

University of Mumbai



No. AAMS_UGS/ICC/2022-23/102

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head of the University Departments in Faculty of Science & Technology is invited to this office circular No. UG/278 of 2017-18 dated 26th October, 2017 relating to the revised syllabus M.Sc. (Life sciences) Specialization in Biotechnology (Sem.III & IV) (CBCS).

They are hereby informed that the recommendations made by the Ad-hoc Board of Studies in **Life Science** at its meeting held on 31st May, 2022 and subsequently passed in the faculty and then by the Board of Deans at its meeting held on 05th July, 2022 vide item No. 6.3 (R) have been accepted by the Academic Council at its meeting held on 11th July, 2022 vide item No. 6.3 (R) and that in accordance therewith, the revised syllabus of M.Sc. (Life sciences) Specialization in Biotechnology (Sem.III & IV) (CBCS), has been brought into force with effect from the academic year 2022-23. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032

11th October, 2022

To

The Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head of the University Departments in Faculty of Science & Technology.

A.C/6.3(R) /11/07/2022

No. AAMS_UGS/ICC/2022-23/102

11th October, 2022

Copy forwarded with Compliments for information to:-

- 1) The Dean, Faculty of Science & Technology,
- 2) The Chairman, Ad-hoc Board of Studies Life Science,
- 3) The Director, Board of Examinations and Evaluation,
- 4) The Director, Board of Students Development,
- 5) The Director, Department of Life Science ,
- 6) The Co-ordinator, MKCL.

(Dr. Shailendra Deolankar)
I/c. REGISTRAR

py for information and necessary action :-

- 1. The Deputy Registrar, College Affiliations & Development Department (CAD),**
- 2. College Teachers Approval Unit (CTA),**
- 3. The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
- 4. The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA)**
- 5. The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
- 6. The Deputy Registrar, Executive Authorities Section (EA)**
He is requested to treat this as action taken report on the conce resolution adopted by the Academic Council referred to the a circular.
- 7. The Deputy Registrar, PRO, Fort, (Publication Section),**
- 8. The Deputy Registrar, Special Cell,**
- 9. The Deputy Registrar, Fort Administration Department (FAD) Record Section,**
- 10. The Deputy Registrar, Vidyanagari Administration Department (VAD),**

Copy for information :-

- 1. The Director, Dept. of Information and Communication Technology (DICT), Vidyanagari,**
He is requested to upload the Circular University Website
- 2. The Director of Department of Student Development (DSD),**
- 3. The Director, Institute of Distance and Open Learning (IDOL Administration Vidyanagari,**
- 4. All Deputy Registrar, Examination House,**
- 5. The Deputy Registrars, Finance & Accounts Section,**
- 6. The Assistant Registrar, Administrative sub-Campus Thane,**
- 7. The Assistant Registrar, School of Engg. & Applied Sciences, Kaly**
- 8. The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
- 9. P.A to Hon'ble Vice-Chancellor,**
- 10. P.A to Pro-Vice-Chancellor,**
- 11. P.A to Registrar,**
- 12. P.A to All Deans of all Faculties,**
- 13. P.A to Finance & Account Officers, (F & A.O),**
- 14. P.A to Director, Board of Examinations and Evaluation,**
- 15. P.A to Director, Innovation, Incubation and Linkages,**
- 16. P.A to Director, Department of Lifelong Learning and Extension (DLLE),**
- 17. The Receptionist,**
- 18. The Telephone Operator,**

Copy with compliments for information to :-

- 19. The Secretary, MUASA**
- 20. The Secretary, BUCTU.**

UNIVERSITY OF MUMBAI



**Revised Syllabus for
M.Sc.
(LIFE SCIENCES)
Specialization in Biotechnology**

**Semester: III & IV
(CBCS)**

(With effect from the academic year 2022-23)

UNIVERSITY OF MUMBAI



Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	M.Sc. (Life Sciences) Specialization in Biotechnology
2	Eligibility for Admission	M. Sc. Life Sciences Semester I and II, of University Department of Life Sciences, University of Mumbai.
3	Passing Marks	240/600 every semester.
4	Ordinances / Regulations (if any)	No. PG/ Univ./VCD/ ICC/ 201213/18.
5	No. of Years / Semesters	2 Semesters (Semester III & IV)
6	Level	Certificate/Diploma/UG/ PG
7	Pattern	Semester /Yearly
8	Status	Revised /New /
9	To be implemented from Academic Year	From Academic Year: 2022-2023

Date: 1st June 2022

Signature:

Name: Dr. Indu Anna George
Chairman of BoS of Life Sciences

Signature:

Dr. Anuradha Majumdar
Dean, Science and Technology

M. Sc. LIFE SCIENCES

SEMESTER III & IV

PREAMBLE:

The designers of the Master's Programme in Life Sciences are conscious of the fact that the learners who chose to pursue this programme in Life Sciences are from different disciplines and would need to be familiarized with the scope of Life Sciences. The courses in this programme are common to all learners in the first year (Semester I and II) and they are given a firm and comprehensive foundation in this multidisciplinary subject in this year.

The syllabus of the Semester III and IV of the Masters level in Life Sciences allows the learner to explore the different facets of Life Sciences. The learner has the option to select between the four specializations offered at the Second Year (Semester III and IV) of the programme namely: Biochemistry, Biotechnology, Environmental Biotechnology and Aquaculture Technology which would be awarded on the basis of seats available and merit.

The Semester III would allow the learner to appreciate the finer nuances of the specialization selected which would be detailed in each of the courses (4 theory and 4 practical) specific to that specialization.

The Semester IV gives the learner an opportunity for hands-on extension of the theory that was taught in the preceding semesters and design projects or develop methods that are scientifically relevant or mitigate a social challenge with the appropriate application of the tenets of this discipline through a comprehensive Literature Review (Course 403) and Project (Course 404). The learners would be encouraged to publish the results of their research or present them at relevant platforms such as seminars/ conferences etc.

The learner would earn 48 credits at the end of Semester III and IV (24 credits in each semester) that includes both theory and practical aspects as detailed below. In both semesters, the learner would be exposed to courses that impart core knowledge of the specialization and also expose the learner to skills relevant in that particular specialization. There are about 13 credits (denoted by an Asterix) devoted to this aspect of learning.

Value added courses would also be recommended to the learner as extra but pertinent reading.

The design of the M. Sc. Life Sciences – Specialization Biotechnology course for Semester III and IV have been outlined below:

Dr. Anuradha Majumdar (Dean, Science and Technology)

Prof. Shivram Garje (Associate Dean, Science)

Name of Chairperson (BoS): Dr. Indu Anna George.

Member (BoS): Dr. Nandita Mangalore

Member (BoS): Dr. Hemlata Ramchandran

Member (BoS): Dr. Tejashree Shanbhag

Member (BoS): Dr. Priya Sundarajan.

Member (BoS): Dr. Nilima Gajbhiye

Syllabus framework and details as per University style and template

STRUCTURE FOR THE SEMESTER III AND SEMESTER IV

MASTER'S COURSE IN LIFE SCIENCES – SPECIALIZATION IN BIOTECHNOLOGY.

SEMESTER III

UNITS	Theory Credit 4				Practical credit 2	
Paper	UT1	UT2	UT3	UT4	P1	P2
PSLSCBT301	Core	Core	Skill*	Core	1.5 Cr	0.5 Cr
PSLSCBT302	Core	Core	Skill*	Skill*	1.0 Cr	1.0 Cr
PSLSCBT303	Skill*	Core	Skill*	Core	1.0 Cr	1.0 Cr
PSLSCBT304	Core	Core	Core	Core	2.0 Cr	

Total Credits: 4 x 4 = 16; 2 x 4 = 8; 16 + 8 = 24.

EXAMINATION DETAILS:

Paper	PSLSCBT301			PSLSCBT302			PSLSCBT303			PSLSCBT304		
	Int	Ext	Total	Int	Ext	Total	Int	Ext	Total	Int	Ext	Total
Theory	40	60	100	40	60	100	40	60	100	40	60	100
Practical		50	50		50	50		50	50		50	50
Total Marks			150			150			150			150

Grand Total: 600 marks.

SEMESTER IV

UNITS	Theory Credit 4				Practical credit 2	
Paper	UT1	UT2	UT3	UT4	P1	P2
PSLSCBT401	Core	Core	Core	Core	2.0 C	
PSLSCBT402	Core	Skill*	Skill*	Core	0.5 + 0.5 C	0.5* + 0.5* C
PSLSCBT403	Skill*	Lit review	Lit review	Lit review	0.5*C	Draft Paper
PSLSCBT404	Skill*	Internship/ Project	Internship/ Project	Internship/ Project	Internship/ Project	Internship/ Project

Examination Details:

Paper	PSLSCBT401			PSLSCBT402			PSLSCBT403**			PSLSCBT404***		
	Int	Ext	Total	Int	Ext	Total	Int	Ext	Total	Int	Ext	Total
Theory	40	60	100	40	60	100	40	60	100	40	60	100
Practical		50	50		50	50		50	50		50	50
Total Marks			150			150			150			150

Grand total: 600 marks.

** Assessment pattern for PSLSCBT403

Internal: 10 marks for skill (test); 30 marks from Lit review Thesis submission = 40

External: 15 marks for skill (exam) and 45 marks of Lit review viva (exam) = 60

** Assessment pattern for PSLSCBT404

Practical: 25 marks skill (exam) and 25 marks draft paper (exam) = 50

*** Assessment pattern for PSLSCBT404

Internal: 10 marks for skill (test); 30 marks internal assessment of project/ internship by guide = 40

External: 15 marks for skill (exam) and 45 marks for thesis submission = 60

*** Assessment pattern for PSLSCBT404

Practical: 50 marks internship/ project viva by external (exam).

UNIVERSITY OF MUMBAI

Syllabus for the M.Sc. Part – II: Life Sciences – Specialization in Biotechnology

Semester III and IV

Choice Based Credit and Grading System

The academic year 2022 - 2023

Program Objectives:

- To expose the learner to various aspects of Biotechnology
- To give an insight in developing skills and knowledge in Biotechnology industry

Program Outcome: The learner will be able to:

- Comprehend various techniques and scope of the discipline.
- Appreciate the applications of Biotechnology in industry.
- Enhance skills in the field of Biotechnology.
- Increase his/ her employability prospects.
- Develop ideas and plans to establish an industrial venture.

SEMESTER III

CODE	UNIT		Credits	Hours
PSLSCBTT301		Medical Biotechnology	4	60
	I	Therapeutics I	1	15
	II	Therapeutics II	1	15
	III	Pharmacogenomics*	1	15
	IV	Pharmacovigilance	1	15
PSLSCBTT302		Genetic Engineering and Bioprocesses	4	60
	I	Microbial Strain Improvement	1	15
	II	Recombinant Protein Expression	1	15
	III	Bioprocess I: Upstream and Downstream Processes*	1	15
	IV	Bioprocess II – Industrial Applications*.	1	15
PSLSCBTT303		Bio-sustainability of Natural Resources		
	I	Biotechnology and Aquatic systems*	4	60
	II	Green technology	1	15
	III	Biotechnology and sustainable methods *	1	15
	IV	Biotechnology Industry and Bioentrepreneurs	1	15
PSLSCBTT304		Emergent Technologies	4	60
	I	Nanotechnology	1	15
	II	Biosensors and Biomimetics	1	15
	III	Microfluidics and applications	1	15
	IV	Animal Biotechnology	1	15
		PRACTICAL		
PSLSCBTP301		Medical Biotechnology - Practical	2	60
PSLSCBTP302		Genetic Engineering and Bioprocesses - Practical	2	60
PSLSCBTP303		Bio-sustainability of Natural Resources - Practical	2	60
PSLSCBTP304		Emergent Technologies - Practical	2	60

SEMESTER IV

CODE	UNIT		Credits	Hours
PSLSCBTT401		Systems Biology and Quality Assurance	4	60
	I	Introduction to Systems Biology and Synthetic Biology	1	15
	II	GMO Detection and GMO Product Analysis	1	15
	III	ISO, GLP and GMP	1	15
	IV	Regulations in Biotechnological Research and the Authorities	1	15
PSLSCBTT402		Pharmacognosy and Plant Biotechnology	4	60
	I	Natural Products	1	15
	II	Pharmacognosy and Bio-efficacy studies*	1	15
	III	Plant Tissue Culture and Allied topics*	1	15
	IV	Transgenic plants	1	15
PSLSCBTT403		Research Methodology, Scientific Writing and Literature Review	4	60
	I	Research Methodology and Scientific Writing*	1	15
	II	Literature Review	1	15
	III	Literature Review	1	15
	IV	Literature Review	1	15
PSLSCBTT404		Tools for Research and Project	4	60
	I	Digital Packages for statistics in research*	1	15
	II	Internship/Project	1	15
	III	Internship/Project	1	15
	IV	Internship/Project	1	15
PSLSCBTP401		Systems Biology and Quality Assurance - Practical	2	60
PSLSCBTP402		Pharmacognosy and Plant Biotechnology - Practical	2	60
PSLSCBTP403		Research Methodology, Scientific Writing and Literature Review - Practical	2	60
PSLSCBTP404		Tools for Research and Project - Internship/Project	2	60

PSLSCBTT 301: Medical Biotechnology

Course Objectives:

- to understand the role of molecular biology, structural biology and chemical biology for the discovery and development of pharmaceutical products.
- Production of therapeutic proteins and the role of therapeutic proteins in mitigating diseases and genetic disorders.
- Processes involved in engineering vaccines, peptibodies, biosimilars and peptidomimetics.
- To understand the concept of pharmacogenomics and the value of pharmacovigilance.

Course Outcome: On completion of the course, learner will be able to

- Understand differences between various therapeutics and their development.
- The application protein therapeutics in disease management
- Outline and capture the essence of pharmaceutical products.
- Recall aspects of pharmacogenomics and its importance in medicine.
- Extend the concepts of pharmacovigilance in industry and other activities.

Unit I: Therapeutics I:

Pharmaceutical Research: Introduction, Traditional medicine versus emerging areas of focus, Role of Molecular biology - disease Models, Genomic Protein Targets and Recombinant Therapeutics; Structural Biology - Rational Drug Design, Chemical Biology and Molecular Diversity and interplay.

Therapeutic Proteins: Group I, II, III and IV and their applications in humans and animals, mode of action, stability, processing and formulation. Examples of each class - Monoclonal Antibodies, vitamins, blood proteins, human hormones – Growth hormones, insulin, somatostatin, steroid hormones, immune modulators – factors VIII, IX, interferons and interleukins, erythropoietin, relaxin, epinephrine, TNF, tissue plasminogen activator protein and vaccines, glucagon, secretin and antigens.

Unit II: Therapeutics II:

Genetic Engineering of Vaccines: Identification and Cloning of Antigens with Vaccine Potential - DNA/Oligonucleotide Hybridization, Hybrid Selection and Cell-free Translation, Expression cloning and Genomic Sequencing, Analysis of Vaccine Antigens - B-cell Epitopes and T-cell Epitopes.

Generation of Subunit Vaccines, Improvement and Generation of New Live Attenuated Vaccines - *Pseudorabies Virus*, *Vibrio* and *Poliovirus*

Recombinant Live Vectors - *Vaccinia Virus*, Recombinant BCG Vaccines, Attenuated *Salmonella* Strains, Poliovirus Chimeras, adenovirus, Eg: Ebola, Covid

Cross-species Vaccination, 'Live-dead' Vaccines, Other Virus Vectors and Recombinant *E. coli* Strains

Peptide Vaccines, Anti-idiotypes

Nucleic acid vaccines - DNA and RNA vaccines - types, methods of delivery, efficacy, safety

Therapeutic Vaccines - cancers, hypertension, de-addiction vaccines

Enhancing Immunogenicity and modifying Immune Responses - Adjuvants, Carriers and Vehicles, Carriers, Mucosal Immunity, Modulation of Cytokine Profile, Modulation by Antigen Targeting and Modulation of Signalling.

Peptibodies: Definition, peptide-Fc fusion, advantages over monoclonal antibodies, production in *E. coli* using recombinant DNA technology, production, and mechanism of action, applications – pain, ovarian cancer and immune thrombocytopenic purpura, limitations.

Peptidomimetics: Definition, design, features, analysis and application.

Biosimilars: Definition, design, features, analysis and application.

Unit III: Pharmacogenomics*

Concept of Pharmacology: Pharmacodynamics, Pharmacokinetics, Bioavailability, ADME, Adverse Drug Reactions.

Introduction to Pharmacogenomics: Definition, Basic Concepts of Pharmacogenomics and Pharmacogenetics, Concept of Personalized Drugs, Disorders: Monogenic and Polygenic disorders.

Concept of Drug Metabolism: Basic concept of Receptors, Enzymes and signalling involved, Phase I and Phase II Enzymes, Types of drug responders.

Genetics of Drug Metabolism: CYP genes and various mutations Genetic Variations: SNPs, CNVs, Repeat Sequences; Population Genetics: Variance- Major and Minor Allelic Frequencies.

Methods and Markers used in Pharmacogenomics: Genome Wide Associated Studies, Next Generation Sequencing- NGS, Biomarkers and Therapeutic Markers (Drug Design).

Pharmacogenomics of Cancer: Mutations: Proto-oncogene and Tumour Suppressor Gene, Cancer Database: COSMIC, Screening of Cancer biomarkers and therapeutic markers, Application in cancer treatment.

Unit IV: Pharmacovigilance

Introduction: Basic concept of Pharmacovigilance, Types of Adverse Drug Reactions, Management of Adverse Drug Reactions, Various Pharmacovigilance systems.

Methods in Pharmacovigilance: Sources and Documentation of Individual Case Safety Reports (ICSRs) , Medical dictionary (MedDRA) and Medical aspects in Pharmacovigilance

Medical Information System, Standard operating procedures in Pharmacovigilance.

Safety Monitoring and Communication: Pharmacovigilance Database, Risk –benefit assessment and management, Compliance monitoring and Pharmacovigilance inspections

Ethics Committee – Schedule Y, Case: triage, entry and processing

Regulation- Global and Indian: Regulatory submissions (E2b, MHRA, FDA)

Periodic Safety Update Reports (PSURs) For Marketed Drugs (ICH E2C)

Schedule Y - ICMR

PSLSCBTP 301: Medical Biotechnology – Practical

1. Study of polymorphisms using SNP database.
2. Study of phenotypic and genotypic cancer using COSMIC Database
3. Study of pharmacogenomics database – PharmGKB Database
4. Case Study- Cancer Pharmacogenomics- NPM1 mutation in Acute myeloid leukaemia
5. Case Study- Regulatory Affairs
6. Study Restriction Fragment length polymorphism.
7. Residual DNA Analysis of therapeutic proteins.
8. Multiplex PCR of virulence factors/ antibiotic resistance genes/ multiple targets.

REFERENCES:

1. Michael J. Klepper and Barton Cobert (2010) Drug Safety Data: How to Analyze, Summarize and Interpret to Determine Risk;
2. Elizabeth B. Andrews and Nicholas Moore (2014) Mann's Pharmacovigilance;
3. Dr. S. Gunasakaran and R. Satheesh Kumar (2010) A Practical Guide On Pharmacovigilance For Beginners;
4. James Paxton (2012) Topics on Drug Metabolism; InTechOpen
5. Gary Walsh (2007) Pharmaceutical Biotechnology: Concepts and Applications; Wiley.
6. Daan J. A. Crommelin, Robert D. Sindelar, Bernd Meibohm (2019) Pharmaceutical Biotechnology: Fundamentals and Applications; Springer.
7. J. Licinio and M.-L. Wong (2002) Pharmacogenomics: The Search for Individualized Therapies; Wiley.
8. Jogdand S. N. (2008) Medical Biotechnology, Himalaya Publishing House, Mumbai.
9. Judit Pongracz, Mary Keen (2009) Medical Biotechnology, Churchill Livingstone, Elsevier.
10. Pratibha Nallari & V. Venugopal Rao (2010) Medical Biotechnology, Oxford University Press, India.
11. A. K. Banga (2005) Therapeutic peptides and proteins; CRC Press.
12. Bernard R. Glick, Terry L. Delovitch and Cheryl L. Patten (2014). Medical Biotechnology
13. Relevant Research Papers would be discussed.

PSLSCBTT302: Genetic Engineering and Bioprocesses.

Course Objectives:

- To become acquainted with various latest genetic engineering techniques.
- Apply knowledge of genetic engineering in improving microbial strains for industry.
- To comprehend various aspects of fermentation technology.
- To understand various industrial fermentation processes.
- To evaluate the economics of the fermentation products.
- To distinguish between various enzymes used in different food and textile industry

Course Outcome: On completion of the course, learner will be able to

- Customize various latest genetic engineering techniques.
- Understanding the genetic improvement of industrially important strains.
- Understand recombinant protein production and its challenges.
- Explain various fermentation processes.
- Develop and fabricate fermenters and products.
- Understand the applications of enzymes in the food and textile industry.
- Capture the convenience of bio-transformations in this industry.
- Evaluate the effectiveness of the new product formulation.

Unit I: Microbial Strain Improvement:

Gene/ regulatory sequence/ protein engineering: Promoter, Gene, Protein and ribosome engineering – Mutagenesis, recombination and cell/protoplast fusion.

Mutagenesis: Effect of amino acid changes on protein function, Site-directed Mutagenesis – Non-PCR Methods - Cassette mutagenesis, oligo primed mutagenesis and whole plasmid mutagenesis and PCR-based Methods - Overlap PCR; Molecular Evolution/Random mutagenesis – Error prone PCR, Site Saturation mutagenesis, DNA/Domain/Exon shuffling, ICTHY, SCRATCHY, RACHITT; *de novo* Sequence design

Expression of modified genes – phage, cell, DNA, RNA, ribosome and IVC display, analysis and detection.

Genome editing: CRISPR/Cas9, TALENS, Modified nucleases – meganuclease, zinc finger nuclease, genome shuffling.

RNAi based strain improvement: use of siRNA, shRNA, miRNA, ribozymes and riboswitches to regulate and optimize gene expression.

Metabolic Engineering: Metabolic pathway analysis and modeling – approaches, Methods for metabolic engineering, Model organisms – *E. coli*, *B. subtilis*, Yeast, plants and animals, Applications.

Applications - modifying activity, substrate specificity, cofactor requirement, increasing stability, pH and temperature optima, Construction of deregulated mutants resistant to feed back inhibition and repression; Examples of modified proteins - Point Mutations, Domain Shuffling, Domain Fusions for Cell Targeting, Swapping Protein Domains, Whole Protein Shuffling, Protein-Ligand Interactions.

Unit II: Recombinant Protein Expression

Expression Hosts - Characteristics of both Prokaryotic and Eukaryotic expression hosts (Eg: *E. coli*, *Bacillus* spp. *Streptomyces*, yeast, fungi, protozoa, algae, insect and mammalian)

Expression systems – pET, pBAD systems, *Bacillus* and *Streptomyces* expression systems, YAC and *Pichia* expression system, Lexsy, *Chlamydomonas* expression system, Baculovirus, Adenoviral and retroviral expression systems

Choice of host - expression systems - factors that help choose the appropriate host - vector system for recombinant protein expression

Problems in expression of Foreign Genes in different expression hosts – Inclusion body formation, low growth rate and low recombinant protein yield, codon bias, proteolysis, post translational modification

Optimization of expression - host, transcriptional, translational, post translational compatibility, solubility and purification, transport and localization (use of Promoters, Ribosome Binding Site, Fusion Proteins, signal sequences, Tags and cleavage sites), codon optimization, host strain modification
Protein Purification - Precipitation, Dialysis and Chromatography techniques

Unit III: Bioprocess I: Upstream and Downstream Processes*

Isolation and Screening of microorganisms: Isolation of microorganisms from various sources, Preservation, Primary and Secondary Screening of microorganisms.

Microbial growth: General parameters, growth kinetics for various fermentation and types of stock culture, scaling up of culture for fermentation.

Strain improvement: Need for improvement, Criteria for improved strains, Physical and Chemical methods.

Fermentation Media: Definition, Criteria, Various components, Types: crude and synthetic, sterilization, rheology of various components of media.

Fermenter design: Components of the fermenter, sterilization, aeration and agitation.

Types of Fermenters: batch, continuous, air lift, fluidized bed, stirred tank.

Product recovery and Economics: Product: internal, external, cell disruption methods: physical, chemical and biological, precipitation, filtration, centrifugation, extraction and purification, drying, costing of the product.

Effluent Treatment: Need, Traditional methods disposal and disadvantage, physical, chemical and biological methods.

Unit IV: Bioprocess II – Industrial Applications*.

Single Cell Protein and Biomass: Need of single cell production, Production: Sources- sulphite liquor, whey and lignocellulose) and hydrocarbon sources (petroleum, methanol, methane), Production Methods: Bacteria, Yeast, Algae and Fungi.

Biotransformations: Classification and characteristics of enzymes – OTHLIL, applications of enzymes: (chiral synthesis of enantiomerically pure compounds, resolution of isomers). Examples of biotransformations: Oxidoreductases- Oxidation of 1- amino - D - sorbitol in the production of miglitol using *Gluconobacter oxydans*; Hydrolases: any one example; catalytic antibodies.

From microbes: Polymers [dextrans, xanthan gums, alginate], antibiotics [peptide, lantibiotics, aminoglycosides, beta lactam], cyclosporins,

Enzymes in Industries: Textile Processing, Leather Processing, Paper & Pulp Processing, Detergents and laundry.

Food biotechnology: Fruit and vegetable processing: juices, nectars, purees; syrup and glucose isomerases, enzymatic synthesis of aspartame.

Biopreservation: Bacteriocins - Types of bacteriocins, mode of action, applications, LAB bacteriocins and regulation

PSLSCBTP 302: Genetic Engineering and Bioprocesses – Practical

1. Isolation of Cellulase/Pectinase/Amylase from natural resources.
2. Native PAGE and activity staining (zymogram) using a suitable enzyme.
3. Preparation of media for naturally isolated microorganisms
4. Field Visit to Effluent Treatment plant/ food processing plant
5. Effect of bacteriocins on suitable bacteria/ organisms.
6. Pilot Fermentation for Biomass Production
7. Expression of recombinant protein in bacteria.
8. Isolation of Protease producers from soil and estimation of the protease activity.
9. Preparation and regeneration of fungal protoplast.
10. Transformation of Yeast/ Bacteria.
11. Slide culture of filamentous fungi

Reference:

1. Stanbury and Whitaker (2016) Principles of Fermentation Technology;
2. Casida (2004) Industrial Microbiology;
3. Prescott and Dunn (1982) Industrial Microbiology;
4. A. Liese, K. Seelbach and C. Wandrey (2006) Industrial Biotransformations; Wiley – VCH
5. Lehninger, Nelson and Cox (2017) Principles of Biochemistry; WH Freeman.
6. Stryer (2011) Biochemistry;
7. Harper (2018) Biochemistry;
8. Maniatis, Fritsch and Sambrook (1989). Molecular Biology: A laboratory Manual, 2nd edition, Cold Spring Harbor Laboratory Press.
9. M. Green and J. Sambrook (2012). Molecular Biology: A laboratory Manual, 4th edition. Cold Spring Harbor Laboratory Press.
10. Walker John M. and Ralph Rapley (2000). Molecular Biology and Biotechnology 4th Edition. RSC Publishing.
11. Walker John M. and Ralph Rapley (2009). Molecular Biology and Biotechnology 5th Edition. RSC Publishing.
12. Walker John M. and Ralph Rapley (2015). Molecular Biology and Biotechnology 6th Edition. RSC Publishing.
13. Vittal, R. R. and R. Bhat (2009). Biotechnology, Concepts and Applications.
14. Christina D Somlke (2010). The Metabolic Pathway Engineering Handbook - Fundamentals, Taylor and Francis Group, LLC.
15. Christina D Somlke (2010). The Metabolic Pathway Engineering Handbook - Tools and Applications, Taylor and Francis Group, LLC.
16. Oliver Brandenburg, Zephaniah Dhlamini, Alessandra Sensi, Kakoli Ghosh and Andrea Sonnino (2011). Introduction to Molecular Biology and Genetic Engineering, Food and Agriculture Organization of United Nations, Rome.
17. Paulina Balbas and Argelia Lorence (2004). Recombinant Gene Expression. Reviews and Protocols 2nd ed. Methods in Molecular Biology vol. 267, Humana Press.
18. Gerd Gellissen (2005). Production of Recombinant proteins - Novel Microbial and Eukaryotic Expression Systems, Wiley - VCH Verlag GmbH & Co. KGaA
19. Argelia Lorence (2012). Recombinant Gene Expression. Reviews and Protocols 3rd ed. Methods in Molecular Biology #24, Springer Protocols, Humana Press.
20. Primrose, Twymann and Old (2002). Principles of Gene Manipulation, 6th ed,
21. Kakoli Bose (2022). Textbook on Cloning, Expression and Purification of Recombinant Proteins, Springer Nature Singapore Pte Ltd.
22. David P. Clark, Nanette Pazdernik (2009). Biotechnology: applying the genetic revolution, Elsevier Inc.
23. Research and review articles

PSLSCBTT 303: Bio-sustainability of Natural Resources

Course Objectives:

- Correlate biotechnological methods for improved aquaculture.
- Identify and articulate the importance of mangroves.
- To outline various environmental issues and integrate biotechnology in its mitigation.
- Enumerate the environmentally friendly practices and methods for improvement.
- To explain the feasibility in setting up a biotechnology industry.
- To elucidate the fate and legal issues in biotechnology industry

Course Outcomes:

- Assess implantation of new biotechnology techniques in aquaculture and the environment.
- Explore the mangroves resources.
- Adapting biotechnological methods for eco-friendly and sustainable approaches.
- Integrate remediation principles with revenue generation.
- Analyze the feasibility of a biotechnology industry.
- Highlight the legal and economic aspects of the biotechnology industry.

Unit I: Biotechnology and Aquatic systems*

Aquatic Animal Breeding: Marker Assisted Selection, Development of transgenic aquatic animals (for growth rate, disease resistance, usable muscle meat, temperature tolerance), triploid and monosex stocks, Bioflock method.

Aquatic Animal Health: Modified yeasts, Probiotics in feed, Immunostimulants, Molecular diagnostics and Vaccines.

Mangroves: Introduction, Classification of mangroves, Types of mangroves, Mangrove diversity in the world, Role in ecosystem, Medicinal value of secondary metabolites from mangrove Plants

Mangroves Endophytes: Existence of endophytes in mangroves, Compounds secreted by endophytic microorganisms, Bioactivity of the secondary metabolites secreted using endophytes, Commercial application of endophytes

Bioprospecting potential of mangrove resources: Artificial honey using yeasts, Polythene and plastic degrading microbes, Mangrove-derived enzymes, Bioethanol production by mangrove-derived yeasts, Biofertilizer, Mangrove genomics: bioprospecting and valuable genes.

Unit II: Green technology

Bioremediation: Effect of metals and salts on the growth of microbes and higher organisms, Different adaptation mechanisms to tolerate higher concentration of metals by organisms. Bioremediation of soil and water using natural, genetically engineered bacterial systems and other approaches.

Phytoremediation: Mechanism of phytoremediation, Restoration of soil, water and air quality citing suitable examples.

Phytomining and Biomining: Concept, Indicator plants, hyperaccumulator plants, extraction of valuable minerals/ metals from low grade ore/ soil using plants and microorganisms, gold extraction, heaps and dumps.

Biotechnology of coal: The microorganisms involved, mechanism of action, applications - conversion of coal to efficient/ cleaner fuels and methane, Biocoal.

Biofuels: Liquid and gaseous. Bioenergy: Biofuels - Introduction, in the form of gas– hydrogen and methane (biogas), biofuel in form of liquid– ethanol and diesel, biofuel from phytoplankton.

Unit III: Biotechnology and sustainable methods. *

Biofertilizers: definition, methods of manufacture, application to soil and seed.

Nitrogen fixation: Molecular genetics: *nif* genes and regulation of *nif* gene expression. *Mycorrhiza:* Types, importance to plant health (nutrient uptake, resistance to stress, microbial symbiosis), importance of network analysis, role in ecosystem (Plant to plant interaction).

Biopesticides: types, advantage over chemical pesticides, mode of action, stability and formulation in natural and genetically modified organisms, Selective targeting, Molecular mechanism of resistance development and strategies including integrated pest management. *Biopesticides from Plants:* Neem and pyrethrins, mode of action on insect pests,

Bio-control: against fungal diseases of plants. Biological Controls: Viral/ fungal/ bacterial parasites for control of insects pests, life cycle, symptoms and mode of action

Biosurfactants: Types - Glycolipids (Rhamnolipids, Sophorolipids, trehalose lipids) and lipopeptides, lipoproteins, phospholipids, fatty acids and neutral lipids. sources of biosurfactants and applications.

Unit IV: Biotechnology Industry and Bio-Entrepreneurs

The Biotechnology Industry: Scope of biotechnology in the industrial environment, the Biotech industry in India with examples.

The sources of finance: Various sources of finance and their role in the development of an industry/ start-up.

Collaboration and Technology Transfer in Biotechnology: Concepts, motives and limits.

Biotechnology policies, laws and guidelines.

National Biotechnology Development Strategy.

PSLSCBTP 303: Bio-sustainability of Natural Resources Practical

1. Estimation of lycopene.
2. Biopesticide effect of Neem/ Extraction and demonstration of Azadirachtin/ Nimbolide.
3. Demonstration of mycorrhiza in a suitable plant.
4. Effect of bacteriocins on suitable bacteria/ organisms.
5. Regeneration studies in some mangrove species.
6. Determination of free amino acid content in saline plants.
7. Estimation of proline from saline species.
8. Estimation of tannins from bark/stems of different mangroves
9. Determination of Spatial Disturbance Index and similarity index of mangroves.
10. Detection of bioactive compounds in some mangrove species by TLC.
11. Production of biosurfactant using *Bacillus subtilis*.

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2. S. Felix (2010) Marine and Aquaculture Biotechnology: ISBN 10: 8177543970 / ISBN 13: 9788177543971 Published by Agrobios
3. M. H. Fulekar (2010) Environmental Biotechnology; CRC Press
4. Odum Environmental Sciences;
5. Alan Scragg (2004) Environmental Biotechnology; Longman
6. Bimal Bhattachraya and Rintu Banerjee (2008) Environmental Biotechnology; Oxford University Press; 1st edition.
7. C. S. Rao. (2007) Environmental pollution control engineering. New Age International Publishers.
8. T.V.S Rama Mohan Rao (2007) Economics of Biotechnology; New Age International Pvt Ltd; First edition
9. S. N. Jogdand (2007) Entrepreneurship and Business of Biotechnology.
10. Maureen D. McKelvey, Annika Rickne, Jens Laage-Hellman () Economic dynamics of Modern Biotechnology;
11. Ayyapan S et. al. (2006) Handbook of Fisheries and Aquaculture: ICAR.
12. Ujwala Jadhav (2009) Aquaculture Technology and Environment; PHI Publishers.

PSLSCBTT 304: Emergent Technologies

Course Objectives:

- To outline developing technologies in the field of biotechnology.
- Application of these technologies in medicine and novel products.
- To examine different culturing techniques of animal cells.
- Applications of animal tissue culture.
- An introduction to new food categories.

Course Outcomes:

- Identify the effects of structure and their function on nanoscale.
- Extending simulation of nature to novel product development.
- Adapt current diagnostics and methods to a small scale.
- Articulate techniques for animal cell and tissue culture.
- Apply knowledge of animal cell culture in medicine and pharmacology.
- Review biotechnological methods for new food categories.

Unit I: Nanotechnology:

Bionanotechnology: Concept. Types of bio-nanostructures (Carbon nanostructures, nanoshells, dendrimers, quantum dots, nanowires, liposomes).

Synthesis of nanoparticles: Physical, chemical and biological methods.

Applications of nanotechnology: medicine and diagnostics (antimicrobial properties, therapies, drug delivery including rate programmed drug delivery, Microencapsulation of cells. imaging) cosmetics, packaging, agriculture, environment.

Potential risks of Bionanotechnology.

Unit II: Biosensors and Biomimetics:

Biosensors: Concepts. Types of biosensors: amperometric, potentiometric, conductometric, calorimetric, piezoelectric, optical, evanescent wave sensors, Surface Plasmon Resonance.

Construction of Biosensors and their applications.

Biomimetics: Concept and possible applications: Dry adhesion (lizard's foot, seed burrs) Water repulsion (lotus leaf), nanostructures in colour display (butterfly wings/ peacock feather), structure and attachment of a lizard's tail.

Unit III: Microfluidics and applications.

Introduction to Microfluidics: Fundamental characteristics of fluidics at microscale,

Overview of manufacturing methods: Photolithography, moulding and casting and 3D printing methods.

Paper microfluidics: types of papers, paper devices and fabrication, Lateral flow microfluidics and detection.

Application of microfluidics: Cell sorting and separation, dip sticks, PCR methods. ELISA, Chip devices - laboratory, organs on a chip

Environmental applications: water/ soil pollution biosensors, microorganism detection,

Unit IV: Animal Biotechnology:

Animal Cell Culture: Primary Culture, Stem cells, Short term culture, cell lines, therapeutic cloning, Gene therapy (examples: HIV, CarT cell etc.), Mass cultivation – cytodex and biofermentors,

Tissue engineering and 3D printing - bone, skin, vascular grafts, Artificial meat (culturing muscle and fat cells) and their environmental advantage, stem cells in medicine.

Molecular Pharming of animals: Cloning and production of recombinant proteins and vaccines. insect larvae as mini bioreactors.

Applications of Transgenic animals: Various methods to develop transgenic animals – livestock, dairy and other animals (rodents, mosquitos).

PSLSCBTP 304: Emergent Technologies – Practical

1. Preparation of AgNP using a suitable extract and determination of its antimicrobial effect
2. Preparation of AuNP and size analysis using spectroscopy.
3. Construction and demonstration of a biosensor.
4. Demonstration of dry adhesion/ colour display
5. Construction and use of lateral flow strips/ devices.
6. Demonstration of Microfluidic principles: laminar flow/ pumps etc.
7. Establishment of Primary Culture (ATC)/ short term culture using a suitable source.

REFERENCES:

1. Ian Freshney (1999) Culture of Animal Cells Set: A Manual of Basic Technique. 3rd Ed. Wiley–Blackwell
2. J. M. Davis (2005) Basic Cell Culture. 2nd Ed. Oxford University Press.
3. Sudha Gangal (2007) Principles and Practice of Animal Tissue Culture. Universities Press
4. National Academies of Sciences, Engineering, and Medicine. 2017. Preparing for Future Products of Biotechnology. Washington, DC: The National Academies Press. doi: [https://doi.org/ 10.17226/24605](https://doi.org/10.17226/24605).
5. Ujwala Jadhav (2009) Aquaculture Technology and Environment; PHI Publishers.
6. Madhuri Sharon (2012) Bio-Nanotechnology. CRC Press
7. J. M. Walker and R. Rapley (2002) Molecular Biology and Biotechnology, 4th edition.
8. Jean Berthier and Pascal Silberzan (2005) Microfluidics for Biotechnology 2nd Edition. Artech House Publishers
9. Patrick Tabeling and Suelin Chen (2010) Introduction to microfluidics. OUP Oxford
10. Sulabha K. Kulkarni (2017) Nanotechnology: Principles and Practices - 3rd Edition. Capital Publishing Company
11. Elisabeth S. Papazoglou, Aravind Parthasarathy (2007) BioNanotechnology. Morgan and Claypool Publishers
12. B Singh, S K Gautam and M S Chauhan (2013) Textbook of animal biotechnology; TERI.
13. Ashish S. Verma and Anchal Singh (2014) Animal Biotechnology; Elsevier.
14. Relevant research/ review articles.

SEMESTER IV

PSLSCBTT401 Systems Biology and Quality Assurance

Course Objectives:

- To direct a holistic approach to cell biology
- to view any modification of a metabolic pathway or gene expression regulation in the context of the physiology of the whole cell
- Application of systems biology at Genome scale models/ whole cell models to optimize quality and yield of products.
- synthetic biol. to design a system/ device using parts to modify existing products, improve product yield and process, develop novel chemicals/ fuels/ oils and pharmaceutical products.
- To identify various genetic modified organisms, detection of GMOs as per food and pharma regulatory agencies.
- To acquaint the learner with the latest good laboratory practices used in various industries.
- To explain the importance of Quality Management System.

Course Outcomes:

- will get a better understanding of engineering an optimized, efficient metabolic pathway
- projected to help in achieving sustainable development goals by providing eco-safe solutions, food and agricultural security.
- Distinguish between various genetically modified organisms,
- Familiar with the regulatory guidelines of GMOs that govern food and pharma and food labeling,
- Articulate parameters to be met for food and pharma products, environmental monitoring and its agencies.
- Apply and practice good laboratory practices.
- Generate management quality assurance based on ISO tenets.

Unit I: Introduction to Systems Biology and Synthetic Biology:

Introduction to Systems Biology: Omics analysis; *In silico* modelling - Biochemical reactions, Metabolic pathways, gene expression and its regulation, genome scale model, networks, whole cell models; Modelling tools - such as AI, Bayesian, MatLab and Mathematica; Development of improved strains, study of infectious and other complex disease and other applications.

Synthetic Biology: Synthetic designing using BioBricks - DNA, parts, devices and System, BioBricks assembly and Gibson assembly, BioBuilder - iTune Device, Development of synthetic DNA, genome, gene circuits and cell (protocell) and xenobiology, Reengineering pathways, transcription and translation, process controls, iGEM projects, Synthetic biology of Cyanobacteria - Solazyme;

Production of fuels, chemicals, pharmaceuticals, food and eco safe solutions for sustainable development and other applications

Unit II: GMO Detection and GMO Product Analysis:

Methods for detection of GMOs – phenotypic, Molecular methods: DNA based methods - PCR, qPCR and alternate methods and protein-based methods - immunoassays, lateral flow devices and dip sticks, chromatography and infra-red spectroscopy

GMO product analysis - residual DNA analysis - Hybridization, qPCR and Threshold assay, microbial: Microbial load plate count, membrane filtration and qPCR, Pathogen testing - culture method, PCR and qPCR and immunoassays like dipsticks and lateral flow devices, VBNC cell detection - limited growth assay, epifluorescence assays, viability detection and phylogenetic labelling using fluorescently labelled antibodies; biochemical, molecular and toxicological evaluation - Lal test, detection of shiga toxins, aflatoxins and pyrogens.

Unit III: ISO, GLP and GMP:

Introduction of ISO, History of ISO, Overview of standards in ISO 9000 Family, Seven Key principles of ISO 9000, Difference between ISO 9001:2008 and ISO 9001:2015

Application: Sector specific Application of ISO 9001, Twelve quality system essentials

Introduction to GMP (Good Manufacturing Practices) and GLP (good Laboratory Practices) in **Pharmaceutical Industries Overview:** GMPs as enforcement by the U.S. Food Drug Administration (US FDA) under Title 21 CFR.

Documentation: Requirement related to GMP and GLP.

Unit IV: Regulations in Biotechnological Research and the Authorities:

Rules and Regulations, the concerned authorities and their function: for research using animals (CPCSEA.), stem cells (DBT), microorganisms, GMO (RCGM, GEAC, IBSC - Biosafety), plants (National Biodiversity Authority), The Environment Protection Act, Water Act and Air act.

PSLSCBTP401 Systems Biology and Quality Assurance – Practical

1. Modeling of expression network
2. SBML-A markup language for mathematical models in systems biology using cell designer
3. Site directed mutagenesis (Kit based)
4. Microbial analysis of GMO foods
5. BioBrick Assembly of expression cassette (virtual lab)
6. Preparation of SOPs.
7. Calibration of the equipments
8. Case study on CAPA
9. V labs: analysis of biological networks for feature detection.
10. V labs: Import and simulate a model from different databases.

REFERENCES:

1. David Hoyle (2000) Automotive Quality Systems Handbook Second Edition ISO/TS 16949:2002 Publisher : Elsevier
2. ISO 9000 quality systems handbook fourth edition by David Hoyle 8. International standard ISO9001: quality management systems — requirements fifth edition 2015-09-15.
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4. Edda Klipp, Wolfram Liebermeister, Christoph Wierling and Axel Kowald (2016). Systems Biology A Textbook, 2nd Edition, Wiley - VCH Verlag GmbH & Co. KGaA
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7. Christina Smolke, Sang Yup Lee, Jens Nielsen and George Stephanopoulos (2018). Synthetic Biology Parts, Devices and Applications, Wiley - VCH Verlag GmbH & Co. KGaA
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10. Oliver Brandenburg, Zephaniah Dhlamini, Alessandra Sensi, Kakoli Ghosh and Andrea Sonnino (2011). Introduction to Molecular Biology and Genetic Engineering, Food and Agriculture Organization of United Nations, Rome.
11. Knut Heller (2006). Genetically Engineered Food: Methods and Detection, 2nd Ed, Wiley - VCH Verlag GmbH & Co. KGaA
12. Sang Yup Lee, Dong-Yup Lee and Tae Yong Kim (2006). Systems Biotechnology for strain improvement. Trends in Biotechnology. Volume 3 (7): 349 - 358.
13. Research and review articles

PSLSCBTT 402: Pharmacognosy and Plant Biotechnology

Course Objectives: The learner would be:

- Made aware of the different techniques used in plant tissue culture and their applications in improved crop qualities and nutrition
- Able to identify and describe the conservation of the plant biodiversity as well as the engineered plants.
- Given hands on training in one of the most popular and important plant tissue culture techniques and its evolution.
- Introduced to the recent advances in plant biotechnology such as vertical farming.
- Able to tap the potential of plants

Course Outcomes: After going through the course the learner would be able to:

- Develop studies and protocols to improve nutrition and agricultural qualities of plants.
- Prepare methods to conserve biodiversity of plants.
- Design and execute micropropagation procedures for plants.
- Understand and apply propagation techniques in vertical farming
- Demonstrate Green-house management
- Understand the potential of plants to improve human life.
- Scientifically tap and value the bioactivity of plants.

Unit I: Natural Products:

Natural products: History of natural drugs, Sources of natural drugs - Plants, Animals, Microorganisms; medicinal mushrooms

Primary metabolites: carbohydrates, proteins, nucleic acids and lipids and their importance to plants;

Secondary metabolites: Types (Terpenoid, Nitrogenous, Phenolic pathways) mechanism of synthesis and modification of their skeletons and their importance in plants.

Principles used as: Medicine (Artemisinin, paclitaxel, digitoxin, morphine, acetyl salicylate, colchicine) nutraceuticals (isoflavonoids, glucosamine, phytosterol, resveratrol, carotene, lycopene), insecticide (rotenone, pyrethrin, azadirachtin), pigments (cochineal, annatto, indigo), fragrance (linalool, geraniol) flavours (vanillin) and other applications.

Unit II: Pharmacognosy and Bio-efficacy studies*:

Activity Guided Drug Development: Plant collection and Extract preparations: Methods of Plant collection, solvent extraction (cold, hot, critical fluid extraction etc), methods of identification (Qualitative and Quantitative), isolation and purification (Chromatography), Characterization (LC-MS, GC-MS, NMR, XRD, Elemental analysis etc);

In vitro testing - Antimicrobial, Antidiabetic, Antioxidant, Antiinflammatory, anti-larvicidal; Pre-clinical and clinical trials:

Unit III: Plant Tissue Culture and allied topics*

Basics of plant tissue culture: totipotency, macro and micro nutrients, media. Culture: micropropagation -Types of Micropropagation methods, Callus culture, Suspension cell culture, Protoplast culture, Somatic hybridization, Cybrids, Somatic embryogenesis and synthetic seed production.

Secondary metabolite production:(industrial scale): [shikonin, taxol (biosynthesis and bioreactor production) capsaicin/ berberine].

Green-House Management: Greenhouse structure, and design, Environmental Control Systems, Pest management. medicinal plant cultivation.

Vertical Farming: Concept, examples and methods (hydroponics, aquaponics and aeroponics), advantages, Vertical Farming in India, Challenges.

Unit IV: Transgenic Plants:

Plant transformation methods: *Agrobacterium tumefaciens* [including mechanism of T DNA transfer in wild type *Agrobacterium*], *A. rhizogenes*- its plasmid. Biolistic: factors that influence transformation success, chloroplast transformation: vectors, advantages and disadvantages of the technique.

Applications of transgenic plants: Overview, Recombinant proteins of pharmaceutical importance in plants including vaccine subunits, edible vaccines, from hairy root cultures. Transgenic plants: Strategies for virus resistance, Herbicide resistance, Insect resistance, nematode infections and resistance, stress resistance [salt, water, temperature, oxygen],

Improved nutrition and shelf life: [carbohydrate, protein], metabolic engineering,

Novel applications: change in lipid profile for industrial purpose, biodegradable plastics, novel horticultural traits [flower colour, variegation]

Alternative foods: Plant based meat, plants/ algae/yeast: production, nutritional scoring and effect on health. Artificial milk: sources, advantages and challenges.

Conservation: Improvement, exploitation and conservation of genetic resources, Cryopreservation of genetic resources.

PSLSCBTP 402: Pharmacognosy and Plant Biotechnology – Practical.

1. Micropropagation:
 - a. Media preparation
 - b. Shoot culture establishment
 - c. Rooting of the obtained shoots.
 - d. Hardening and Acclimatization of plantlets.
2. Production of bioactives/ pigments/ secondary metabolites from a suitable callus.
3. Study of the Greenhouse.
4. Vertical farming demonstration.
5. Natural product from animals: extraction of chitin/ chitosan from a suitable source.

6. Antimicrobial activity of bioactives and secondary metabolites
7. Measurement of free radicals by spectrophotometric method (Total phenolics, DPPH assay, ABTS assay, FRAP assay)
8. Plant pigments
 - a. Extraction of plant pigments from spinach
 - b. Separation by column chromatography
 - c. Determination of absorption spectra of plant pigments
9. Bioautography and other bioactive guided isolation
10. Separation of compounds using HPLC/ HPTLC/
11. Detection and quantification of compounds using Spectrofluoro/ UV-VIS Spectrophotometry

REFERENCES:

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2. Khan and Khanum (2001) Role of Biotechnology in Medicinal and Aromatics Plants by Vol. 1 to 4. Ukkaz Publications
3. M. K. Razdan (2006) Plant Tissue Culture. Oxford and IBH Publishing.
4. Arupratan Ghosh (2019) Greenhouse Technology: Principle and Practices. CRC Press
5. Dr. Dickson Despommier (2011) The Vertical Farm: Feeding the World in the 21st Century Paperback – 25 October 2011 by (Author), Majora Carter (Foreword)
6. Gary Grending (2019) Vertical Farming: How to combine business with environmental awareness.
7. Relevant Research/ Review papers.

PSLSCBTT 403: Research Methodology, Scientific Writing and Literature Review

Course Objectives:

- To understand the different types of research work.
- To present the research work scientifically.
- Understand the concept of Literature review.

Course Outcomes:

- Design a research framework.
- Develop soft skills in compilation and presentation of their research work.
- Prepare a draft research/ review article based on a Literature Review.

Unit I: Research Methodology and Scientific Writing*

Meaning of Research; Objectives of research, motivation in research;

Types of research – Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, Empirical and Other Types of Research; Research Approaches; Research Methods vs. Methodology; Research and Scientific Method; [Systematic review and meta-analysis](#).

Research Process: Steps of research process; Criteria of Good Research; Sampling, Sample size determination, Plan for data collection, Methods of data collection, Plan for data processing and analysis; Ethical considerations during research

Meaning of Scientific and non-scientific writings: Structures of Research proposals, Synopsis, Dissertations, Thesis, Research paper writings (Abstract, Introduction, Review literature, methodology, Results, Discussions, Summary, Conclusion, Bibliography etc); Presentations: Graphical, Tabular, Animation, Power point

Unit II: Literature Review:

Unit III: Literature review:

Unit IV: Literature Review:

PSLSCBTP 403: Research Methodology, Scientific Writing and Literature Review - Practical

1. Methods of Sampling.
2. Methods of data collection
3. Data analysis: Central tendency and dispersion.
4. Grant proposal writing.

5. Preparation and submission of a Draft Research/ Review Paper.

REFERENCE:

1. Koththari C. R. (2004) Research Methodology Methods and Techniques. Publ : New Age International (P) Limited
2. Dawkins Richard (2009) The Oxford Book of Modern Science Writing. Publ: Oxford Landmark Science
3. Schimel Joshua (2012) Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded.
4. Cohen Jesse (2010) The Best of the Best of American Science Writing (The Best American Science Writing)
5. Katz, Michael J. (2009) From Research to Manuscript A Guide to Scientific Writing (Second Edition); Springer Publication
6. Hilary Glasman Deal (2009) Science Research Writing for Non-Native Speakers of English.: Imperial College Press, London, UK
7. Angellka Hofmann (2014) Scientific Writing and Communication. Oxford University Press

PSLSCBTT 404: Tools for Research and Project

Course Objectives:

- To apply the various digital packages in statistics for the analysis of Research work.
- Apply mathematics to solve problems in biological studies.
- To deliver Hands-on experience in an Industry/ Institute/ Laboratory as an internship or project.

Course Outcomes:

- Analysed Research data using digital packages.
- Apply mathematics in evaluation of biological experiments.
- Experience hands-on application of aspects in biotechnology.

Unit I: Digital Packages for Statistics in research*

The appropriate use of various statistical packages for data analysis such as: SPSS, R, Matlab, Tableau, Graphpad Prism.

Application of biomathematics: Permutation, Combination, matrix, limit, differentiation and integration.

Unit II: Internship/Project

Unit III: Internship/ Project

Unit IV: Internship/ Project

PSLSCBTP404 – Practical and Internship/ Project

Internship/ Project: Viva.

Courses from NPTEL/ SWAYAM / UGC recognized courses would be declared for additional and value-added reading. There will not be any credits or examinations associated with these courses in this syllabus.