curriculum shall serve as guidelines for academicians and researchers from different parts of the country for adoption in their institutions with modifications as per availability of expertise, infrastructure and specific needs.

We wish to put on record our sincere appreciation for constant guidance and encouragement received from Dr. K. VijayRaghavan, Secretary, DBT for bringing out this publication. We wish to acknowledge whole-hearted support of Core Committee and subject specific subcommittees members. Sincere thanks are due to Dr. Manoj Singh Rohilla, Scientist- D, DBT, Ms. Shweta for creative design, Mrs. Rita Bhatla, DBT and Shri. Dilip Joy, BCIL.
# M.Tech. Food Biotechnology

## Recommended Electives:
1. Basics of Human Nutrition
2. Downstream Processing in Biotechnology
3. Food Additives and Ingredients
4. Food Allergies and Allergens
5. Food Packaging
6. Food Safety and Toxicology
7. Nanobiotechnology

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<th>S.No.</th>
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<td>Introduction to Food Science and Technology</td>
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<tr>
<td>2</td>
<td>Biochemistry</td>
<td>3</td>
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<tr>
<td>3</td>
<td>Fundamentals of Food Biotechnology, Genetics and Cell Culture Technology</td>
<td>3</td>
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<td>4</td>
<td>Microbiology</td>
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<td>Basics of Safety and Risk Management</td>
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<td>Seminar and Critical Review of Research Publication</td>
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<td>Principles of Food Analysis</td>
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<td>2</td>
<td>Bioprocess Engineering and Technology</td>
<td>3</td>
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<tr>
<td>3</td>
<td>Biotechnology of Fermented Foods</td>
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<tr>
<td>4</td>
<td>Nutrigenomics</td>
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<td>5</td>
<td>Research Methodology and Scientific Communication Skills</td>
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<td>Bioentrepreneurship</td>
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<td>Project Proposal Preparation and Presentation</td>
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<td>Enzymes in Food and Feed Industry</td>
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<td>2</td>
<td>Bioreactor Operations</td>
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<td>3</td>
<td>Food Process Engineering</td>
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<td>4</td>
<td>Biostatistics</td>
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<td>Intellectual Property Rights, Biosafety and Bioethics</td>
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<td><strong>TOTAL CREDITS</strong></td>
<td><strong>96</strong></td>
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Semester One

Introduction to Food Science and Technology

Course Objectives
This course will offer students a good command of basic principles of food science and technology and applying this understanding to growing and dynamic needs of food and beverage industries.

Student Learning Outcomes
On completion of this course, students should be able to:
- Demonstrate a level of comprehension of concepts of food science;
- Critically evaluate and solve issues or problems pertaining to food science.

Unit I
Introduction to food science and technology
10 lectures
Basics of chemistry of food constituents—carbohydrates, proteins, lipids, vitamins, minerals, water (different forms of water present in foods and their effect on quality and preservation of foods), minor constituents affecting texture, colour, taste, odour; Food microbiology, Food biochemistry, Food additives, General food composition and effect of food constituents on food quality.

Unit II
Standards for food analysis
10 lectures
Standards of identity, purity and methodology for analysis of: a) Cereals, legumes, oil seeds and their products; b) Fruits, vegetables, tubers and their products; c) Tea, coffee, cocoa, chocolate, spices, condiments; d) Milk and milk products; e) Meat, fish and poultry products; f) Miscellaneous foods e.g. fermented products.

Unit III
Food processing and preservation
10 lectures
Introduction to food processing of various foods including dairy, bakery, brewing, fruit and vegetable products, plantation products; pro and prebiotics and nutraceutical. Principles of food preservation by: Dehydration, Thermal treatments like pasteurization, sterilization, canning, retorting etc. Low temperature i.e. chilling and freezing, Chemical preservation/bio-preservation, Traditional methods like salting/syruping, pickling, fermentation etc. Non thermal processes like MAP, irradiation, high pressure processing etc. Hurdle technology.

Recommended Textbooks and References:
Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies; Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.

Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in...
Course Objectives
Fermentative production of enzymes used in food industry; solid state fermentation; recovery of enzymes from natural sources; cheese making and whey processing, impact of enzyme technology (bioethanol, protein hydrolysates, bioactive peptides); enzymatic processing of fruit juices. Role of enzymes in baking, meat and meat processing; comparative methods of toxicity test in (novel) foods; biosensors; enzymatic approach to tailor made fats; catabolic processes and oxygen-dependent reactions in food; use of lipases and reactions in organic solvents and two phases.

Recommended Textbooks and References:

Student Learning Outcomes
On completion of this course, students shall become aware of fundamentals of food biotechnology, genetics and also gain basic knowledge of cell culture technology.
Introduction to plant and animal tissue cultures and cell cultures in general; Cell culture lab design and equipments, Media and reagents; Animal, mammalian and other cell lines for in vitro testing of drugs, toxicity of environmental pollutants, production of vaccines and therapeutic proteins & production of stem cells; Principles of cryobiology and molecular diagnostics, Technological aspects for commercial utilization of cell cultures: Reactor studies, scale up and biosafety.

Recommended Textbooks and References:

Course Objectives
The objectives of this course are to introduce the students to the field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host-microbe interactions.

Student Learning Outcomes
On completion of this course, students should be able to:
• Identify the major categories of microorganisms and understand their classification, diversity, and ubiquity;
• Describe the structural, physiological, and genetic similarities and differences of the major categories of microorganisms;
• Demonstrate how to control microbial growth;
• Evaluate the interactions between microbes, hosts and environment.

Unit I
Microbial characteristics
6 lectures
Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.

Unit II
Microbial diversity
5 lectures
Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma; Archaea: Halophiles, Methanogens, Hyperthermophilic archaea, Thermoplasm; Eukaryotes: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes, introduction to metagenomics.

Unit III
Control of microorganisms
3 lectures
Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

Unit IV
Virology
5 lectures
Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.
Host-pathogen interaction, ecological impacts of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; biofilms, bacterial quorum sensing; microbial fuel cells.

### Recommended Textbooks and References:

3. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); *Microbiology* by Tortora Pearson Education.

### Basics of Safety and Risk Management

**Credits**

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<tr>
<th>Unit I</th>
<th>Safety and risk management</th>
<th>3 lectures</th>
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<tr>
<td>Unit II</td>
<td>Material hazards and evaluation techniques</td>
<td>3 lectures</td>
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<tr>
<td>Unit III</td>
<td>Biosafety</td>
<td>3 lectures</td>
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<tr>
<td>Unit IV</td>
<td>Laboratory safety and storage, handling and transportation of hazardous substances</td>
<td>3 lectures</td>
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<tr>
<td>Unit V</td>
<td>SHE and OSHA</td>
<td>3 lectures</td>
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</table>

**Course Objectives**

The objectives of this course are to make the students aware of risks of handling chemical and biological materials and hazardous, toxic, explosive, inflammable, infective effects of some chemical and biological substances. The students shall also be taught methods of safe handling and disposal of these substances.

**Student Learning Outcomes**

Students should become capable of handling chemical and biological materials in a safe manner in laboratories and industry. They should also learn safe and approved methods of disposal of substances and contaminated materials as well. Students should be able to gain awareness about national and international regulatory aspects of safety.
**Unit VI**

**Safety devices, fire safety, prevention and fighting**

5 lectures

Protection of equipment; electrical safety; Relief valve, Rupture disk, Flare stack. Equipment: Smoke detector, leak detector, gas sensors, flare, stack, electrical safety devices, earthing and grounding; Fire types, Agents to do fire fighting, Fire hydrant and sprinkler system, Fire tenders. Grounding and Earthing, Automatic fire fighting systems, sprinkler, remote operation etc.; Introduction to National Fire Protection Association (NFPA) standard on Explosion Prevention system, NFPA 69 (2008), DOW fire index, MOND index.

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**Recommended Textbooks and References:**


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**Course Objectives**

The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach utility of experimental methods in biochemistry in a problem oriented manner.

**Student Learning Outcomes**

Students should be able to:

- Elaborate concepts of biochemistry with simple experiments;
- Understand principle and working of basic laboratory instruments.

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**Syllabus**

2. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
3. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of institution's choice).
   - Preparation of cell-free lysates
   - Ammonium Sulfate precipitation
   - Ion-exchange Chromatography
   - Gel Filtration
   - Affinity Chromatography
   - Generating a Purification Table (protein concentration, amount of total protein)
   - Computing specific activity of the enzyme preparation at each stage of purification
   - Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis
   - Enzyme Kinetic Parameters: Km, Vmax and Kcat.
   - Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method.
4. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools.
5. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy)
6. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

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**Laboratory II: Microbiology**

**Credits** 2

**Course Objectives**

The objective of this laboratory course is to introduce students to experiments in microbiology. The course is designed to teach utility of experimental methods in microbiology in a problem oriented manner.

**Student Learning Outcomes**

On completion of this laboratory course, students should be able to:

- Isolate, characterize and identify common bacterial organisms;
- Determine bacterial load of different samples;
- Perform antimicrobial sensitivity test;
- Preserve bacterial cultures.

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**Syllabus**

**Basic technique**

1. Sterilization, disinfection and safety in microbiological laboratory, good laboratory practices
2. Preparation of media for cultivation of bacteria, liquid and agar.

**Staining techniques**

1. Preparation of bacterial smear and Gram’s staining.
2. Acid fast staining.
3. Endospore staining.
4. Capsule staining
5. Negative staining
6. Flagellar staining.

**Microscopy-related techniques**

1. Bright field light microscopy
2. Hanging drop slide preparation
3. Motility of bacteria
4. Dark field light microscopy
5. Phase contrast microscopy
6. Fluorescence microscopy.

**Biochemical and antibiotic tests**

1. MR test
2. VP test
3. Sucrose fermentation
4. Lactose fermentation
5. Indole test
6. Antimicrobial sensitivity test and demonstration of drug resistance
7. Zone of clearance, zone of inhibition.

**Environmental factors**

1. Effect of pH and temperature on microbial growth
2. Determination of phenol co-efficient of antimicrobial agents
3. Determination of Minimum Inhibitory Concentration (MIC)
4. Isolation and identification of bacteria from soil/water samples.

**Recommended Textbooks and References:**

Course Objectives
This course will cover areas in application and new methodology development in analytical chemistry with focus on food analysis.

Student Learning Outcomes
On completion of this course, students should be able to:

- Identify and determine errors and uncertainty of analytical results;
- Apply measures taken to control quality and ensure reliability of analytical results.

Unit I
Introduction to food analysis
5 lectures
Types of food samples analysed, steps in food analysis, choice of methods; sampling procedures, considerations and sample preparation; Evaluation of analytical data – accuracy and precision, sources of errors, specificity, sensitivity and detection limits, regression analysis, reporting results.

Unit II
Characteristics of food analysis
5 lectures
Analysis of chemical constituents, their characterization and significance – moisture, ash, minerals, lipids, fat, proteins, fibre, titratable acidity, starch, reducing sugars.

Unit III
Methods in food analysis
12 lectures
Spectroscopic analysis of foods – basic principles, UV, visible, fluorescence, IR, AAS, MS, NMR; Chromatographic analysis of foods – basic principles, HPLC, GC, GLC, principles and applications.

Unit IV
Advanced techniques in food analysis
8 lectures
Analysis of vitamins, pigments, flavours, extraneous matter, pesticides and mycotoxins; Microscopic analysis of foods, SEM and XRD; other methods- potentiometry, enzymatic, immunoassays, thermal analysis; Techniques for sensory analysis of foods and electronic tongue/ nose; Analysis of genetically modified foods.

Recommended Textbooks and References:
7. Yeshajahu Pomeranz; Clifton E. Meloan, (2002), Food Analysis- Theory and Practice, 1st Indian Ed. CBS Publisher; Distributors, New Delhi
## Bioprocess Engineering & Technology

### Course Objectives
The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

### Student Learning Outcomes
Students should be able to:
- Appreciate relevance of microorganisms from industrial context;
- Carry out stoichiometric calculations and specify models of their growth;
- Give an account of design and operations of various fermenters;
- Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products;
- Calculate yield and production rates in a biological production process, and also interpret data;
- Calculate the need for oxygen and oxygen transfer in a bioproduction process;
- Critically analyze any bioprocess from an economics/market point of view;
- Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

### Unit I
#### Basic principles of biochemical engineering
4 lectures
Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

### Unit II
#### Stoichiometry and models of microbial growth
4 lectures
Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth, MATLAB basics for modelling and solving the equations.

### Unit III
#### Bioreactor design and analysis
8 lectures
Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformations; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

### Unit IV
#### Downstream processing and product recovery
4 lectures
Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

### Unit V
#### Applications of microbial technology in food processing and biorefineries
5 lectures
Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria:
production and applications in food preservation; biofuels and biorefinery; production of antibiotics in a reactor; single cell protein; probiotics and prebiotics.

Unit VI
Applications of biotechnology in production of biologicals
5 lectures

Industrial production of penicillin via fungal route, insulin from recombinant E. coli; Production of metabolites such as shikonin using plant cell culture, astaxanthin from algae, and biotransformation routes for novel/specialty chemicals; Production of HBsAg using yeast cultures, erythropoietin using CHO cells, monoclonal antibodies such as Humira using mammalian cells.

Recommended Textbooks and References:

Course Objectives
The course will allow students to know biological phenomena behind use of virtuous microorganisms for production of main fermented foods.

Student Learning Outcomes
On completion of this course, students should be able to gain in-depth understanding of biotechnology of fermented foods.

Unit I
Overview of fermented foods
15 lectures

Traditional applications of food biotechnology- Fermented foods: e.g. dairy products, oriental fermentations, alcoholic beverages, and food ingredients; role of biotechnology in fermented food products (dairy, meat, vegetable); Starter culture development, process development; Enzymes in dairy industry: cheese making and whey processing, impact of enzyme technology; Functional foods.

Unit II
Biotechnology of fermented foods
15 lectures

Enzymatic processing of fruit juices; Role of enzymes in baking, meat and meat processing; Applications of immunological techniques to food industry; Detection methods for E. coli, Staphylococci, Yersinia, Campylobacter, B. cereus, Clostridium botulinum & Salmonella from food samples; Newer Processing Technology, Pesticide Residues, Newer Sources of Ingredients, Nutraceuticals, Use of Antibiotics & Hormones in Food Processing & Agricultural Practices etc.

Recommended Textbooks and References:
Nutrigenomics

Course Objectives
This course will develop an understanding of genomics and gene regulation with respect to diet and to obtain an appreciation for role and importance of nutrition in prevention of polygenic diseases amongst students.

Student Learning Outcomes
On completion of this course, students should be able to understand basics of genetics, genomics and gene regulation with relation to diet.

Recommended Textbooks and References:

Research Methodology and Scientific Communication Skills

Course Objectives
The objectives of this course are to give background on history of science, emphasizing methodologies used to do research, use framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

Student Learning Outcomes
Students should be able to:
- Understand history and methodologies of scientific research, applying these to recent published papers;
- Understand and practice scientific reading, writing and presentations;
- Appreciate scientific ethics through case studies.

Unit I
History of science and science methodologies
3 lectures

Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

Unit II
Preparation for research
3 lectures

Choosing a mentor, lab and research question; maintaining a lab notebook.
Concept of effective communication - setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication - interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Recommended Textbooks and References:

Course Objectives
Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

Student Learning Outcomes
Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.
Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Negotiating the road from lab to the market (strategies and processes of negotiation with financers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collabortions & partnership, Information technology.

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

Recommended Textbooks and References:

Course Objectives
The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Student Learning Outcomes
Students should be able to demonstrate the following abilities:
- Formulate a scientific question;
- Present scientific approach to solve the problem;
- Interpret, discuss and communicate scientific results in written form;
- Gain experience in writing a scientific proposal;
- Learn how to present and explain their research findings to the audience effectively.
Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources. Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

**Course Objectives**
This course will equip students with basic hands-on information of food processing and analysis.

**Student Learning Outcomes**
On completion of this course, students should be able to understand various aspects of food processing and different processes used for different type of food products. They should also be able to analyse quality of processed and raw food products.

**Syllabus**
**Food Processing and Analysis**

**Credits**

1. Fruit Processing: fruit squash
2. Fruit processing: jelly, jam, marmalade
3. Vegetable processing: pickles, juices, dehydrated vegetables
4. Tomato processing: ketchup/sauce, soup, juice
5. Milk processing
6. Dehydration
7. Baking: biscuits/cookies
8. Traditional food
9. Premix formulation
10. Demo of spray drier, extruder, SCFE, tray drier.

**Syllabus**
**Food Analysis**

1. Analysis of milk (liquid)
2. Analysis of wheat flour
3. Analysis of tea
4. Analysis of coffee
5. Analysis of alcoholic beverages
6. Detection of Food adulteration
Enzymes in Food and Feed Industry

Credits

Course Objectives
This course will acquaint students with issues related to use of enzymes in the basic processes of food as well as feed industry and provide students with characteristics of enzymes and mechanism of their actions in processing.

Student Learning Outcomes
On completion of this course, students should be able to:
- Co-relate enzymes used in various branches of food and feed industry;
- Explain mechanism of action of enzymes used in specific processes;
- Choose appropriate process conditions (temperature, pH, time), depending on the type of enzyme in the process.

Unit I
Introduction to enzymes in food industry
7 lectures

Introduction to enzymes used in Food industry, Objectives of using enzymes in food processing and in food product development, Merits and demerits of using enzymes, Sources of enzymes, Microbial enzymes and their advantages/disadvantages, Commercially important enzymes used in Food industry and their mode of action, Overview of applications of enzymes in Food industry, Newer enzymes and their actual
and potential applications, Fermentative production of enzymes used in food industry by SSF or SmF, Recovery and purification of enzymes.

Unit II  
Enzyme applications in foods  
4 lectures

Use of enzymes in: Dairy, Bakery, Brewery, Fruit and Vegetable Processing, Plantation Products, Starch industry and confectionery, Protein hydrolysis for protein hydrolysate and bioactive peptides, Oilseeds processing, formation of TAGs, extraction of fish oil, Meat, seafood (like surimi product), poultry, eggs, Animal feed, treatment of wastes from food industry, flavor bio-transformations.

Unit III  
Applications of enzymes in feed industry  
4 lectures

Use of enzymes in poultry feed, animal feed.

Unit IV  
Advances in utilization of enzymes  
5 lectures

Enzymes in biosensors, Enzymes as additives e.g. antioxidant or antimicrobial, Novel food applications of enzymes, Enzymes in active packaging and in edible coatings and films, safety of enzymes used in foods, food grade enzymes, Immobilization of enzymes for food applications, Recombinant enzymes from GMO.

Recommended Textbooks and References:

Course Objectives
The course is an overview on biological reactions, elements of bioreactor design, and fundamentals of mass and energy balances in biological reactions. It gives an idea on various types of important bioreactors for microbial, animal and plant cell processes. It covers mechanical design considerations for various kinds of bioreactors.

Student Learning Outcomes
Student should be able to gain strong understanding on design and applications of various bioreactors. They will be able to analyse bioprocess from an economics/market point of view.

Unit I  
Introduction to bioreactor design  
3 lectures

Introduction; General design information; Material and energy balance calculations; Process Flow.

Unit II  
Scale up and scale down processes  
8 lectures

Scale up and scale down issues: Effect of scale on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply; Bioreactor scale-up based on constant power consumption per volume, mixing time, impeller tip speed (shear), mass transfer coefficients. Scale-up of downstream processes: Adsorption (LUB method); Chromatography (constant resolution etc.); Filtration (constant resistance etc.); Centrifugation (equivalent times etc.); Extractors (geometry based rules). Scale-down related aspects.
Food Process
Engineering
Credits
2

Unit I
Principles of food
process engineering
6 lectures
Transport phenomenon; heat transfer, mass transfer in food processing; problems of equipment design with reference to common food processing unit operations such as drying, freezing, evaporation, membrane filtration.

Unit II
Methods in food
process engineering
5 lectures
Principles of thermal processing; calculation of process time temperature-schedules; other important principles of preservation of food.

Unit III
Bioreactor
equipment
8 lectures
Selection of bioprocess equipment (upstream and downstream); Specifications of bioprocess equipment; Mechanical design of reactors, heat transfer and mass transfer equipment; Design considerations for maintaining sterility of process streams and process equipment; Piping and instrumentation; Materials of construction for bioprocess plants.

Unit IV
Basic bioreactor
operations
6 lectures
Spectrum of basic bioreactor operations: immobilized cell system, animal cells, plant cell cultures and waste management; Enzyme immobilization techniques; Bioconversion using immobilized enzyme preparation; Bioconversion in batch, Fed-batch and continuous bioreactors; Mass transfer in immobilized cell/enzyme reactor.

Unit V
Bioreactor facility
design
5 lectures
Facility design aspects; Utility supply aspects; Equipment cleaning aspects; Culture cell banks; cGMP guidelines; Validation; Safety; Process economics; Case studies.

Recommended Textbooks and References:
8. Relevant articles from Bioprocess journals

Course Objectives
The objectives of this course are to introduce students to unit operations in food process engineering and machines/equipment used in food processing. Some inputs on product development and process flow sheet also need to be given.

Student Learning Outcomes
By end of the course, students should be familiar with basic unit operation, principles of several food processing methods including thermal pasteurization, blanching, freezing, dehydration, non-thermal processing, separation, concentration and extrusion.
## Biostatistics

### Credits

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
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<tbody>
<tr>
<td>Unit I</td>
<td>Introduction</td>
</tr>
<tr>
<td>2 lectures</td>
<td>Types of biological data (ordinal scale, nominal scale, continuous and discrete logical systems data), frequency distribution and graphical representations (bar graph, histogram, box plot and frequency polygon), cumulative frequency distribution, populations, samples, simple random, stratified and systematic sampling.</td>
</tr>
<tr>
<td>Unit II</td>
<td>Descriptive statistics</td>
</tr>
<tr>
<td>2 lectures</td>
<td>Measures of Location, Properties of Arithmetic Mean, median, mode, range, Properties of the Variance and Standard Deviation, Coefficient of Variation, Grouped Data, Graphic Methods, Obtaining Descriptive Statistics on the Computer, Case study.</td>
</tr>
<tr>
<td>Unit III</td>
<td>Probability and distribution</td>
</tr>
<tr>
<td>3 lectures</td>
<td>Introduction to probability and laws of probability, Random Events, Events-exhaustive, Mutually exclusive and equally likely (with simple exercises), Definition and properties of binomial distribution, Poisson distribution and normal distribution.</td>
</tr>
<tr>
<td>Unit IV</td>
<td>Correlation and regression analysis</td>
</tr>
<tr>
<td>3 lectures</td>
<td>Correlation, Covariance, calculation of covariance and correlation, Correlation coefficient from ungrouped data Spearson's Rank Correlation Coefficient, scatter and dot diagram, General Concepts of regression, Fitting Regression Lines, regression coefficient, properties of Regression Coefficients, Standard error of estimate.</td>
</tr>
<tr>
<td>Unit V</td>
<td>Statistical hypothesis testing</td>
</tr>
<tr>
<td>3 lectures</td>
<td>Making assumption, Null and alternate hypothesis, error in hypothesis testing, confidence interval, one-tailed and two-tailed testing, decision making.</td>
</tr>
</tbody>
</table>

### Course Objectives

The objective of this course is to introduce to statistical methods and to understand the underlying principles, as well as practical guidelines of “how to do it” and “how to interpret it” statistical data particularly for bio systems.

### Student Learning Outcomes

On completion of this course, students should be able to:

- Understand how to summarise statistical data;
- Apply appropriate statistical tests based on an understanding of study question, type of study and type of data;
- Interpret results of statistical tests and application in biological systems.

Recommended Textbooks and References:

### Bioinformatics

**Credits**

<table>
<thead>
<tr>
<th>Unit I Biological databases</th>
<th>3 lectures</th>
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</thead>
<tbody>
<tr>
<td><strong>Unit II Sequence alignment and database searching</strong></td>
<td>3 lectures</td>
</tr>
<tr>
<td><strong>Unit III Phylogenetic analysis</strong></td>
<td>4 lectures</td>
</tr>
</tbody>
</table>

**Course Objectives**

The objectives of this course are to provide students with theory and practical experience of use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

**Student Learning Outcomes**

Student should be able to:

- Develop an understanding of basic theory of these computational tools.
- Gain working knowledge of these computational tools and methods.
- Appreciate their relevance for investigating specific contemporary biological questions.

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**Unit VI Tests of significance**

3 lectures

Steps in testing statistical significance, selection and computation of test of significance and interpretation of results; Sampling distribution of mean and standard error, Large sample tests (test for an assumed mean and equality of two population means with known S.D.), z-test; Small sample tests (t-test for an assumed mean and equality of means of two populations when sample observations are independent); Parametric and Non-parametric tests (Mann-Whitney test); paired and unpaired t-test, chi-square test.

**Unit VII Experimental designs**

4 lectures

Introduction to study designs: Longitudinal, cross-sectional, retrospective and prospective study, Principles of experimental designs, Randomized block, and Simple factorial designs, Analysis of variance (ANOVA) and its use in analysis of RBD, introduction to meta-analysis and systematic reviews, ethics in statistics.

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**Recommended Textbooks and References:**


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**Unit I Biological databases**

3 lectures

Introduction, Primary & Secondary database, Sequence file formats, Introduction to structures, Protein Data Bank (PDb), Molecular Modelling Database (MMDb), Structure file formats, Visualizing structural information, Database of structure viewers, Collection of sequences, sequence annotation, sequence description.

**Unit II Sequence alignment and database searching**

3 lectures

Evolutionary basis of sequence alignment, Optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, Database similarity searching, FASTA, BLAST, Low complexity regions, Repetitive elements, Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, Clustral, Muscle; Scoring matrices, Distance matrices.

**Unit III Phylogenetic analysis**

4 lectures

Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD).
3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules; External coordinates and Internal Coordinates, Molecular Mechanics, Force fields etc. Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran map, anatomy of proteins – Hierarchical organization of protein structure –like CATH (class, architecture, topology, homology), SCOP (Structural Classification of Proteins), FSSP (families of structurally similar proteins).

DNA & RNA secondary and tertiary structures, t-RNA tertiary structure; Protein Secondary structure prediction: Algorithms viz. Chou Fasman, GOR methods, Tertiary Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology/comparative modeling, fold recognition, threading approaches, and ab initio structure prediction methods; CASP (Critical Assessment of protein Structure Prediction); Computational design of promoters, proteins & enzymes.

Designing of oligo probes; Image processing and normalization; Microarray data variability (measurement ad quantification); Analysis of differentially expressed genes; Experimental designs.

Recommended Textbooks and References:
4. Web-resources and suggested reviews/ research papers.

Course Objectives
The objectives of this course are:
• To provide basic knowledge on intellectual property rights and their implications in biological research and product development;
• To become familiar with India’s IPR Policy;
• To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products;
• To become familiar with ethical issues in biological research.

Student Learning Outcomes
On completion of this course, students should be able to:
• Understand the rationale for and against IPR and especially patents;
• Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations;
• Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;
• Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations;
• Understand ethical aspects related to biological, biomedical, health care and biotechnology research.
## Unit I
**Introduction to IPR**
5 lectures

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of ‘prior art’: invention in context of “prior art”; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

## Unit II
**Patenting**
5 lectures

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.

## Unit III
**Biosafety**
5 lectures

Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.

## Unit IV
**National and international regulations**
5 lectures

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).

## Unit V
**Bioethics**
5 lectures

Recommended Textbooks and References:
4. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/

Semester Four

Dissertation

Course Objectives
The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

Student Learning Outcomes
Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:
- In-depth knowledge of the chosen area of research.
- Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
- Competence in research design and planning.
- Capability to create, analyse and critically evaluate different technical solutions.
Basics of Human Nutrition

Course Objectives
This course will provide an integrated overview of physiological requirements and functions of protein, energy, and major vitamins and minerals that are determinants of health and diseases in human population.

Student Learning Outcomes
On completion of this course, students should be able to:
- Apply knowledge of role of nutrition and healthy eating for disease prevention and wellness;
- Understand principles of biochemistry and physiology to human nutrient metabolism;
- Explain rationale for nutrient intake recommendations across lifespan.

Unit I
Introduction to human nutrition
5 lectures

Introduction to human nutrition, energy value of foods and its determination by calorimetry and from proximate principles, daily caloric needs for basal metabolism, physical activity and diet induced thermogenesis.

Unit II
Dietary requirements of nutrients
5 lectures

Requirements and role of carbohydrates, lipids, water, vitamins and minerals in human health, recommended dietary allowance (RDA), dietary sources.
### Unit III
**Role of proteins**
5 lectures

### Unit IV
**Different types of diets**
5 lectures
- Diet vs Disease, therapeutic diets, dietetic foods, health foods, formulation of diets and foods for special needs, sports nutrition.

### Unit V
**Nutrition management**
5 lectures
- Techniques of diet and health surveys, assessment of nutritional status, lifecycle nutrition, infant nutrition and infant foods, geriatric nutrition and geriatric foods, maternal nutrition.

### Unit VI
**Advances in nutrition**
5 lectures
- Effect of processing, preservation and storage on nutritional quality of foods, nutrient interactions, food fortification, nutritional labelling, nutraceuticals, functional foods and introduction to nutrigenomics.

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**Recommended Textbooks and References:**


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### Downstream Processing in Biotechnology

**Credits**

3

**Course Objectives**
- The objective of this course is to provide an overview of various aspects of recovery and processing of biological products.

**Student Learning Outcomes**
- Students should be able to identify and design relevant unit operations for recovery of a biological product.

**Unit I**
**Biomass removal**
3 lectures
- Characteristics of biological materials: pretreatment methods; Separation of cell mass: centrifugation, sedimentation, flocculation and filtration; Continuous operation.

**Unit II**
**Cell disruption**
4 lectures
- Mechanical approaches: sonication, bead mills, homogenizers; non-mechanical approaches: freeze/thaw, osmotic shock, chemical lysis, enzymatic lysis; measurement of cell disruption.

**Unit III**
**Membrane processes**
3 lectures
- Filtration theory; Micro and ultrafiltration; Reverse osmosis; dialysis; electrodialysis, diafiltration; pervaporation; perstraction; Multistage and continuous operation.
### Course Objectives

This course will enable students to understand about food additives and determination of toxicity and various types and chemical properties of preservatives, emulsifiers, and antioxidants.

### Student Learning Outcomes

On completion of the course, students should able to:

- Understand applications of food additives and how to study toxicity of food additives;
- Understand various types and composition of food ingredients.

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<thead>
<tr>
<th>Unit IV</th>
<th>Adsorption and chromatography</th>
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<tbody>
<tr>
<td>5 lectures</td>
<td>Adsorption equilibrium, Van Deemter equation; Chromatography: size, charge, polarity, shape, hydrophobic interactions; Biological affinity; Process configurations (packed bed, expanded bed, simulated moving beds).</td>
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<tr>
<th>Unit V</th>
<th>Extraction processes</th>
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</thead>
<tbody>
<tr>
<td>5 lectures</td>
<td>Solvent extraction: phase equilibrium and distribution, counter-current operation, dissociative extraction, multiple stage analysis; Reciprocating-plate and centrifugal extractors; Reverse micellar extraction; Aqueous two phase, Supercritical fluid extraction; Aqueous two-phase extraction.</td>
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<tr>
<th>Unit VI</th>
<th>Concentration steps</th>
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</thead>
<tbody>
<tr>
<td>8 lectures</td>
<td>Precipitation: effect of size and charge, solvent effects, ionic strength effects, precipitate growth and aging models. Crystallization: nucleation and growth aspects; Drying: solvent removal aspects, dryers (vacuum, freeze, spray); Scale up aspects.</td>
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<tr>
<th>Unit VII</th>
<th>Product characterization</th>
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<tbody>
<tr>
<td>4 lectures</td>
<td>Biophysical characterization, chemical characterization, modern spectroscopy, QbD, stability Bioassays: Cell based assay, receptor mediated assay, <em>in vivo</em> evaluation, immunogenicity.</td>
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<tr>
<th>Unit VIII</th>
<th>Process design</th>
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<tbody>
<tr>
<td>8 lectures</td>
<td>Process synthesis: Identification and ordering of unit operations relevant for a case study. Analysis: comparison of different process synthesis steps. Case studies such as production and recovery of therapeutics, metabolites, and antibodies.</td>
</tr>
</tbody>
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### Recommended Textbooks and References:

Colours, flavours- chemistry, properties, food applications.

Emulsifiers, stabilizers, sweeteners- chemistry, mechanism of action, properties, food applications.

Sequestrants, humectants, acidulants - chemistry, mechanism of action, properties, food applications.

Ingredients- carbohydrate, protein, fat based and nutraceutical ingredients, their production, properties and food applications

Recommended Textbooks and References:

Course Objectives
This course will raise awareness amongst students about various food allergens and also provide guidance on handling and preparing foods for population with allergies.

Student Learning Outcomes
On completion of this course, students should be able to recognize role of genetic, dietary and environmental factors in pathogenesis of food allergies.

Food Allergies and Allergens

Credits
3

Unit I
Introduction to food allergies and allergens
5 lectures

Overview of food allergies, allergens, immune system, antigen antibody interactions; sign & symptoms of food allergy; global prevalence of food allergies; classification of hypersensitivity reactions, use of bioinformatics in understanding and identification of potential cross allergens.

Unit II
Factors: food allergies and allergens
5 lectures

Factors affecting food allergenicity, issues related to food additives and ingredients, genetic inheritance of food allergy, Immunological response, Oral allergy syndrome, GM foods and risk of allergy.
Course Objectives
This course will provide a fundamental understanding of various food packaging materials and their respective properties.

Student Learning Outcomes
On completion of this course, students should be able to:

- State functions of packaging;
- Describe various forms of packaging materials in common use contemporarily;
- Describe risks associated with potential food contamination.

Unit I
Introduction to food packaging
10 lectures
Introduction to food packaging, causes of food spoilage, Packaging as a method for preservation of foods; functions of food packaging, levels of packaging, different materials used in food packaging such as paper, board, glass, metal containers, aluminium foil, plastics, composites, traditional materials and their physico – chemical characteristics, additives used in packaging materials, packaging applications for various food commodities.

Unit II
Design and materials for food packaging
10 lectures
Testing of various packaging materials and packages for evaluation of quality, for identification, for evaluation of performance (barrier and strength properties) for transport worthiness, for biodegradability, for migration etc.; Package design; Criteria for selection of packaging materials and package design for food products; shelf life testing of packaged foods; food labelling.

Recommended Textbooks and References:
Packaging materials for newer techniques like radiation processing, microwave and radiowave processing, high pressure processing, CAP/ MAP and thermal processing as retortable pouches, aseptic packaging; biodegradable packaging; active packaging; intelligent packaging; migration; flavor scalping, application of nanotechnology in food packaging, environmental concerns and life cycle assessment.

Recommended Textbooks and References:
5. Pallin S.J. (1980), *Developments in Food Packaging V1*.

Course Objectives
This course will give a brief introduction about different food safety issues and hazards associated with it.

Student Learning Outcomes
On completion of this course, students should be able to understand various food safety parameters and also different toxicity issues in food industry.

Unit I
Food safety
10 lectures
Types of food hazards: biological, chemical and physical; Risk assessment; Existing and emerging pathogens due to globalisation of food trade; Newer systems of safety evaluation such as HACCP.

Unit II
Food testing
10 lectures
Testing of food ingredients & additives; Animal studies including LD50; Ames test for teratogenicity; Natural toxic constituents in plant foods; Shellfish poisoning; Chemicals from processing such as fumigants, chlorinated solvents, autoxidation products, carcinogens in smoked foods and pyrolysis, pesticides and herbicides.

Unit III
Food toxicity
10 lectures
Intentional and unintentional additives; Toxicity due to microbial toxins including botulinum and staphylococcal toxins, mycotoxin and due to other food pathogens; Food allergy and intolerance; Detoxication strategy.

Recommended Textbooks and References:
2. Tannenbaum SR, (1979), *Nutritional and Safety Aspects of Food Processing*. Marcel Dekker Inc
# Nanobiotechnology

## Course Objectives

The course aims at providing general and broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with combination of top-down approach of microelectronics and micro-mechanics with bottom-up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies. The course will also give an insight into complete systems where nanotechnology can be used to improve everyday life.

## Student Learning Outcomes

On successful completion of this course, students should be able to describe basic science behind the properties of materials at the nanometre scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials.

## Unit I

**Introduction to nanobiotechnology**

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Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures; Synthesis and characterization of different nanomaterials.

## Unit II

**Nano - films**

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Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

## Unit III

**Nano - particles**

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Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

## Unit IV

**Applications of nano - particles**

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Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

## Unit V

**Nano - materials**

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Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.

## Unit VI

**Nano - toxicity**

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Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life cycle assessment, containment.

## Recommended Textbooks and References:

5. Recent review papers in the area of Nanomedicine.
DBT Supported Teaching Programme

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<th>Name of University</th>
<th>Contact Details of Course Coordinator</th>
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</table>
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Deptt. of Food Engineering & Technology  
022-33612506  
laxmi.ananth.iyer@gmail.com | 

Annexure I

Subject Specific Subcommittee of M.Tech. Food Biotechnology

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Members
2. Dr. Ashok Pandey, Eminent Scientist, Center of Innovative and Applied Bioprocessing, Mohali
3. Dr. Gautam Ghosh, Sr. Vice President, Panacea Biotec Ltd., New Delhi
4. Dr. Aditya Basu, Manager, Protein and Assay Technology, Novozymes South Asia Pvt. Ltd., Bangalore

Member Secretary
5. Ms. Shreya Malik, Deputy Manager, Biotech Consortium India Limited, New Delhi
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Universities/ Institutes offering M.Sc./ M.Tech teaching programmes in biotechnology in India with DBT support
As on May, 2017

M.Sc. GENERAL BIOTECHNOLOGY
M.V.Sc. ANIMAL BIO TECHNOLOGY
M.Sc. MARINE BIO TECHNOLOGY
M.Sc. NEUROSCIENCE
M.TECH. FOOD BIO TECHNOLOGY
M.Sc. ENVIRONMENTAL BIOTECHNOLOGY
M.TECH. PHARMACEUTICAL BIOTECHNOLOGY

M.Sc. AGRICULTURAL BIOTECHNOLOGY
M.Sc. MEDICAL BIOTECHNOLOGY
M.Sc. MOLECULAR & HUMAN GENETICS
M.Sc. INDUSTRIAL BIOTECHNOLOGY
M.Sc. BIORESOURCE BIOTECHNOLOGY