M.Sc., Biotechnology
(Specialization in Marine)

Curriculum Structure

&

Syllabus

(July, 2025 onwards)

Department of Marine Biotechnology

School of Marine Sciences

Bharathidasan University

(A State University Accredited with A^{+} Grade by NAAC)

Tiruchirappalli-24

Department of Marine Biotechnology

School of Marine Sciences

Bharathidasan University

Tiruchirappalli-620024

M.Sc., Biotechnology (Specialization in Marine)

(July, 2025 onwards)

Programme Outcomes

PO 1	PG Graduates are **Professionally Competent** with characteristic **Knowledge-bank, Skill-set, Mind-set** and **Pragmatic Wisdom** in their chosen fields.
PO 2	PG Graduates demonstrate the desired sense of being **seasoned** and exhibit unequivocal **Spiritedness** with excellent qualities of productive contribution to **society** and **nation** in the arena Science and Technology.
PO 3	PG Graduates are mentored such that they exert **Leadership Latitude** in their chosen fields with
PO 4	Commitment to novelty and distinction.
PO 5	PG Graduates are directed in understanding of ethical principles and responsibilities, moral and social values in day-to-day life thereby attaining **Cultural** and **Civilized** personality.

Programme Specific Outcome

PSO 1	Explore the Biotechnological methods and understand the diverse richness of ocean bioresources.
PSO 2	Impart knowledge of the fundamentals, developments and methodologies and avenues in biotechnology specialization in marine areas.
PSO 3	Learn about the Microbiology, Cell and Developmental Biology, Genetic Engineering, Molecular Biology and Microbial Genetics, Immunology, Marine products and processing, Micro algal biotechnology, Bioprocess Technology and Mariculture, etc.
PSO 4	Venturing knowledge in marine pharmacology, bioinstrumentation and bioresources.
PSO 5	Cost effective process, product or technology for future need in blue biotechnology
PSO 6	Lab-oriented hands-on investigative and research skills leading to research, teaching, technical placements
PSO 7	Inculcated ability to write research papers and develop communicative and oral skills
PSO 8	Self-motivated to solve the problems and critically analyze and interpret the results.
PSO 9	Opportunities that are available in Biotechnology and Marine is emphasized
PSO 10	Explore the Biotechnological methods and understand the diverse richness of ocean bioresources.

Regulations for M. Sc., Biotechnology (Specialization in Marine)

(Semester pattern – Choice Based Credit System - CBCS)

Eligibility for admission

A B.Sc., degree in Science with one or more branches of biology at the major or ancillary (subsidiary) levels with at least 55% marks. A candidate seeking admission shall not be more than 25 years of age on 1st July of the year of admission.

Duration of the Programme

Two Academic years (consisting of two semesters each year).

Programme Fees

Each student admitted to the M. Sc., Biotechnology degree (Specialization in Marine) Programme will pay: Tuition Fees, Special Fees, Library Fees, Caution Deposit (refundable), Laboratory Fees, Computer, Internet, Chemicals, Alumni Registration, Registration Fee, Recognition Fee, Matriculation Fee, Stationery, Identity Card Fee, Group Insurance, Sports Fee, Cultural Fee, Youth Development Fee, Youth Red Cross, etc., These fees are subject to change as per University norms.

Board of Studies

The Board of Studies for academic programme, syllabi etc., will consist of all members of the faculty of the Department of Marine Biotechnology, two external experts from other Universities, Industrial expert and special invitees if required. The Head of the Department of Marine Biotechnology shall be the Chairman.

Syllabus

The Syllabi for the various courses are designed keeping in view the usefulness of the course to the students for (1) continuation of academic activity leading to research, (2) teaching employability in Biotechnology (Marine) related vocations and self-employment.

Academic visits to institutions and/or industries related to the courses during the semesters study will form part of the curriculum. The students depending on their performance and choice would either have to carry out a project or undergo training or submit a report at the end of the final semester in an area of **Biotechnology (Specialization in Marine).**

From the academic year (2002-2003) choice based credit system (CBCS) is introduced in all departments of the University. According to this system the **M.Sc., Biotechnology (Specialization in Marine)** Programme requires a student to earn 92 credits in four semesters. The basic Course structure and the scheme of examinations are given in tables that follow.

A student has to undergo 9 core courses (with two choices), two electives, two non-major electives (EDC), mini and major projects. Students who need to pursue the Core courses have to be taken in the Department of Marine Biotechnology only. Each course contains 6 units among which the first 5 units are taught in view of examination purpose and the 6th Unit is for enhancing their knowledge and not for examination. Students are required to undergo a mini project/ internship/ fieldwork at the end of the second semester, and this activity carries a weight of 2 credit scores. In addition, they need to undergo two electives (one in each) during the second and third semesters. The elective courses can be taken either in the department of Marine Biotechnology and another in any other department in the University and the fourth semester includes a Self-study paper and project work.

Continuous Internal Assessment (IA)

The internal assessment component for theory for each student will include attendance, tests, model exams, seminars and/or assignments.

The internal assessment component for the laboratory Course for each student will consist of attendance, performance in the laboratory, observation notebook, tests and model exams. The Internal assessment component for each course will be 25% of the marks allotted to the course. This applies to theory as well as laboratory courses. The passing minimum marks for internal assessment is 10.00 (i.e. 40% of the IA). Project carried out in the IV semester will be valued by both internal and external examiners. (25 marks for internal assessment and 75 marks for external examination).

University Examination (UE)

The question paper setters for the University examinations in theory will be selected from a panel of examiners suggested by the course teachers. There will be a single valuation of the theory papers by external examiners. (As per syndicate resolution No. 2010.049 dated 18.02.2010, Vice-Chancellor's order dated 07.02.2012). The University exam will be conducted for a total of 75 marks.

The candidate should have scored at least 30.00 marks (i.e. 40% of the EA). To pass each course the candidate should get in an aggregate of >/=50 marks [(IA) + (EA) must be >/= 50 (i.e. 50% of the total)] out of 100.

There will be two examiners for each lab course, of whom one will be external and the other internal. There will be combined evaluation of the students by the two examiners. Each laboratory course examination will include a viva- voce component, the marks for which should not exceed 20% of the marks allotted.

A student has to obtain at least 50% of the marks allotted for the external component and at least 50% in the internal plus external aggregate to pass the theory or lab course component. Each course passing minimum for the Non-Major Elective (NME) in the University examinations will be 40%. Successful completion of a course requires a minimum of 'C' grade or 4 grade points.

Grade for the Subjects

Marks	Grade Points	Letter Grade
96 and Above	10	S+
91-95	9.5	S
86-90	9.0	D++
81-85	8.5	D+
76-80	8.0	D
71-75	7.5	A++
66-70	7.0	A+
61-65	6.5	A
56-60	6.0	B
50-55	5.5	C
Below 50	0	F

A student who fails in one or more of the theory papers will be permitted to appear for those papers in the subsequent semesters.

A student who fails in one or more of the laboratory course examinations in the first two semesters will be permitted to reappear for those examinations only along with the regular batch of students in the concerned semester in the following year. However, if a student fails in the lab course examination of the III Semester, the candidate will be permitted to reappear at the end of the IV Semester itself.

A student who fails in the project/field training-related examinations will have to redo the same in the subsequent semester and appear for the examination at the end of that semester.

Examination Fees

As per the University norms. (It is subject to change)

Assessment & Evaluation

Student evaluation is based on exams, assignments, quizzes and class participation. The grade allocation is as follows:

Continuous Internal Assessment: 25 Marks	End-Semester Exam: 75 Marks
Two internal tests, Assignments, Seminars, Attendance and Model etc.	Three hour examination for the theory courses and Six hour examination for lab courses.

Attendance

Students must have earned 75% of attendance in each course to appear for the examination. Students who have earned 70% to 74% of attendance to be applied for condonation in the prescribed form with the prescribed fee of Rs.400/- (Rupees four hundred). Students who have earned 60% to 69% of attendance to be applied for condonation in the prescribed form with the prescribed fee of Rs.400/- (Rupees four hundred) along with the medical certificate.

Students who have earned below 60% of attendance are not eligible to appear for the examination and they shall re-do the semester(s) after completion of the course, with the prior permission of the Registrar of the University.

Punctuality

The achievement of the students will be better only if they are punctual to the class and attend the class completely. It also creates a negative attitude and distracts the other students in the class. Hence students arriving late to the class by 10 minutes, without any valid reason, will be marked absent in the attendance record. However valid excuses including personal or medical emergencies are acceptable, with prior approval by the Head of the department.

Class Participation

Knowledge will be effectively imparted to the students only if they concentrate in the class and be more interactive. Also, providing an opportunity to the students to interact in the class will enable the teacher to know the strengths and weaknesses of the students. Hence the students are expected to get involved during the class hours and make the learning process interesting.

Submission of Assignments

The students are allocated two assignments for the course, covering the entire topics included in the course. They are prompted to submit the assignment to the teacher by the deadline. Careful preparation of the assignment is requested, since assignment preparations will also aid the students for final exam preparation.

Presentation of Seminars

Each student is supposed to give an oral presentation in the class seminar, where the students discuss the recent research findings and latest developments related to the topics assigned to them. This promotes the students to read more research articles and get acquainted with the scientific research undertaken around the world on a specified research theme. The other students attending the seminar are encouraged to actively participate in the seminar by asking valid questions.

Internship training/Field work

Each student must take internship training/ field work in any biotechnology or aquaculture related fieldwork for a period of minimum 30 days anywhere in the globe during their II semester vacation

period. After completion she/he should submit their report and give a presentation about their work in the department meeting. All the faculties in the department evaluate it and give internal marks based on the training and presentation.

Preparedness

Prior-learning will help the students to understand better about the topic taken in the class. Hence the students are intimated about the topics to be covered in advance, so that it will also help them to clarify their doubts on the topic, when the class is taken.

Academic Dishonesty

Since many of the students don't have proper knowledge about academic integrity, they may commit academic dishonesty unintentionally. Hence the students will be first made to understand about what plagiarism is, avoid copying of others assignments, and prevent violation of copyright laws and so on, so that academic dishonesty may be avoided.

Subject change clause

Depending upon the requirement of the students, the contents mentioned in the syllabus and the course details are subject to minor changes which will be informed to the students.

Question paper pattern (Theory)

Section	Marks (Max: 75 Marks)
Part A Answer all 10 questions (Two questions from each unit)	10 x 2 = 20 Marks
Part B Answer any 5 questions, out of 7 (Two questions from each unit)	5 x 5 = 25 Marks
Part C Answer all 3 questions choosing either (a) or (b) (One question from each unit)	3 x 10 = 30 Marks

Question paper pattern (Practical)

Section	Marks (Max: 75 Marks)
Part A (Major)	1 x 20 = 20 Marks
Part B (Minor)	1 x 15 = 15 Marks
Part C (Spotters)	5 x 5 = 25 Marks
Record	1 x 5 = 05 Marks
Viva-voce	1 x 10 = 10 Marks

Programme Specific Qualification Attributes

Programme specific qualification attributes achieved through courses in the programme in terms of

- Knowledge and understanding level (K1 and K2)
- Application level (K3)
- Analytical level (K4)
- Evaluation capability level (K5)
- Scientific or synthesis level (K6)

Result Passing Board

All the faculty members from the Department of Marine Biotechnology will be the Board of Examiners to pass the Results. The Head of the Department of Marine Biotechnology shall be the Chairman of board of examiners.

M.Sc., Biotechnology (Marine)

(Applicable to the candidates admitted from the Academic year **July, 2025** onwards)

Curriculum Structure

S. No	Course Code	Title	Credits	Hours / Week	Marks		Total	Page No
					Internal	External		
SEMESTER I								
1	25CC1	Microbiology (T)	5	5	25	75	100	
2	25CC2	Biochemistry (T)	5	5	25	75	100	
3	25CC3	Cell and Developmental Biology (T)	5	5	25	75	100	
4 a	25CC4a	Marine Bioresources & Aquaculture (T)	5	5	25	75	100	
4 b	25CC4b	Marine Environmental Biotechnology (T)						
5	25LC1	Microbiology (L)	4	4	25	75	100	
6	25LC2	Biochemistry & Cell and Developmental Biology (L)	4	4	25	75	100	
SEMESTER II								
7	25CC5	Molecular Biology and Microbial Genetics (T)	5	5	25	75	100	
8 a	25CC6a	Industrial Biotechnology (T)	5	5	25	75	100	
8 b	25CC6b	Genomics and proteomics (T)						
9 a	25EC1a	Bioinformatics and Biostatistics (T)	5	5	25	75	100	
9 b	25EC1b	Marine Pharmacology (T)						
10 a	25EC2a	Marine Product and Processing (T) – NME	2	3	25	75	100	
10 b	25EC2b	Micro algal Biotechnology (T) - NME						
11	25LC3	Molecular Biology and Microbial Genetics (L)	4	4	25	75	100	
12	25LC4	Industrial Biotechnology (L)	4	4	25	75	100	
13	25MPW	Mini project/Internship/Field Visit	2	-	-	-	50	
SEMESTER III								
13	25CC7	Immunology (T)	5	5	25	75	100	
14 a	25CC8a	Genetic Engineering (T)	5	5	25	75	100	
14 b	25CC8b	Synthetic Biology (T)						
15 a	25EC3a	Marine Biotechnology (T)	5	5	25	75	100	
15 b	25EC3b	Coastal Zone Management (T)						
16 a	25EC4a	Bioinstrumentation (T) – NME	2	3	25	75	100	
16 b	25EC4b	Mariculture (T) - NME						
17	25LC5	Immunology (L)	4	4	25	75	100	
18	25LC6	Genetic Engineering (L)	4	4	25	75	100	
SEMESTER IV								
19	25CC9	Self Study	4	15	25	75	100	
20	25PW	Project Work	8	15	25	75	100	
Total Number of Credits			**92**				**2000**	

(T) – Theory, (L) Laboratory Course, NME – Non-Major Elective, At each semester Students can choose either a or b as their optional paper

VALUE ADDED COURSE								
21	25VAC1	Good Laboratory Practices (T)	2	3	25	75	100	
22	25VAC2	Biomolecule Separation Techniques (T)	2	3	25	75	100	
23	25VAC 3	Ornamental Fish Culture(T)	2	3	25	75	100	

SEMESTER I

Title of the Paper : Microbiology

Course code: 25 CC 1

Course Objectives

1	To understand the fundamentals of microbiology and classification systems of bacteria, fungi and virus.
2	To know the structural organization of microbial cellular components and, their functions.
3	To sensitize students about microbial physiology, biochemistry and energy transfer through metabolic pathways.
4	To impart knowledge and experimental skills in identification, application and evaluation of microorganisms in various industrial fields.
5	To explore the significance of microbiology in environmental and public health, emphasizing the role of microorganisms in ecological processes and disease prevention.

Course Outcome

1	Gain the fundamental concepts of microorganisms, their cellular components and taxonomical classification systems.
2	Know the diversity of microbes based on their nutrition, growth and various microbial interactions in the ecosystem.
3	Know the basics of microbial metabolism through various cycles and pathways.
4	Comprehend the structural organization, classification and life cycle of different viruses, viroids, prions etc.
5	Recognize, explore and critically evaluate the significance of microorganisms in food and dairy industries.

UNIT – I: Ultra structure and Classification of microorganisms	
Content	**PSQA Level**
Cell structure and function of prokaryotes and eukaryotes.** Bacteria morphological types - cell walls of Archaebacteria, Gram-positive and Gram-negative Eubacteria, photosynthetic bacteria, Cyanobacteria, Actinomycetes, Rickettsiae, L-forms, Mycoplasmas.	K1, K2, K3 & K4
Structure and functions: Cell membrane, Cilia, Flagella, Slime Layer, Capsule, Pili, Gas Vesicles, lipopolysaccharides. Inclusion bodies - Chlorosomes, Carboxysomes, Magnetosomes and Phycobilisomes.	
Reserve food materials - PHB, Polyphosphate granules, Sulphur inclusions, Cyanophycean granules. Endospores - structural properties and cell division	
Classification Basis of microbial classification, - Purpose, Basic principle. Taxonomy- Haeckel's three kingdom concept*, Whittaker's five kingdom and Carl Woese's three domain classification system. Bergey's Manual of Systematic Bacteriology	
16s rRNA sequencing, 23s rRNA sequencing, ITS region and its applications. Stress response - quorum sensing, biofilm formation and bacterial chemotaxis	
Fungi – Introduction, general characteristics and distribution. Mycorrihiza and lichens, and Algae.**	
Brief account of polyphasic taxonomy markers*	

UNIT – II: Microbial Nutrition and Growth:	
Content	**PSQA Level**
Nutrition: Autotrophs - Phototrophs – Chemotrophs – Lithotrophs. Organotrophs – Heterotrophs – Auxotrophs: Symbiotic* - Parasitic.	K1, K2, K3, K4 & K5
Media - Classification, Preservation. Culture media: Enrichment media, Selective media**, Differential media, Resuscitation media, General purpose media, Anaerobic culture media.	
Microbial growth curve, Growth phases: Synchronous and Asynchronous – batch and continuous cultures - Chemostat, Turbidostat	
Role of Microorganism on the earth - Symbiosis, mutualism, commensalism and parasitism.	
Probiotics and Biological Control Agents (BCA)	
Biodegradation and biodeterioration of oil, plastics and Xenobiotics.	

UNIT – III: Microbial Metabolism	
Content	**PSQA Level**
Oxidative phosphorylation and Theories of ATP formation, Inhibition of Electron Transport Chain.	K1, K2, K3, K4 & K5
Bacterial anaerobic respiration: Nitrate, carbonate and sulphate as electron acceptors (Electron Transport Chain in some anaerobic bacteria)	
Metabolism: EMP (Embden-Meyerhof Parnas), HMP (Hexose Monophosphate Pathway), - TCA cycle - Oxidative Phosphorylation, Substrate level Phosphorylation*, Entner-Doudoroff pathway.	

UNIT – IV: Viruses	
Content	**PSQA Level**
History, General properties of Viruses; classification and taxonomy of Viruses* - based on host, nucleic acid and structure, ICTV classification. Bacterial viruses -Structural organization	K1, K2, K3, K4 & K5
Life cycle - Transcription - Replication - Phage production - Lysogenic cycle, Genetics of bacteriophages: T4, Lambda, M13.	
General characterization of animal and plant viruses*. Plant viruses - General characters of TMV, CMV – brief account** Animal viruses - General characters - Myxo, Herpes, Adeno, Retrovirus, Corona virus, HIV, Hepatitis viruses.	
A brief account of Viroids, Virusoids, Satellite RNAs & Prions, Cyanophage and Mycophage	

UNIT – V: Food and Dairy Microbiology	
Content	**PSQA Level**
Microbial fermented food products and dairy products*: Cheese, Yoghurt, Butter milk, Sour cream. Fermented vegetables: Sauerkraut, pickles, olives and soy sauce. Fermented meat and fermented Indian foods.	K1, K2, K3, K4 & K5
Food preservation* - Heat processing, Irradiation, High-pressure processing - Low-temperature storage and Chemical preservatives**	
Food spoilage: fruit, meat, sea foods and milk products.	
Food borne diseases* - Food borne pathogens, Toxins - Endotoxin, Exotoxin and Mycotoxin**	

UNIT –VI: Current contours
Discussion on current research in microbiology and the importance of basic microbiology in research. Visit to Food processing Research Institutes and Industries. Developing knowledge on the role of microorganisms in various fields - Antibiotics, Antimicrobial peptides, Probiotics, Bioremediation, Superbugs.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC1	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	M	S
CO 3	S	S	S	S	S
CO 4	S	S	S	M	M
CO 5	M	S	S	S	S
S-Strong; M-Medium; L-Low					

References	
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11.	https://www.sciencedirect.com/science/article/pii/B9780444636683000019
12.	https://courses.lumenlearning.com/suny-microbiology/chapter/biogeochemical-cycles/
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Title of the Paper : Biochemistry

Course code: 25 CC 2

Course Objectives

1	To understand basic concepts about Biomolecules in the Cell.
2	To improve knowledge on types, classification and importance of Carbohydrates.
3	Metabolism of Carbohydrates related to phosphorylation and energy transfer.
4	To know the structure, function and application of Amino acids and Proteins and Enzymes Lipid and Fatty acid structure and function including membrane transport mechanism.
5	To study about structure, function and application of Nucleic acids.

Course Outcome

1	The successful completion study of an organism's complete set of DNA is one related of biochemistry long – term implications for drug development and clinical workflows.
2	Students acquire knowledge on chemical compounds human body in Carbohydrate, Lipids, Amino acid, Protein, Blood, Plasma & Nucleic acids (DNA & RNA).
3	To understand knowledge on cell development, enzyme activity, membrane transport mechanisms. Homeostasis, blood coagulation (clotting) & oxygen transport.
4	To understand how living systems operate, survive and die.
5	To gain an over view on functions of bio molecules interactions biochemical pathways.

UNIT – I: Introduction

Content	PSQA Level
Biomolecules: General account. Chemical basis of Life	K1, K2, K3 & K4
Molecular assemblies - Structure – Function, relationships.	
Bond types – Ionic, Covalent, Vander walls, Hydrogen, Hydrophobicity and Hydrophilicity.	
Water and its properties. Brief account of major Pigments – Chlorophyll, Carotenoids, Astaxanthin, Phycobilins, Antenna pigments.	
Fat- and Water-soluble Vitamins.	
pH, pH meter and Buffer	

UNIT – II: Carbohydrates

Content	PSQA Level
Carbohydrates: Structure and Properties – Mono – Di – Trisaccharides	K1, K2, K3 & K4
Types of sugar	
Optical isomerism – Epimers – Anomers.	
Important reaction of sugar	
Biological importance of Oligo and Polysaccharide	
Cellulose, Starch, Glycogen, Chitin, Glycoprotein – Blood group polysaccharides	

UNIT – III: Proteins

Content	PSQA Level
Protein: Amino acids	K1, K2, K3 & K4
Types - Aliphatic, Aromatic amino acid, Acidic – Basic, Essential – Non essential	
Zwitter ion – Isoelectric pH	

Primary – Secondary – Tertiary and Quaternary structures	
Peptide bond – Protein folding	
Genetic - Triplet Codon, - Non-sense Codon,	
Protein types – Fibrous / Globular	
Enzymes: Definition, Classification – Structure – Properties – Co-Enzymes. Vitamins and Essential metals.	
Isoenzymes, non-protein catalysts – Ribozymes. Hormones – Classification and Functions.	

UNIT – IV: Fatty acids	
Content	**PSQA Level**
Fatty acids: Classification – Saturated – Unsaturated – Essential Fatty Acids	K1, K2, K3 & K4
Lipids: Types	
Triglycerides: Properties and Characterization of Fats – Hydrolysis, Saponification – Halogenation – Acetyl Number – Iodine Number.	
Types: Phospho – Glyco – Sphingo lipids, Sterols.	
Lipoproteins, Liposomes, Lipid Micelles and its Uses.	

UNIT –V: Nucleic acids	
Content	**PSQA Level**
Nucleic acid: Classification – DNA – RNA.	K1, K2, K3,K4 &K5
Structure of Nitrogenous Bases: Purine – Pyrimidine.	
Synthesis of Nucleic acids, DNA – De-Renaturation. Hyperchromic effect and Tm.	
Application of Nucleic acid Hybridization.	
Chromosome organization – Pro – Eukaryotes - Replication – Okazaki fragments.	
Extra Chromosome – Importance of RNA types 16/18s as Molecular Markers.	

UNIT –VI: Current contours
To discuss biological macromolecules such as proteins, carbohydrates, lipids and nucleic acids. To have understanding the interaction and function of biological molecules. To inform the students recent trends in biochemistry.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC2	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	M
CO 2	S	S	S	M	L
CO 3	S	S	S	M	L
CO 4	S	S	S	M	L
CO 5	S	S	S	M	L
S-Strong; M-Medium; L-Low					

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2	Lehninger Principles of Biochemistry: 8th Edn, 2021, David L. Nelson, Michael Cox, Aaron A. Hoskins, W.H. Freeman, USA.
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Title of the Paper : Cell and Developmental Biology

Course code: 25 CC 3

Course Objectives

1	To provide a conceptual overview of cellular systems and functioning of prokaryotic and eukaryotic cells.
2	To discuss detailed study about life cycle of cell.
3	To discuss the basic concept of developmental biology.
4	To acquire detailed knowledge on stem cell biology.
5	Enlighten knowledge about genome and chromosomal organization.

Course Outcome

1	To gain knowledge on the structural and functional organization of pro and eukaryotic cells.
2	Acquire knowledge on different phases of cell cycle, cell signals, their molecular mechanism and control.
3	Understand the concepts of genesis and genetics of cell development.
4	Explore on the basic concepts, classifications, types and applications of stem cells.
5	Understand the structural, functional and molecular organization of chromosomes.

UNIT – I: Structure and functions of pro and eukaryotic cells

Content	PSQA Level
Cell theory and Endosymbiotic Theory, Major intracellular compartments in Prokaryotic and Eukaryotic cells - brief description	K1 & K2, K3 & K4
Detailed structure of Nucleus, Mitochondria, Golgi bodies, Lysosomes, Endoplasmic reticulum, Chloroplast, Plastids, Vacuoles, Peroxisomes and Glyoxysomes with reference to their functional inter relationship	
Genetic systems in mitochondria and chloroplast	
Structural organization, chemical composition and functions of cell wall and membranes. Structure of model membrane: Unicellular, Lipid bilayer, fluid mosaic model, membrane proteins (intrinsic, extrinsic, lipid-linked)	
Transport mechanisms (mediated and non-mediated), ion channels and pumps.	

UNIT – II: Life cycle of the cell

Content	PSQA Level
Cell growth and Division, Phases of Cell cycle**	K1 & K2, K3 & K4
Cell Cycle Control System; Extracellular and Intracellular signals	
Cell cycle checkpoints – DNA damage checkpoint, Centrosome duplication checkpoint, Spindle assembly checkpoint, Cyclins and Cyclin-dependent kinases.	
Significance of Meiosis in generating genetic variation. *	
Programmed cell death – Molecular Mechanism and Control - Paraptosis, Apoptosis	

UNIT – III: Basic Concepts of Developmental Biology

Content	PSQA Level
Introduction, Potency, Commitment, Specification, Induction, Competence, Determination, Differentiation, Morphogenetic Gradients, Cell Fate and Cell	K1, K2, K3, K4 & K5

Lineages.	
Genomic equivalence and the cytoplasmic determinants, Imprinting, Transgenics in analysis of development.	
Gametogenesis- Zygote formation, Cleavage, Blastula and Gastrula.	
Morphogenesis and Organogenesis of Heart in Zebrafish.	

UNIT –IV: Genome and Chromosome Organization	
Content	**PSQA Level**
Structure of Chromatin and Chromosomes - Histones and Non-Histone Proteins, Nucleosomal Organization of Chromatin, Higher Levels of Chromatin Structure	K1, K2, K3, K4 & K5
Heterochromatin and Euchromatin, Formation of Heterochromatin	
Chromosomal packing and structure of Metaphase chromosomes	
Molecular structure of the Centromere and Telomere.	

UNIT – V: Stem Cell Biology	
Content	**PSQA Level**
Stem Cells: Properties, Classification and Therapeutic applications.	K1, K2, K3, K4 & K5
Different Types – Embryonic Stem Cells, Hematopoietic Stem Cells, Mesenchymal Stem Cells, Induced Pluripotent Stem Cells and Fetal Stem Cells.	
Stem cells from adult organs- Isolation, Culturing and Characterization	

UNIT –VI: Current contours
Discussion on updated information about Molecular Biology, Recent innovation and creative happenings in the field of Cell Biology. Awareness on different types of stem cells and their significance.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC3	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	S	S	S	S	S
CO 2	S	S	M	M	M
CO 3	S	S	M	M	L
CO 4	S	S	M	M	L
CO 5	S	S	M	M	L
S-Strong; M-Medium; L-Low					

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Title of the Paper : Marine Bioresources and Aquaculture

Course code: 25 CC 4a

Course Objectives

1	To identify and characterize the flora of marine ecosystem.
2	To identify, characterize and understand the life history of marine fauna.
3	To explore the assessment of marine resources.
4	To study population dynamics of marine bioresources and protect marine environment.
5	To gain knowledge on basic characterization and importance of aquaculture.

Course Outcome

1	Understood the biodiversity of marine flora and fauna.
2	Gained knowledge on surveillance and assessment of marine bioresources.
3	Attained knowledge on marine population dynamics and marine environment protection.
4	Gained basic knowledge on aquaculture its scope, nutritional values and feed supplements.
5	Developed the ability to analyze and propose solutions to challenges related to marine ecosystems, considering factors such as climate change, pollution, and overexploitation of resources.

Unit I: Introduction to Marine Biology	
Content	**PSQA Level**
Introduction to Marine Environment; Marine Flora and Fauna - Characteristics, Classifications, and Identification - Phytoplankton*, Zooplankton, Macroalgae, Sea grasses and Mangroves, Food chain and Food web.	K1, K2 & K3

Unit II: Economically Important Marine Fauna and their Characteristics	
Content	**PSQA Level**
Major Marine Invertebrates (Crustaceans & Molluscans); Vertebrates (Pisces) and Marine Mammals (Dolphin and Whales) – Characteristics, Classifications and Identification.	K1, K2 & K3
Biology of Marine Fauna: Invertebrates and Vertebrates	
Life Cycle of Crustaceans (crab, shrimp - *P. vannamei*, *P. monodon*), molluscans (Oysters) and fishes (Groupers, Seabass, Cobia).	

Unit III: Marine Resources Assessment	
Content	**PSQA Level**
Methods of surveying the Living Resources (Acoustic, Aerial, Remote Sensing, Potential Fishing Zone (PFZ) and Artificial Intelligence).	K1, K2, K3 & K4
Types of–Marine ecosystems, Population dynamics - Principles of population dynamics; Unit stocks; Age & size composition of the population; Abundance and density; Recruitment; Growth; Mortality (Fishing & Natural), Biodiversity & Oceanography	
Conservation and Management- *in situ* and *ex situ*; IUCN categorization; Marine biosphere reserves; Marine parks** - heritage sites.	

Unit IV: Aquaculture	
Content	**PSQA Level**

Definition and scope, Types, Methods and necessity, Criteria for selection of candidate species for aquaculture, quantity and quality of water, sources of pollution and conflicts.	K1 K2, K3 & K4
Live Feed: Importance in aquaculture; Bacterioplankton, phytoplankton and zooplankton and their role in larval nutrition, Their cultivation Techniques.	
Supplementary feeds: Types of Feeds - Wet Feed, Moist Feed, Dry Feed, Mashes, Pellet feed. Feeds - Floating and Sinking Feeds, Microencapsulated Diets and its significance.	
Feed additives: Binders, Antioxidants, Enzymes, Pigments, Growth Promoters, Feed Stimulants, Minerals and Preservatives.	

Unit V: Aquaculture Types	
Content	**PSQA Level**
Fin fish - Monoculture, Polyculture. Shell fish -Mud crab, Shrimp (*P. monodon*, *P. vannamei*) Molluscans and Fishes. Ornamental fish cultivation.	K1, K2 K3, K4 & K5
Integrated Aquaculture Techniques – Recirculation Aquaculture Systems, Aquaponics systems, Integrated Aquaculture (IMTA), Fish cultured in waste water, Biofloc technology. Seaweed farming, polychaete culture	

Unit VI: Current Contours
To inform the students about recent biological resources in marine & oceanography and selected happenings. Threats faced by marine ecosystem and its impacts. Blue economy, DOM project
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC4a	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	S	S
CO 3	S	S	S	M	S
CO 4	S	S	S	M	M
CO 5	S	S	S	M	M
S-Strong; M-Medium; L-Low					

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Title of the Paper : Marine Environmental Biotechnology

Course code: 25 CC 4b

Course Objectives

1	To familiarize students with different types of marine environments.
2	To extend knowledge on marine pollution indicators and minimization of pollutants.
3	To understand the structure and functions of ecosystem and biomaterial interaction.
4	To know about the fouling and corrosion of marine environment.
5	To understand the marine ecosystem, waste disposal and management.

Course Outcome

1	Understood the environmental characteristics of marine ecosystem and their interaction with marine life.
2	Gained knowledge on marine pollution and its management.
3	Familiarized with the interaction of biotic and abiotic factors in marine ecosystem.
4	Understood about the fouling and corrosion of marine structures.
5	Acquired knowledge on marine ecosystem and its waste management.

Unit I: Marine organisms and environment interaction	
Content	**PSQA Level**
Types of marine environment, Physical, Chemical and Biological aspects and their interaction with marine life*; Air – Sea interaction; Greenhouse gases** (CO_2 and Methane).	K1, K2, K3 & K4
Toxic chemicals in the environment- air, water & their effects, Pesticides in water, Biochemicals aspects of arsenic, cadmium, lead mercury, carbon monoxide, ozone and pesticide.	

Unit II: Pollution	
Content	**PSQA Level**
Marine pollution-major pollutants (heavy metal, pesticide, oil, thermal, radioactive, plastics, litter and microbial)** - Ballast water mediated associated invasive species	K1, K2, K3, K4 & K5
Biological indicators (Marine microbes, algae and crustaceans) and accumulators	
Application of Protein biomarkers; Biosensors and biochips*.	
Mode of entry of toxic substance, biotransformation of xenobiotics detoxification, chemical carcinogenicity, mechanism of carcinogenicity, Environmental carcinogenicity testing, MIC effects, Concept of major, trace and Rare Earth Element (REE)- possible effects of imbalance of some trace elements.	

Unit III: Biomaterial interaction	
Content	**PSQA Level**
Biodegradation and Bioremediation; Biodegradation of natural and synthetic waste materials; Bioremediation, Xenobiotics; Separation, purification and bio removal of pollutants*.	K1, K2, K3 & K4
Ecosystem structure and functions, abiotic and biotic components.	
Energy flow, food chain, food web, Ecological Pyramids-types, biogeochemical cycles, ecological succession.	

Unit IV: Fouling and corrosion	
Content	**PSQA Level**
Biofouling*; Biofilm formation; Marine fouling and boring organisms - their biology, adaptation.	K1, K2, K3, K4 & K5
Factors influencing the settlement of macrofoulers; Antifouling and Anti boring treatments; Corrosion Process and control of marine structures**.	

Unit V: Ecosystem restoration	
Content	**PSQA Level**
Earth's major ecosystem - terrestrial and aquatic ecosystem, marine microorganism and their functions.	K1, K2, K3, K4 & K5
Coastal management, criteria employed for disposal of pollutants in marine ecosystem, coastal water system and man-made reservoirs, biology and ecology of reservoirs.	
BOD, COD; Biomolecules; membrane and transducer; Bioaugmentation-estimation of microbial load; Methods of Inorganic and Organic waste removal**.	

Unit VI: Current Contours
Group discussion on various currently available topics of marine pollution and prevention. Discussion about greenhouse effect and removal of pollutants using biological methods.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC4b	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	S	S
CO 3	S	S	S	M	S
CO 4	S	S	S	M	M
CO 5	S	S	S	M	M
S-Strong; M-Medium; L-Low					

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Title of the Paper : Microbiology (Lab Course)

Course code: 25 LC 1

Course Objectives

1	To perform basic laboratory practices for the morphological identification of microbes.
2	To inculcate knowledge on microbial nutrition, growth and reproduction characteristics.
3	To gain knowledge on biochemical characteristics of different microorganism.
4	To get acquaintance with potability of water and quality food products.
5	To mastering molecular techniques for microorganism identification and characterization via DNA/RNA analysis and molecular biology applications.

Course Outcome

1	Understand the microbial diversity and its existence in the environment and food products.
2	Develop skills in isolation and identification of various microorganism morphologically.
3	Helps to analyze the culture growth and biochemical characterization of different microorganisms.
4	Through this course the students developed practical skills in microbiology helping them to be placed in clinical laboratories, research laboratories and in various microbial biotechnology industries.
5	Apply microbiological principles to address real-world challenges in environmental monitoring, food safety, and healthcare.

Content	PSQA Level
1. Isolation and Pure Culture Techniques 1. Water, Air and Soil microorganisms, Microorganisms from fermented foods and spoiled foods. 2. Serial Dilution Technique 3. Pour, Spread and Streak plate methods. 4. Isolation of discrete colonies from a mixed culture.	K2, K3, K4 & K5
2. Cultivation of Microorganisms 1. Preparation of culture media for cultivation of various Bacteria and Fungi. 2. Differential media for Bacteria, Actinomycetes, Fungi and Cyanobacteria. Selective media - Coliforms, Azotobacter, Azospirillum, Phosphobacteria, and Nitrogen fixers. 3. Cultivation of Viruses (Theory)	K2, K3, K4 & K5
3. Staining techniques & Microscopic Examination 1. Microscopic observation of Bacteria, Fungi and Cyanobacteria. Staining Techniques: 2. Simple Staining, 3. Differential Staining - Gram staining and Acid fast staining 4. Structural staining- Capsular, Endospore and Flagella staining 5. Fungi- Lactophenol cotton blue staining	K2, K3, K4 & K5
4. Biochemical characterization 1. Sugar (different sugars) fermentation 2. IMViC test	K3, K4 & K5

3. Catalase test 4. Oxidase test 5. Urease test 6. Nitrate reduction test 7. TSI test 8. Starch Hydrolysis test	
5. Measurement of Growth 1. Synchronous culture 2. Asynchronous culture 3. Growth curve and generation time by Optical Density and cell count. 4. Antibiotic susceptibility test	K3, K4 & K5
6. Quality Assessment tests 1. Water quality analysis- MPN method. 2. Milk quality analysis- Methylene blue Reductase	K3, K4 & K5

Mapping with Programme Outcomes

Course Code 25LC1	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	S	S
CO 3	S	S	S	M	M
CO 4	S	S	S	M	M
CO 5	S	S	S	M	M
S-Strong; M-Medium; L-Low					

References

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Title of the Paper : Biochemistry & Cell and Developmental Biology (Lab course)

Course code: 25 LC 2

Course Objectives

1	This Lab course can help the candidate to quantify the amount of Biological Macro molecules from various Biological samples.
2	To find out the concentration of Pigments (Chlorophyll-Carotenoids, Phycobiliproteins) present in Plant extract and Separate pigments and Proteins using Chromatographic techniques.
3	To understand the effect of Physical and Chemical on the Growth of Bacteria - Temperature, pH, Oxygen, Radiation, Water activity, Macro and Micro nutrients.
4	To study principle of Nitrogen fixation by Acetylene reduction assay and perform Gas chromatographic technique.
5	To assay Glutamine synthetase and Nitrite reductase by colorimetric technique.

Course Outcome

1	Familiarize with the Biochemical procedures and equipment's used for Biochemistry research.
2	Extract and Estimate Macromolecules Carbohydrates, Proteins, Amino acids and Lipids, Nitrogen- fixing ability of microbes.
3	Analyze the photosynthetic major and accessory pigments and other Phytochemicals.
4	Understanding the effect of Physical and Chemical factors on Microbial growth.
5	Provides handling experience in microorganisms and various samples Biomolecular extraction and quantification.

	Content	PSQA Level
1.	**Nucleic Acids:** 1. Quantification of RNA by Orcinol method Quantification of DNA by Diphenylamine method	K3, K4 & K5
2.	**Amino Acids:** 1. Qualitative estimation of Aminoacid by Ninhydrin method. 2. Qualitative analysis of-Amino acids by Paper Chromatography	K3, K4 & K5
3.	**Proteins:** 1. Quantitative estimation of Protein by Biuret method 2. Quantitative estimation of Protein by Lowry's method 3. Quantitative estimation of Protein by Bradford method	K3, K4 & K5
4.	**Carbohydrates:** 1. Quantitative analysis of Carbohydrate reducing and non-reducing sugars – Phenol Sulphuric acid method	K3, K4 & K5
5.	**Lipids:** 1. Estimation of Lipids (Gravimetric) 2. Estimation of Cholesterol by Acetic anhydride method	K3, K4 & K5
6.	**Pigments:** 1. Calibration and estimation of Pigments (Chlorophyll Carotenoids, Phycobiliproteins)	K3, K4 & K5

	2. Quantitative analysis of Pigments by TLC	
7.	Fixation of Nitrogen by Acetylene reduction assay using Gas chromatographic techniques.	K3, K4 & K5
8.	Assay of Glutamine synthetase, Nitrite reductase and Nitrate reductase by colorimetric technique.	K3, K4 & K5

Mapping with Programme Outcomes

Course Code 25LC2	PO1	PO2	PO3	PO4	PO5
CO 1	S	S	S	S	M
CO 2	S	S	S	S	M
CO 3	S	S	S	S	M
CO 4	S	S	S	S	M
CO 5	S	S	S	S	M
S-Strong; M-Medium; L-Low					

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SEMESTER II

Title of the Paper: Molecular Biology and Microbial Genetics

Subject Code: 25 CC 5

Course Objectives

1	Acquire knowledge on gene expression in both Pro and Eukaryotes including post translational modifications.
2	To understand and acquire knowledge on advanced molecular biology techniques.
3	Basic molecular biology knowledge may be helpful in performing advanced biotechnology research as developing technical skills in sequencing, and getting jobs related to it.
4	Acquire knowledge on recent research advanced molecular biology techniques and recent research in genetics.
5	Understanding the basic knowledge in mutation studies and cloning techniques.

Course Outcome

1	Acquire knowledge about the historical experiments to prove DNA as a genetic (central dogma) element and its related progress.
2	The course explains the students on DNA replication both in Pro and Eukaryotes, different types of mutation and DNA Repair mechanisms.
3	Learn more about mechanisms of horizontal gene transfer, recombination, DNA repair methods
4	To make aware of students about genomics, various types of plasmids, transposable elements and gene mapping.
5	To make them knowledgeable about the concepts of gene regulations.

UNIT – I: Central Dogma of Molecular Biology

Content	PSQA Level
Identification of genetic material (Griffith, Avery &Hershey and Chase experiments). Structure of DNA and RNA.	K1, K2, K3, K4 & K5
DNA Replication in Prokaryotes and Eukaryotes; Replication origin, Replication fork, Okazaki fragment, Fidelity of replication, Inhibitors of DNA replication.	
Enzymes involved – Polymerases, Helicase, Primase, Telomerase, Aminoacyl tRNA synthetase.	
Transcription and Translation - Initiation, Elongation and Termination.	
Universal Genetic code, Codon degeneracy, Wobble hypothesis.	
Protein translation machinery, RNA Polymerases, RNA processing – capping, polyadenylation.	
-RNA Editing and Splicing. RNA Transport and Transcription inhibitors. Amino acylation of tRNA.	

UNIT – II: Mutations, Recombination & DNA repair

Content	PSQA Level
Genetics nomenclatures - Mutagenesis, mutations and mutants. Types of mutants – biochemical basis of mutations, Spontaneous and induced mutations.	K1, K2, K3, K4 & K5
Isolation and characterization of mutants, reversion, suppression; causes of mutation – physical, chemical and biological.	
Types of mutations – Lethal, Conditional, Biochemical, Loss of function;, Detection of mutants.	

Discovery insertion sequences (IS) elements, complex and compound transposons – T10, T5, Retrotransposon. Recombination– homologous, non-homologous and site-specific recombination.	
DNA repair mechanism, SOS repair mechanism and adaptive responses and the ir regulation.	

UNIT – III: Biology of Plasmids	
Content	**PSQA Level**
General features of Plasmids	K1, K2, K3, K4 & K5
Types of Plasmids-Extrachromosomal heredity, Biology of Bacterial Plasmids	
Structure of representative plasmids (F, ColE1, pSC101 and Ti plasmids)	
Different mode of plasmid replications –Regulation of plasmid copy number	
Plasmid curing* – Partitioning – Incompatibility and gene transfer**.	

UNIT – IV: Gene Transfer Mechanisms	
Content	**PSQA Level**
Transformation - Competence (natural and artificial) –Regulation of Competency (com) genes	K1, K2, K3, K4 & K5
General machinery of transformation – Plasmid transformation*.	
Transduction: Discovery, Generalized Transduction – Transducing phage – Specialized Transduction.	
Conjugation: Discovery, F and Hfr strains – Conjugation machinery - Triparental mating - Self transmissible and mobilizable plasmids, Pili.	

UNIT –V: Concept of Gene & Gene Regulation	
Content	**PSQA Level**
Organization of Gene in Pro and Eukaryotes - Operon concept, *lac* and *trp* operons, promotors and repressors.	K1, K2, K3, K4 & K5
Regulation of gene expression; role of insulator and locus control system. Transcriptional control – promoters and enhancers, terminators, attenuators and anti-terminators.	
Induction and repression; the lac operon – catabolite repression; post-transcriptional control: miRNAs and siRNAs (small non coding RNAs).	
Basics of RNAi- CRISPER-cas9 system- an introduction.	
Biosynthesis: *trp* operon – upstream activator sequences and enhancers, two component regulatory systems, co- & post-translational modifications, antisense RNA; Epigenetics.	

UNIT –VI: Current contours
Discussion on new events and innovations in molecular biology and microbial genetics and their related researches. Recent innovation of advanced molecular biology techniques to be discussed *via* blend method of teaching.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC5	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	M	L
CO 2	S	S	S	S	M
CO 3	S	S	M	S	L
CO 4	S	M	M	S	L
CO 5	S	M	M	M	M
S-Strong; M-Medium; L-Low					

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Title of The Paper: Industrial Biotechnology
Subject Code: 25 CC 6a

Course Objectives

1	To know the various Microbial Metabolites and their Importance.
2	To learn various Upstream and Downstream techniques for Microbial products production.
3	To learn various strategies for Biotransformation process.
4	To be aware of Institutional Biosafety Committees and its importance.
5	To know about Intellectual property Rights(IPR).

Course Outcome

1	Describe the principle and applications of Bioprocess technology.
2	To get knowledge in Microbial product production and purification, the importance of institutional bioethical committee's in research.
3	Gain the Upstream and Downstream processing for Product production and Purification.
4	Discuss the important aspects in Bioprocess technology for Commercialization purpose.
5	To get opportunity in Biotech Industries and Research centers.

UNIT–I: Introduction

Content	PSQA Level
Definition, Concepts & History.	K1, K2, K3, K4 & K5
Isolation, Preservation and Strain improvement of Industrial important microorganism.	
Biotechnological potentials of Viruses, Bacteria, Fungi, Actinomycetes, Cyanobacteria, Algae and Dinoflagellate and higher forms.	
Primary and Secondary metabolites and Products,	
Growth phases–Tropho–Idiophase; Solid and Liquid fermentation.	
Media formulation – Media for Microbial fermentation	

UNIT–II: Upstream Processing

Content	PSQA Level
Bioreactors– Batch reactors, Hyper performance bioreactors, Industrial Bioreactors,	K1, K2, K3, K4 & K5
Fermentor types – Mass and energy transfer in bioreactors, Rheology	
Mass transfer, Liquid mixing.	
Performance of Standard Bioreactors – Temperature control	
Aeration and agitation system	
Sterilization, O_2 transfer, Anaerobic fermentor – Sampling methods.	
Classification of Fermentors – Stirred tank reactors; Batch operation, Continuous operation, Fed – batch operation,	
Tubular reactors, Cell culture bioreactor. Photo bioreactors – definition and classification.	

UNIT–III: Downstream processing

Content	PSQA Level
Objectives and criteria; Foam separation	K1, K2, K3, K4 & K5
Bioseparation – Precipitation methods and its principles – Ammonium sulphate,	

Organic solvents, polymers etc.	
Filtration – various devices – Filter Aids - Ultrafiltration; Industrial scale centrifugation	
Cell Disruption methods; Liquid–Liquid extraction; Solvent recovery	
Chromatography: Types and operation principles of Adsorption Chromatography – Ion exchange chromatography and size exclusion chromatography	
Inorganic, Hydrophobic - reverse phase, Affinity, Non adsorption Chromatography – Molecular sieve	
Two-phase aqueous extraction; Super critical fluid extraction; Drying devices; Crystallization and Whole broth processing*.	

UNIT–IV: Microbial Products	
Content	**PSQA Level**
Microbial and Fermented foods – Prebiotics – Probiotics – Lactic acid bacteria in Fermented foods – its Nutritional and Therapeutic values.	K1, K2, K3, K4 & K5
Types of Fermented Milk products – Butter milk,Yoghurt, Kafir,Tofu,Cheese; Fermented Vegetables**.	
Microbial products and organisms – Penicillin – Ethanol – Vinegar – Vitamin B12 – Citric acid – Glutamic acid	
Microbial Enzymes–Amylase, Protease, Lipase. Biotransformation products–Steroids, Acrylamide, Pigments.	
Biosenors; Biofilm; Biofertilizers – Phosphate bacteria, N_2 fixing bacteria	
Biosurfactants; Biopesticides – Bacillus, BT toxins, NPV	
Single cell Protein; Single Cell Oil; Biofuel– Biogas, Biohydrogen, Syngas, and Biodiesel	

UNIT–V: BioSafety & Intellectual Property Rights	
Content	**PSQA Level**
Biosafety: Purpose, Scope, Terminology, Constitution of IBSC,Tenure of IBSC	K1, K2, K3& K4
Composition, Procedure of Registration, Role of IBSC in approval, Functions, IBSC meetings, Conflict of interest, Confidentiality, Reporting requirement, IBSC records	
Persons responsible for Compliance, Addressing Noncompliance, Training, Laboratory Inspections, Security of GMOs / LMOs / rDNA materials, Disposal*.	
Intellectual Property: Types of IP; Patents, Trademarks, Copyright & Related Rights,	
Industrial Design, Traditional Knowledge, Geographical Indications.	
Protection of GMOs, IPs relevance to Biotechnology and Bioethics.	

UNIT–VI: Current contours
Discussion on day-to-day updates in Bioprocessing techniques, news, events related to newly produced Bioproducts and their purification, updated information in funding agency and their schemes.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC6a	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	L	L	L
CO 2	S	S	M	M	M
CO 3	S	S	M	M	L
CO 4	S	S	S	S	L
CO 5	S	S	S	S	L
S-Strong; M-Medium; L-Low					

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Title of the Paper : Genomics and Proteomics
Subject Code : 25 CC 6b

Course Objectives

1	To impart the overview of genomics and proteomics.
2	Employ the knowledge of proteomics to understand the gene expression, metabolomics and transcriptomics.
3	To learn fundamentals of different types of sequencing and mapping.
4	To provide a comprehensive understanding on Integrating genomics, proteomics, transcriptomics, and metabolomics.
5	To gain skills in genomic and proteomic techniques for integrated omics analysis, enabling effective experimentation and data interpretation.

Course Outcome

1	Learning this course helps the students to get basic and advanced knowledge in this field to perform Genetic and Protein Engineering and systems biology.
2	To understand the concept and acquire knowledge on different types of Omics such as Transcriptomics, Proteomics, Metabolomics etc.
3	Learn the techniques involved in Genome mapping. Elucidate the High Throughput Techniques of genomics, proteomics and their applications.
4	Know where and how to access the immense volumes of - Omics data.
5	Understand how to perform simple analysis of data, and remember examples of research tools in studies.

UNIT – I: Concepts of Genomics

Content	PSQA Level
History of genomics; genome projects in model organisms	K1, K2, K3, & K4
Human genome structure and comparative genomics. Genomic elements*	
SNPs and genome-wide association studies.	
Important findings of the completed genome projects: Human , *E. coli*, *Caenorhabditis elegans*, Tuberculosis.	

UNIT – II: Sequencing and Genome mapping

Content	PSQA Level
Basic steps in genome sequencing. Shotgun sequencing of small genomes.	K1, K2, K3, & K4
Map based sequencing: Hierarchical shotgun sequencing (clone-by-clone approach) - steps involved; Whole genome shotgun approach.	
Steps involved Next generation sequencing strategies – Pyrosequencing.	
Genetic mapping and physical mapping. Cytogenetic and linkage map- a brief account.	
Molecular markers* – RFLP, RAPD, AFLP, SSLP, SNP.	
Construction of linkage maps using molecular markers – E.g., RFLP maps Physical mapping – restriction mapping,	
STS, SNP, EST.	

UNIT – III: Transcriptomics

Content	PSQA Level
Types of coding and non coding RNAs and the respective roles in cells.	K1, K2, K3,

Expression profiling (mRNA profiling).	K4 & K5
Gene expression analysis using dot blotting and microarrays. Fabrication of microarrays – spotted arrays, *in situ* synthesis**.	
Chromatin immunoprecipitation (ChIP) and its applications.	
Determination of gene functions – Knock in and Knockout mutants, antisense RNA and RNAi, gene overexpression.	

UNIT – IV: Proteomics &Metabolomics	
Content	**PSQA Level**
Proteome, proteomics	K1, K2, K3, K4 & K5
Separation and identification of cellular proteins by 2D gel electrophoresis and image comparison. Protein expression analysis using Protein microarray	
Application of GFPs, Protein localization Protein profiling, yeast two-hybrid system	
Protein arrays, mass spectrometry data processing and analysis; pathway analysis and identifying protein**	
Protein interactions with mass scale expression data. Comparing transcriptomics with genomics and proteomics.	

UNIT –V: Metagenomics and Population genomics	
Content	**PSQA Level**
Overview of metagenomics principles, microbial and ecological aspects underlying Metagenomic experiments, applications and limitations of metagenomics	K1, K2, K3, K4 & K5
Differences between metagenomics and single-cell genomics. Definition and principle of population genomics, difference between metagenomics and population genomics	
Applications of Population genomics. Orthologs and Paralogs, gene identification by Comparative genomics; comparative genomics as a tool in evolutionary studies*.	

UNIT –VI: Current contours
Group discussion on new events and innovations in genomics and proteomics. Current news and techniques available in genome mapping, current trends in proteomics and metagenomics.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC6b	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	M	L	M
CO 2	S	S	S	M	L
CO 3	S	M	S	M	M
CO 4	S	M	L	S	L
CO 5	S	S	M	S	M
S-Strong; M-Medium; L-Low					

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Title of the Paper: Bioinformatics and Biostatistics
Subject Code: 25 EC 1a

Course Objectives

1	To familiarize the students with basic Bioinformatics *viz.* different types of Biological databases and Data mining etc.
2	To extend their knowledge to address research problems through Biological Molecules, Sequence alignments, Phylogenetic tree analysis and Protein analysis.
3	To interconnect the *in-silico* studies and analysis to aid wet lab and *vice versa*.
4	To make meaningful inferences about Data obtained in experiments.
5	To know the current Software's in Data analysis - Biological applications.

Course Outcome

1	Describe Internet perception, various search engines, an overview of Bioinformatics, and the basic Molecular structure and properties of Nucleic acids and Proteins.
2	Categorize biological databases and perform Data mining, retrieve Gene sequences and Blast services. Learn to design primer and restriction site analysis.
3	Carry out Sequence alignment - Pairwise and Multiple sequences, Local, Global and Dynamic programming. Understand the basis for Phylogeny construction and analyse Phylogeny tree using various methods.
4	Acquire knowledge on prediction and visualization of the Protein Secondary and Tretiary structure. Help to gain knowledge in Data collection.
5	Attain Knowledge about Statistical analysis - Probability and Sampling distribution, Tests of significance, Analysis of Variance, Multi variate statistics. Resolve problems quantitatively using appropriate statistical measures.

UNIT–I: Basics of Bioinformatics

Content	PSQA Level
Internet, Perception, www, Search Engines, Search Techniques.	K1, K2, K3 & K4
Definition and History of Bioinformatics. Overview of Bioinformatics, Introduction to Data mining, Application of Data mining,	
Physical and Chemical properties of Protein–Molecular weight, Theoretical pI (Isoelectric point), Amino acid composition.	
Extinction coefficient, Estimated half-life, Instability index, Aliphatic index and Grand average of Hydropathicity *	
ProtParam, ISOTOPIDENT.	
Programming languages – Introduction to "R"	

UNIT–II: Database and Data Mining

Content	PSQA Level
Introduction and overview of biological database- Nucleic acid database (Primary- NCBI, DDBJ, EMBL and Secondary- UNIGENE, EMI Genomes).	K1, K2, K3 & K4
Protein sequence database - SWISS PROT/TrEMBL, PIR. Sequence motif database - Pfam, PROSITE. Protein structure database - PDB, SCOP, CATH.	
Other relevant database - KEGG, PQS. Finding Scientific articles -Pubmed, Highwire, Press, Plos.**	
Analysis at Nucleotide level – Restriction mapping, Primer synthesis, ORF	

prediction.	
Insilico drug modeling and data mining – ADMET analysis*	

UNIT–III: Sequence Alignment	
Content	**PSQA Level**
Sequence alignments (Pairwise alignment)–Local, Global, Dotplot, Dynamic programming. Scoring Matrix – BLOSUM, PAM, GAP PENALTY.	K1, K2, K3 & K4
Inferring Data relationships (Heuristic method) - BLAST: blastn, blastp, blastx, PSI, PHI. Sequence Alignment Score: E-Value, P-Value.	
Multiple Sequence Alignment: Progressive, Iterative and Block based alignment. Clustalw2, Clustal Omega, MUSCLE, T-COFFEE*	
Phylogenetic Analysis – Neighbor - Joining, Maximum parsimony, Minimum livelihood, UPGMA.	

UNIT–IV: Analysis at Protein level	
Content	**PSQA Level**
Signature, Profiles and Motifs – My Domains, My Hits, PRATT, Scan Prosite.	K1, K2, K3 & K4
Protein Secondary Structure Prediction: Methods for predicting secondary structure: Chou-Fasman method, GOR method.	
Protein Tretiary Structure Prediction; Comparative modeling - Modeller, SWISS-MODEL Threading – GenTHREADER, PROSPECTOR, *Ab initio* Modeling* - ROSETTA, TOUCHSTONE.	
Visualization of Protein structure: RASMOL, SWISSPDB, CHIMERA, YASARA	

UNIT–V: Biostatistics	
Content	**PSQA Level**
Primary and Secondary Data collection**, Classification, Tabulation. Sampling and Sampling methods	K1, K2, K3, K4 & K5
Descriptive Statistics: Measures of Central tendency – Mean (Arithmetic, Harmonic & Geometric) Median and Mode, Population parameters, Sample Estimates and Confidence intervals.	
Correlation Co-efficient*,Simple linear Regression; Basic idea of Significance Test, Hypothesis tests, Levels of Significance, Student 't', 'Chi' square and Goodness of fit	
Dispersion and Skewness, kurtosis, ANOVA (One way classification and Two way classification), Hypothesis Testing – Null Hypothesis, Alternative Hypothesis. SPSS, PRISM, MATLAB, Origin.	

UNIT–VI: Current contours
Group discussion on various currently available databases in Bioinformatics and their updated innovations. Discussion about Application of updated Statistical methods in Research.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25EC1a	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	M	M	L
CO 2	S	M	M	M	L
CO 3	S	M	M	M	L
CO 4	S	L	M	M	L
CO 5	S	M	S	M	L
S-Strong; M-Medium; L-Low					

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Title of the Paper: Marine Pharmacology
Subject Code: 25 EC1b

Course Objectives

1	To gain integrated knowledge about pharmacologically related marine products.
2	To identify and characterize the biomedical potential of marine natural products.
3	To gain knowledge on the diverse applications of fish pharmacology.
4	To know about the synthesis, characterization and applications of nanomaterials from marine bioresources.
5	To explore marine pharmacogenomics and its applications in drug discovery.

Course Outcome

1	Gained knowledge on medicinal compounds derived from marine sources and their pharmacological activities.
2	Get knowledge on the potentials of marine biomedical natural products.
3	Gained knowledge on applications of fish pharmacology.
4	Understood the exploration of nanomaterials in aquatic pharmacology.
5	Understood about marine pharmacogenomics and its applications in drug discovery.

UNIT- I: Introduction to Marine Pharmacology	
Content	**PSQA Level**
Medicinal compounds from Marine Flora (Algae, Seagrass, Mangroves)	K1, K2, K3 & K4
Medicinal compounds from Marine Fauna (Sponges, Coelenterates, Bryozoans, Tunicates, Dinoflagellates, Marine bacteria)	
Pharmacological activities – Antitumor, Antiviral, Anti helminthic, Antiparasitic, Anti-inflammatory.	

UNIT-II: Biomedical potential of Marine Natural Products	
Content	**PSQA Level**
General Methods of Isolation, Structural elucidation – Pharmacologically important novel marine metabolites (Loihichelins A-F, Palmerolide A, Bryostatins, Dolastatin-10, Discodermolide)	K1, K2, K3 & K4
Mode of action and Clinical Applications.	
Marine flora pigments and its therapeutic applications	

UNIT-III: Applied Fish Pharmacology	
Content	**PSQA Level**
Fish disease control agents – Antibacterial drugs, Chemotherapeutic agents.**	K1, K2, K3 & K4
Pharmacodynamic agents – Anaesthetics, Breeding induction agents, Sex control, Immunostimulants, Probiotics, Vaccines, Disinfectants, Osmoregulators.	

UNIT-IV: Introduction to Nanoparticles	
Content	**PSQA Level**
Biological synthesis of nanoparticles from Marine Flora and Fauna.	K1, K2, K3 & K4
Characterization- (UV-Vis, XRD, SEM, EDX, HRTEM, FTIR analysis)	

Biomedical applications of nanomaterials in wound healing, Antimicrobial agents –Medical therapeutics and diagnosis – Cell labelling – Cancer therapy.	
Role of Nanoparticles in the Drug delivery system.	

UNIT-V: Introduction to Pharmacogenetics	
Content	**PSQA Level**
High throughput screening for drug discovery*, Identification of drug targets	K1, K2, K3, K4 & K5
Drug development – Pharmacogenomic based therapeutic applications.	
Recent advances in Pharmacology.	
Role of Biostatics in Pharmaceutical Industry, Drugs used during fish transportation.	

UNIT-VI: Current Contours
Discussion on day-to-day current events about marine pharmacology in aquaculture and their related research, recent innovation of pharmacological agents from marine resources are to be discussed via the blended method of teaching.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25EC1b	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	M	L	L
CO 2	S	M	M	M	L
CO 3	S	L	M	M	L
CO 4	S	M	S	S	M
CO 5	S	M	S	S	M
S-Strong; M-Medium; L-Low					

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Title of the Paper: Marine Products and Processing
Subject Code: 25 EC2a

Course Objectives

1	To gain knowledge in traditional methods of Fish processing.
2	To explore knowledge on technologies involved in fish food preservation, processing and product development.
3	To acquire skill-based knowledge on value addition of marine products.
4	Explore methods that align with conservation principles and minimize ecological impact.
5	To understand the regulatory and quality assurance aspects related to fish processing, ensuring compliance with industry standards and promoting consumer safety.

Course Outcome

1	Acquired knowledge on the traditional methods of fish processing.
2	Gained theoretical and technical knowledge on fish food processing and preservation.
3	Acquired skill-based knowledge on various equipment and materials required for fish food processing.
4	Gained knowledge on value addition and food safety measures of marine products.
5	Developed the ability to assess and implement sustainable practices in fish processing, considering environmental impact and resource conservation.

UNIT – I: Fish Processing by Traditional Methods

Content	PSQA Level
Fish Processing by Traditional methods- Salting, Sun drying, Smoking, Marinating and Fermentation.	K2 & K3
Theory of salting, Methods of salting – Wet salting and Dry salting.	
Different types of spoilage in Salt cured fish.	
Fish preservation by smoking- Chemical composition of wood smoke and their role in preservation.	

UNIT – II: Instrumentation and Theory of Food Processing

Content	PSQA Level
Hurdle technology in fish preservation and processing.	K2, K3 & K4
Drying and Dehydration- Theory, Importance of water activity in relation to microbial growth.	
Different types of driers and chillers in modern food processing technology	

UNIT – III: Marinated and Fermented Fish Products

Content	PSQA Level
Role of acids in marinades, Fish and prawn pickles, fish sauce and Fish paste, traditional Indian fermented fish products, Role of probiotics in fish products preservation.	K2, K3 & K4
Principles and methods of fish paste products preparation like Fish sausage, Fish ham, Surimi, Fish cake, Kamaboko etc.	

UNIT – IV: Value Added Marine Products

Content	PSQA Level
Fish maws, Shark leather, Fish oil, Chitin, Chitosan, Fish glue, Fish gelatin,	K2, K3 &

Isinglass, Pearl essence, Shark fin rays.	K4
Biochemical and Pharmaceutical products, Agar Agar, Algin, Carrageenan, Products from Sponges.	

UNIT –V: Fish Products and Quality management	
Content	**PSQA Level**
Fish finger, Fish cutlet, Fish wafer, Fish soup powder etc. and Imitation products.	K2, K3 & K4
Quality standards- National & International, Role of FSSAI & HACCP in Food Safety.	

UNIT –VI: Current contours
Discussion about fish processing by traditional methods,Value addition of products, recent innovation of fish product development and quality standards for food safety.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25EC2a	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	M	L	L
CO 2	S	M	M	L	M
CO 3	S	S	S	M	M
CO 4	S	S	S	M	M
CO 5	S	M	S	S	S
S-Strong; M-Medium; L-Low					

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Title of the Paper: Micro Algal Biotechnology
Subject Code: 25 EC 2b

Course Objectives

1	To provide knowledge on the fundamentals of algal biotechnology and its environmental relations.
2	To integrate knowledge on isolation and strain selection of micro algae.
3	To give knowledge on industrially important micro algae production.
4	To have an overview on issues in micro algal mass culture systems.
5	To make students aware about industrial application of micro algae.

Course Outcome

1	Understand the basics like types, classification, identification and economic importance of micro algae.
2	Acquire knowledge on isolation techniques.
3	Students explore on different culture methods and types of culture media preparation.
4	Understand the various issues and troubleshoot of cultivation methods.
5	Gain the knowledge about various commercially important products and its industrial cultivation methods.

UNIT – I: Introduction of Micro Algae	
Content	**PSQA Level**
Morphological identification of Micro algae.	K2 & K3
Bioprospecting and Commercial utility of micro algae	
Economic importance of microalgae. Microalgae as a bioindicator, microalgal blooms.	

UNIT – II: Microalgal Isolation and Strain Selection Techniques	
Content	**PSQA Level**
Direct isolation, Single-cell isolations using capillary pipette, Micromanipulation, Serial dilution, Streak plating, Density centrifugation and Antibiotics. Source, single cell isolation,-Axenic culture development.	K2, K3 & K4
Microalgal growth curve, Microalgal growth phases, Measurement of algal growth by Cell density - Optical density and cell counts.	

UNIT – III: Microalgal Production System	
Content	**PSQA Level**
Basic culturing techniques. Types of microalgal culture: Phototrophic, Heterotrophic, Mixotrophic.	K2, K3 & K4
Culture methods: Batch culture, Fed-batch culture, Continuous, Semi-continuous culture.	

UNIT – IV: Mass culture of Microalgae	
Content	**PSQA Level**
Indoor cultivation methods and scaling up, Large-scale cultivation of microalgae, Indoor/outdoor, Open/Closed, Fermenter, Bubble column, Tubular, Open aeration	K2, K3 &

ponds, Raceways.	K4
Raceway Pond types; Harvesting and marketing strategies.	

UNIT –V: Industrial application of Microalgae	
Content	**PSQA Level**
Lipid, Food, Feed formulation/ supplements: Method of preparation and application.	K2, K3, K4 & K5
Pharma-neutra-cosma-ceuticals compounds- Pigments (including UV photoprotective), Extracellular polysaccharides, Fatty acids (EPA, DHA), Secondary metabolites, toxins and other immunomodulatory compounds.	

UNIT –VI: Current contours
In this study we will know about the microalgae growth, production and applications to the industries.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25EC2b	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	M	L	M
CO 2	S	M	M	L	L
CO 3	S	M	M	M	L
CO 4	S	L	S	S	M
CO 5	S	S	S	S	M
S-Strong; M-Medium; L-Low					

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Title of the Paper: Molecular Biology and Microbial Genetics

(Lab Course)

Subject Code: 25 LC 3

Course Objectives

1	To improve the practical skills on Screening of antibiotic-resistant microbes, Isolation of auxotrophic, UV mutants etc.
2	To know how to isolate and analyze the plasmid DNA, chromosomal DNA and characterize them by Agarose Gel Electrophoresis.
3	To develop the practical knowledge on Molecular biological techniques and methods involved in microbial genetics.
4	To evaluate quantification of DNA and RNA by spectrophotometric method.
5	To explain the hyperchromic and hypochromic effects of DNA.

Course Outcome

1	Students will gain laboratory skills in micro pipetting, electrophoresis etc. Helpful to create awareness on antibiotic resistance and their control.
2	Gives experience in handling genetic molecules. Provides experience in mutation studies by which students can easily.
3	Students will acquire knowledge in DNA purification and quantification.
4	Helpful to get hands on experience in purification of molecules like DNA, plasmids etc. Students will train the students in appropriate laboratory equipments.
5	Helpful to create students with the ability to use and apply that knowledge in a wide range of situations within the professional discipline.

Content	PSQA Level
1. Isolation of antibiotic-resistant microbesagainst Ampicillin and Chloramphenicol	K3, K4 & K5
2. Isolation of Auxotrophic mutants (amino acid)	K3, K4 & K5
3. Induction of mutation by ultra-violet radiation	K1 & K2
4. Isolation of plasmid DNA from *E. coli*/cyanobacteria (mini preparation)	K3, K4 & K5
5. Characterization of Plasmid ~~of~~ DNA by Agarose Gel Electrophoresis	K3, K4 & K5
6. Quantification of DNA and Plasmid by Spectrophotometric Method	K3, K4 & K5
7. Isolation of Chromosomal DNA from Microorganisms/ Cyanobacteria/ Fish.	K3, K4 & K5
8. Induction of mutation by chemical mutagens (Theory).	K3, K4& K5

Mapping with Programme Outcomes

Course Code 25LC3	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	M	S	M	S

CO 3	S	S	S	S	S
CO 4	S	S	M	S	S
CO 5	S	S	S	S	S
S-Strong; M-Medium; L-Low					

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Title of the Paper: Industrial Biotechnology (Lab Course)
Subject Code: 25 LC4

Course Objectives

1	Course creates a general understanding of Industrial Biotechnology with emphasis, on process to identify the products.
2	To acquaint students with technical and biological aspect of microbial utilization for production of metabolites.
3	To learn various strategies of Immobilized techniques
4	To learn various upstream and downstream processing of protein purification
5	To learn bio encapsulation methods for industrially important enzymes.

Course Outcome

1	Course provides necessary practical hands- on exposure in all Divisions of Bioprocess technology sufficient enough to pursue a professional career. Ability to work with microorganisms to demonstrate a technical lexicon, that allows productive interface with complementary disciplines.
2	Understand and perform various chromatographic separation techniques namely Gel exclusion, Ion exchange and Inorganic Adsorption chromatography.
3	Elucidate the basic principles and perform various Protein electrophoresis PAGE, SDS PAGE and 2D PAGE.
4	Produce and estimate biofuel. a) Hydrogen using microbes by Thermal Conductivity Detector and b) Fatty acid profile by FID by Gas chromatography.
5	Produce Intra / extracellular microbial enzyme and its optimization in view of technological development.

Content	PSQA Level
1. Separation of proteins by column chromatography	K3, K4 & K5
a. Ion exchange chromatography–DEAE sephadex G50 column	
b. Gel exclusion/Gel permeation chromatography- sephadex G100	
c. Adsorption chromatography.	
2. Protein gel Electrophoresis	K3, K4 & K5
a. Separation of proteins based on molecular weight (SDS-PAGE)	
b. Separation of Enzymes using native gel electrophoresis (Gradient native PAGE)	
c. Iso Electro Focussing and 2D PAGE (Demonstration only)	
3. Enzyme production from microbes	K3, K4 & K5
a. Screening and selection of microorganism intra/extra cellular Protease production	
b. Optimization of pH for the maximum Protease production	
c. Optimization of temperature for the maximum Protease production	
4. Hydrogen Photo production	K3, K4 & K5
a. Hydrogen gas producing microbes, advantages and constraints using different microbes (Theory only)	
b. Hydrogen (fuel) gas production.	
c. Estimation of Hydrogen gas using Gas chromatography-Thermal conductivity detector	
5. Immobilization methods	K3
Entrapment and Bonding.	
6. Designing of Industrial Fermentors	K3& K4

Mapping with Programme Outcomes

Course Code 25LC4	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	S	M
CO 3	S	S	S	M	S
CO 4	S	M	S	S	S
CO 5	S	S	S	S	S
S-Strong; M-Medium; L-Low					

References	
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Title of the Paper: Mini Project / Internship / Field Visit
Subject Code: 25 MPW

Course Objectives

1	Course creates a general understanding of Industrial Biotechnology with emphasis on process to identify the products.
2	To acquaint students with technical and biological aspect of microbial utilization for production of metabolites.
3	To learn various strategies of Immobilized techniques
4	Motivate students to work in different lab atmospheres
5	Motivate students to develop entrepreneur skills

Course Outcome

1	Gain necessary practical hands- on exposure in all divisions of bioprocess technology sufficient enough to pursue a professional career. Ability to work with microorganisms to product demonstrates a technical lexicon that allows productive interface with complementary disciplines.
2	Get hands on experience and perform various chromatographic separation techniques from reputed institute and labs
3	Get hands on experience to run an aquaculture farm / biotech startup industry
4	Gain hands on experience to work with any research team
5	Gain knowledge to be an entrepreneur

Mapping with Programme Outcomes

Course Code 25MPW	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	M	S	S	S
CO 3	S	S	S	M	S
CO 4	S	S	S	M	S
CO 5	S	S	S	S	S
S-Strong; M-Medium; L-Low					

SEMESTER III

Title of the Paper: Immunology
Subject Code: 25 CC7

Course Objectives

1	To understand the basic concepts of Immunology and immune system.
2	To study immune molecules like antigen, antigen receptor and antigenic determinants.
3	To know about various types of immunoglobulins and their interaction with antigen.
4	To understand about immune response, immune regulation and immunosuppression.
5	To know about the concept of immunoprophylaxis, vaccines and their significance.

Course Outcome

1	Helps to understand the overall organization of immunology. Helps to develop skills necessary for analysis of health and diseases.
2	Students will get knowledge on infection and host defence mechanisms. Helps to understand the mechanisms involved in the immune system and their responsiveness.
3	Students can apply immunological techniques in the field of biotechnology. Provides knowledge on allergic responsiveness and autoimmune disorders.
4	Gives knowledge on fighting mechanism antibodies and their expression.
5	Provides knowledge on vaccine and how to approach them.

UNIT – I: Introduction

Content	PSQA Level
Infection and immunity. Types of immunity - innate and adaptive. Immunity to specific infection. Nonspecific immunity – phagocytosis, extracellular killing and complement mediated lysis	K1, K2 & K3
Milestones in Immunology*. Evolution of Immunology – microbes, invertebrates & vertebrates.	
Immune Systems: Anatomy of the lympho- reticular system.	
Primary lymphoid organs - bone marrow and thymus.	
Secondary lymphoid tissues - spleen, lymph nodes, gut and mucosal associated lymphoid tissue.	
Immunoreactive cells - T and B lymphocytes, macrophages, granulocytes and NK cells. Mediators of immune systems.	

UNIT – II: Antigens and Immunogenicity

Content	PSQA Level
Terminologies and definitions - antigen, immunogen, haptens, super antigens, tolerogen, epitope, Adjuvants, paratope and antigenic determinants.	K1, K2 & K3
Features associated with antigenicity and immunogenicity. Basis of antigen specificity.	
Antigen receptors: Cell surface protein and receptors.	
Major Histocompatibility Complex (MHC): types - class I, II and III- distribution and function.	
MHC in relation to transplantation and HLA typing.	
T cell receptor complex (TCR)	

UNIT – III: Antibodies – B cell receptors

Content	PSQA Level
Three-dimensional structure of immunoglobulin molecule -Types of immunoglobulins.	K2, K3, K4 & K5
Biological and chemical properties of immunoglobulin.	
Antigen, antibody attraction - forces, affinity, avidity and specificity.	
Antigen-Antibody interaction – Serology applications	
Antibody synthesis and diversity - genetic basis. **	
Monoclonal Antibody, Hybridoma Technology.	

UNIT – IV: Immune response and immune regulation	
Content	**PSQA Level**
Acquired immune response: Humoral immune response - various phases of humoral immune response. Cell mediated immune response - cell mediated cytotoxicity, delayed type hypersensitivity.	K2, K3, K4 & K5
Immune regulation: Immune response - various events in induction of immune response.	
Means of immunosuppression - physical, chemical and biological. Immune checkpoint inhibitors- Definition, Mode of action, side effects eg; PD-1/PD-L1&CTLA-4/B7-1/B7-2. Tolerance - auto and acquired.	
Immunopotentiation - specific and nonspecific potentiations (adjuvants and lectins) - Cytokines, Lymphokines and Chemokines. Modern immunotherapy- CAR therapy.	

UNIT –V: Prophylaxis	
Content	**PSQA Level**
Vaccines - heat killed, attenuated. Genetically Engineered Vaccines- rDNA vaccine, synthetic peptide vaccine, plasma derived vaccine, anti - idiotypic antibody vaccine and DNA vaccine.	K2, K3, K4 & K5
Active immunization - vaccines and toxoids – bacterial and viral. Passive immunization - antitoxins, immunoglobulin, specific immunoglobulin, hyperimmune-gamma globulin.	
Immunopathology – Biology of infectious disease and host pathogen interaction *	
Immunodeficiency disorders - primary and secondary.	
Hypersensitivity reactions. Immunologic mechanism of tissue damage. Autoimmune diseases**.	

UNIT –VI: Current Contours
Group discussion on recent research topics in immunology and to apply practically.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC7	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	M	M

CO 2	S	S	M	M	S
CO 3	S	S	S	M	M
CO 4	S	S	S	M	S
CO 5	S	S	S	S	S
S-Strong; M-Medium; L-Low					

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Title of the Paper: Genetic Engineering
Subject Code: 25 CC 8a

Course Objectives

1	To integrate knowledge on cloning system and recombinant DNA technology.
2	To understand the modern genetic engineering concepts in biotechnology.
3	To provide knowledge on advanced PCR techniques and related applications.
4	To have an overview on microbial genomics and gene therapy.
5	To have knowledge provide on Blotting technique and Genome library construction.

Course Outcome

1	Understand the construction and functions of different vectors implied in the field of Genetic engineering.
2	Acquire knowledge on various enzymes involved in recombinant DNA technology.
3	Students acquire knowledge on cloning system and genetic engineering after Completion.
4	Understand the various PCR and its application.
5	Understand the modern genetic engineering concepts for biotechnology thereby employ the students in research.

UNIT – I: Fundamentals of Genetics, Hosts & Vectors

Content	PSQA Level
Laws of inheritance: Mendal`s law, concept of dominance, segregation, independent assortment, chromosome theory of inheritance.	K2, K3 & K4
Host –Different strains of Escherichia, Bacillus, yeast. Vectors – plasmid vectors – pUC18/19, pBR322, Cosmids, pBluescript vector – Lambda, and M13 vectors, phagemid, expression vector - pET, shuttle vector and artificial chromosomes - YAC, PAC & BAC.	
Vectors with tags – Histidine, MAB, Thioredoxin.	

UNIT – II: Enzymes

Content	PSQA Level
Types and Mechanisms of action endonucleases- restriction enzymes – blunt end & cohesive end cutter, 5’ & 3’ overhang cutter,	K2, K3 & K4
Different DNA Polymerases, Klenow, T4/T7 DNA polymerase; Reverse Transcriptase, Terminal transferase, T4 polynucleotide kinases,	
Exonucleases – S1 nuclease, Bal 31, Mungbean nucleases, Ribonucleases, Ligases, Methylase, Alkayline phosphatase, Kinases.	

UNIT – III: Cloning and Analysis of recombinant DNA

Content	PSQA Level
Cloning strategies of pro and eukaryotic organisms: DNA Cloning – Sticky end, Blunt end, adapters & linkers, homopolymeric tailing, Gateway cloning.	K2,K3, K4 & K5
Cloning without restriction and ligation methods - Identification of clones – Antibiotic resistance, *lac*Z complementation (Blue-white selection), insertional inactivation method, fluorescent markers (GFP)	
Labelling of DNA by radiolabeled / non-radiolabeled DNA & RNA probes	
Blotting technique – Southern, Northern, Western and Eastern	
Fluorescence in situ hybridization (FISH).	

Fusion proteins Techniques and Genome library construction - cDNA library.	

UNIT – IV: PCR and Sequencing	
Content	**PSQA Level**
PCR Procedural variations – Multiplex PCR, Expression cassette PCR, Real time PCR, Nested; Reverse-transcription PCR, Real time PCR - Molecular Probes; Hot start PCR, Colony PCR, RACE PCR, Quantitative PCR, Digital PCR.	K2,K3, K4 & K5
Principle of PCR based site specific mutagenesis; PCR in Molecular diagnostics; Viral and Bacterial detection; Mutation detection; SSCP, DGGE, RFLP	
DNA Sequencing: First generation DNA sequencing method – Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; Second generation Sequencing – Pyrosequencing (454 Roche), SOLiD Sequencing, Illumina sequencing, Ion semiconductor sequencing; Third Generation sequencing – Single Molecule Real-Time (SMRT) Sequencing, Nanopore sequencing	
RNA Sequencing	
Genome mapping, Mutagenesis, Pathogen diagnostics, Environmental monitoring. **	

UNIT –V: Gene silencing and genome editing technologies	
Content	**PSQA Level**
Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing;	K2, K3, K4 & K5
Gene knockouts and gene therapy; CRISPRS Golden Gate assembly	
Creation of transgenic fishes: Glow fish, Transgenic applications in Aquaculture – Growth enhancement, Disease resistance.	
Introduction to methods of genetic manipulation in different model systems e.g. fruit flies*	

UNIT –VI: Current contours
To discuss the Cloning strategies of pro and eukaryotic organisms. To discuss the pros and cons of GMO's and GEAC. To inform the students about recent trends in Genetic Engineering Technology to be discussed *via* blended learning method of teaching*.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC8a	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**
CO 1	S	S	L	M	S
CO 2	S	S	M	S	S
CO 3	S	S	M	S	S
CO 4	S	S	S	L	L
CO 5	S	S	M	L	M
S-Strong; M-Medium; L-Low					

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Title of the Paper: Synthetic Biology
Subject Code: 25 CC 8b

Course Objectives

1	To impart the overview of synthetic biology and fundamentals.
2	To explore the concept of genetic engineering techniques and biocomputers.
3	Employ the knowledge of proteomics to understand the gene expression, metabolomics and transcriptomics.
4	To have an overview of CRISPR-Cas9 technology.
5	To gain the protein engineering technology into different biological models.

Course Outcome

1	Understanding the concept of synthetic biology and its usefulness.
2	Understand the genetic engineering techniques and future potential of biocomputers.
3	Understand the concept of genomics.
4	Conceptual learning of CRISPER-Cas9 and its applications in human welfare.
5	Acquired the knowledge on characterization and application of engineered protein.

UNIT – I: Synthetic Biology

Content	PSQA Level
Overview of synthetic biology – history, current status, challenges and future prospects. Biological background of gene regulation. Reverse genetic tools of synthetic biology.	K2 & K3
Recent applications of synthetic biology: Understanding biological parts and their respective properties; behavior of basic network motifs in cellular and synthetic systems; structure of biological networks; risk, opportunities, ethical and social challenges associated with synthetic biology. BioBrick cloning and chromo protein reporters in synthetic biology.	

UNIT – II: Genetic Engineering

Content	PSQA Level
Genome sequencing – Sanger Maxam–Gilbert, Next generation; cloning strategies - Isolation of genes, cloning, mutagenesis, polymerase chain reaction, synthesis of nucleic acids, DNA sequence determination, preparation of recombinant proteins, host organisms, protein expression*.	K2 & K3
Biological computers- Biochemical, biomechanical, bioelectronic systems. Future potential of biocomputers**.	

UNIT – III: Transcriptomes &Proteomes

Content	PSQA Level
Transcript analysis: DNA chips and microarray gene screen technology, qPCR, ChIP, SAGE, protein gel electrophoresis (SDS, Native & 2D), MALDI-TOF multidimensional chromatography, biological mass spectrometry, NMR spectroscopy, crystallography, spectroscopic and colorimetric methods.	K2, K3 & K4
PCR and its Applications - primer design; fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex – nested - reverse transcriptase - real time – touchdown - hot start - colony PCR.	
Gene sequencing - Next Generation Sequencing (NGS).	

UNIT – IV: CRISPR	
Content	**PSQA Level**
Introduction – structure and function of Cas9, genome editing, Genome editing and DNA repair, genome editing in practice gRNA, design reducing off-Target effects*. Identification of PAM and its importance.	K3, K4 & K5
CRISPR Tool box and Applications: Genome editing in plants - bacteria, human therapeutics, CRISPR Model Systems, CRISPR Ethics and Policy*.	

UNIT –V: Protein Engineering	
Content	**PSQA Level**
Definition, steps involved, applications; Features or characteristics of proteins that can be engineered (definition and electives methods of study) – affinity and specificity; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc.	K3, K4 & K5
Enhancement of enzyme activity – site directed mutagenesis - modifying specificity methods of addition of disulphide bonds – amino acid – substitutions – reducing free sulfhydryl residues; Evolutionary mutagenesis**; DNA shuffling - uses of engineered protein – advantages of protein engineering.	
SynBio Enabling techniques – Designed nucleic acid and protein algorithms*.	

UNIT –VI: Current contours
Group discussion on new events and innovations in genomics and proteomics. Current news and techniques available in CRISPR and Protein Engineering.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25CC8b	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	M	L	M
CO 2	S	S	M	L	L
CO 3	S	M	M	M	M
CO 4	S	S	M	S	S
CO 5	S	S	S	M	M
S-Strong; M-Medium; L-Low					

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Title of the Paper: Marine Biotechnology
Subject Code: 25 EC 3a

Course Objectives

1	To inculcate the thirst of research in marine bioresource, an unexplored field with huge hidden resource.
2	To provide knowledge on importance of aquaculture and generate professionally qualified fisheries managers through the provision of visiting various aquaculture forms and Institutes.
3	To enhance the quality production of Fin and Shellfish contributing the economic progress of the nation.
4	To enrich the diversified marine ecosystem for novel product development with technological approaches.
5	To create interest in exploration of marine resources transforming the students into entrepreneurs and seek job in various biotechnological sectors.

Course Outcome

1	Gain knowledge on marine bioresources, their biotechnological importance, novel metabolites produced.
2	Acquire knowledge on biotechnological applications in enhancing the quality production of Fin and Shellfish thereby contributing to the economic sustainability of the nation.
3	Understand the Fin and Shellfish immunology in order to predict the infection caused by various pathogens and manage the health of the reared animals through molecular diagnosis for sustainable aquaculture.
4	Exploit and realize novel pharmacological compounds from marine resources. Explore the importance of marine products in pharmacological and food industries and conservation of marine resources for future use and stop over exploitation.
5	Technological transfer from Lab to land, enabling the students to grasp the job opportunities in the fields of biotechnology, fisheries and pharma.

UNIT – I: Blue Biotechnology	
Content	**PSQA Level**
History, Scope & Applications of Marine aquaculture, Marine natural products (MNPs), Marine Neutraceuticals and Marine Bioenergy	K2, K3 & K4
Algal Biotechnology: Single cell protein from Spirulina; Vitamins, Minerals and Omega3 fatty acids from Microalgae; Enrichment of microalgae with micronutrients	
Biotechnological importance of Marine microbes: Primary and Secondary metabolites - Enzymes, Antibiotics, Organic acid, Toxins etc.	
Marine Genomics: Methods, Applications & Current trends.	

UNIT – II: Molecular Breeding	
Content	**PSQA Level**
Biotechnology in fish Breeding: Hatchery management, brood stock & Seed Maintenance, Selective breeding.	K2, K3, K4 & K5
Genetics of fish breeding: Hormonal and Genetic manipulation, Sterile fish production. Artificial insemination - *in vitro* fertilization*.	
Transgenic fish production: Advantages of transgenics in high health brood stock development; Risk associated with transgenic fishes; Ethical issues involved.	
UNIT – III: Fish Immunotechnology	
Content	**PSQA Level**
Fish and Shrimp Diseases: Bacterial, fungal, viral and parasitic. Biotechnological applications in diagnosis and treatment of Fish and Shrimp diseases.	K2, K3, K4 & K5
Molecular diagnosing – Fluorescent in-situ hybridization (FISH), * Polymerase	

Chain reaction (PCR), Sequencing.	
Recent advancements in fish vaccines preparation, Mode of administration of vaccines – oral, immersion and injection. Prebiotics, probiotics, immunostimulants **.	

UNIT – IV: Marine Pharmacognosy	
Content	**PSQA Level**
Pharmaceutical compounds from marine flora: Algae, Sea grass & Mangroves	K2, K3 & K4
Bioactive compounds from marine fauna: Sponges, Coelenterates, Bryozoans, Tunicates, Dinoflagellates & Marine bacteria)	
Pharmacological activities – Antibacterial, antiviral, antihelminthic, antiparasitic, antitumor, anti-inflammatory.	

UNIT –V: Marine Food technology	
Content	**PSQA Level**
Marine Food Processing: Area selection, layout, receiving area, processing area, processing methods, preservation (physical, chemical and biological) and packing methods.	K2, K3, K4 & K5
Food Storage: Storage plate and IQF freezers, cold stores, sanitary maintenance. Role of MPEDA in product development and export.	
Quality Standards of Marine products: ISO standards, Food Safety and Standard Authority of India (FSSAI), Hazard Analysis and Critical Control Point (HACCP) of marine products and Industries**.**	

UNIT –VI: Current contours
Group discussion on various currently available topics on Aquaculture. Discussion about physical, chemical and biological preservation methods. Visits to Aquaculture forms and Industries.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25EC3a	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	M	S	M
CO 2	S	M	L	L	L
CO 3	S	M	S	L	L
CO 4	S	S	M	L	L
CO 5	S	M	S	L	M
S-Strong; M-Medium; L-Low					

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Title of the Paper: Coastal Zone Management
Subject Code: 25 EC 3b

Course Objectives

1	To provide a wide spectrum of knowledge about the Coastal zone.
2	To minimize the harmful effects of activities upon resources and the Environment.
3	To know the concept of Integrated Management and Planning on Marine resources.
4	To understand the Developmental activities of Coastal resources activities.
5	Enlighten knowledge about Coastal Policy.

Course Outcome

1	Through this course the students may know about the Marine influences on Coastal zone.
2	To make them understand the classification of Coastal zones of the World.
3	The students can be able to understand the fact of Climate change, Sea level response and Coastal responses.
4	To get knowledge on Coastal zone based on GIS and MSP.
5	Acquire knowledge to Uses of Coastal zone.

UNIT–I: Concepts, Definition and approach

Content	PSQA Level
General classification of Coastal zones of the World** – Dominant Natural processes - Asia–Pacific coastal zone – State of the Environment – Terrestrial and Marine influence on Coastal zone – Catchment Coast interactions. Major Oceans and their Wealth: Three major Oceans – Importance.	K1 & K2

UNIT–II: Coastal Management

Content	PSQA Level
Coastal resources and utilization – Conservation measures – Developmental activities – Human pressures and responses – Hotspot management – Hazards and Vulnerability analysis. Coastal Management strategies: Shoreline Management Plans, Integrated Coastal Zone Management, Hard Engineering Coastal Management.	K1, K2 & K3
Management options - DPSIR* - Matrix approach - Participatory Dialogues and Stakeholder roles – Voluntary Partnerships - Integrated management and Planning – Sustainable development.	

UNIT–III: Laws of Coastal Zone

Content	PSQA Level
Legal Regime – Law of the Sea – Territorial sea and EEZ*– Indian coastal policy –Implementation of policy – Traditional practices and Modern Engineering Innovation.	K1, K2 & K3

UNIT–IV: Environmental Crisis

Content	PSQA Level
Global Environmental change – Climate change and Impacts on coastal zone – Sea level changes and Coastal responses – Approaches to Sustainable coastal zone management – Adaptive management in contextual scenarios**.	K1, K2 & K3

UNIT–V: Spatial Planning

Content	PSQA Level
Marine spatial planning and ICZM* – Concepts and Application – Coastal and Marine spatial data – Zoning and uses of Coastal zones based on GIS and MSP. Technical approaches to Coastal Planning and management.	K2, K3 & K4

UNIT–VI: Current contours
To discuss with the students about Coastal resources. Discussion about Climate change and Impacts on coastal zones.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25EC3b	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	S	M	M
CO 2	S	S	S	M	M
CO 3	S	S	M	L	L
CO 4	S	S	M	M	L
CO 5	S	M	M	M	L
S-Strong; M-Medium; L-Low					

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Title of the Paper: Bioinstrumentation
Subject Code: 25 EC 4a

Course Objectives

1	To introduce various analytical and bio-separation techniques
2	To make them understand the different concepts and principles of separation techniques.
3	To make aware to employ the different techniques in relation to their need and application
4	To make them understand the different molecular techniques.
5	To develop skills in diverse analytical and bio-separation techniques for specific needs and applications.

Course Outcome

1	The course students will get thorough knowledge on various biological instruments principles and applications, and acquire knowledge to apply in various biological macromolecules.
2	This course provides instrumentation skills for getting job in the field of Life sciences
3	This course helps to learn fundamentals for instrumental operations.
4	To perceive the strengths, limitations and creative use of techniques for problem-solving. Familiarity with working principles, tools and techniques of analytical techniques.
5	The course helps the students to get job in various biotechnology research labs and industries.

UNIT – I: Filtration

Content	PSQA Level
Filtration methods, Filter media, Filter aid	K1, K2 & K3
Ultrafiltration	
Industrial filters – Dead end filter, Cross flow filter	
Rotary Vacuum filter, Frame filter etc.	

UNIT – II: Centrifugation

Content	PSQA Level
Centrifugation Principles	K2, K3 & K4
Methodology and application Analytical centrifugation and Preparative centrifugation.	
Differential Centrifugation, Density Gradient Centrifugation	
Ultra – Centrifuge.**	

UNIT – III: Chromatography

Content	PSQA Level
Principle and applications – Paper, Thin layer and Column Chromatography	K2, K3, K4 & K5
Gel filtration, Inorganic, Adsorption, Ion exchange and Affinity chromatography	
Gas Chromatography – Principle & application Detectors (Thermal Conductivity Detector, Flame Ionising Detector)	
Gas Chromatography, Mass Spectrophotometer	
High Performance Liquid Chromatography – principle & application, various detectors; FPLC*	

UNIT – IV: Electrophoresis

Content	PSQA Level
Electrophoresis - Principle, types and applications – Poly Acrylamide Gel Electrophoresis, continuous & discontinuous buffer system	K2, K3, K4 & K5
Dissociating (Sodium Dodecyl Sulphate – PAGE) & Non –dissociating (NATIVE PAGE) buffer system.	
Agarose gel, Pulse field gel electrophoresis, Iso electrophoresis (IEF)	
Two-dimensional PAGE. Immuno Electrophoresis	
Blotting Techniques –Western, Northern & Southern	

UNIT –V: Molecular Biology Techniques	
Content	**PSQA Level**
Basic principles of PCR	K2, K3, K4 & K5
Electroporation, shotgun, Genegun, Micro injection	
Microarray – Oligonucleotide array	
DNA array*.	
DNA Sequencing methods, Molecular structure determination using X-ray diffraction and NMR. RFLP – DNA Finger printing, Next Generation Sequencing.	

UNIT –VI: Current contours
Discussion on the day-to-day current instruments in Biological science, related news and issues on available bio instruments, recent innovations of Advanced Biological Instruments.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25EC4a	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	M	M	M
CO 2	S	S	M	M	S
CO 3	S	S	M	M	S
CO 4	S	M	M	L	M
CO 5	S	M	L	M	M
S-Strong; M-Medium; L-Low					

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Title of the Paper: Mariculture
Subject Code: 25 EC 4b

Course Objectives

1	To provide a wide spectrum of knowledge about the marine organism culturing.
2	To know the concept of integrated management and planning on marine resources.
3	To understand the possibilities of utilizing marine resources for the betterment of humans in an eco- friendly manner.
4	Enhance knowledge about the commercial importance of marine species.
5	To ensure proper mariculture expertise.

Course Outcome

1	Students will get an understanding of principles of fish nutrition and nutritional biochemistry of nutrients.
2	Feed technology for manufacturing different types of feeds.
3	Methods of planning for aquaculture development.
4	Criteria to be followed for selection of aquaculture sites.
5	Important aspects of farm/hatchery standards and biosecurity measures.

UNIT – I: Commercially Important Mariculture Species

Content	PSQA Level
Status of farming of selected species - Marine finfish - Crustaceans - Molluscs – Sea cucumbers – Sponges – Corals – Seaweeds.	K2, K3 & K4
Different farming systems- Cage and Pen culture types - site selection - Raft and rack culture site selection - Open sea cage farming systems.	

UNIT – II: Important Cultivable Fin fishes

Content	PSQA Level
Seed production, Seed collection, nursery rearing - culture techniques – (Groupers, Seabass, milk fish, mullets, pearl spots, yellowtail, cobia, pompanos).	K2, K3 & K4
Species cultured (mussels, edible oysters, pearl oysters, clam, sea cucumber and squid).	

UNIT – III: Culture of Seaweeds

Content	PSQA Level
Seaweed species of commercial importance – Culture methods – Open sea culture – Integrated Multi Trophic Aquaculture (IMTA) systems – Products of commercial importance from seaweeds. - agar agar, alginates, carrageenan, Nutraceutical, phytocolloids.	K2, K3, K4 & K5

UNIT – IV: Non-food Products

Content	PSQA Level
Non-Food products from mariculture – Fish meal/shrimp meal – Cultured pearls (marine pearl oyster) – Cosmetics. Chitin, chitosan, collagen.	K2, K3, K4 & K5

UNIT –V: Nutrition and Feeds	
Content	**PSQA Level**
Brood stock nutrition – Larval nutrition – Marine microalgae – Brine shrimp – Processed feeds – Larval feeds. Current trends in Mariculture.	K2, K3, K4 & K5

UNIT –VI: Current contours
To discuss with the students about Mariculture. Discussion about application and impacts on seaweeds and nutritional products.
*Blended Learning topics, **Group discussion topics

Mapping with Programme Outcomes

Course Code 25EC4b	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	M	M	S
CO 2	S	S	M	M	M
CO 3	S	S	M	S	S
CO 4	S	S	L	S	M
CO 5	S	M	L	M	S
S-Strong; M-Medium; L-Low					

References	
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Title of the Paper: Immunology (Lab Course)
Subject Code: 25 LC 5

Course Objectives

1	To improve knowledge on immunological diagnosis methods.
2	To enhance the practical skills on detecting, analyzing, and identifying biological molecules as proteins.
3	To study about the theory of primary and secondary lymphoid organ, phagocytosis, phagocytic cells, Identification of specific antigens and lympho proliferation.
4	Develop the knowledge on advanced knowledge on immuno diagnosis and monoclonal antibody production methods.
5	To gain expertise in immunoassay design and monoclonal antibody production techniques for advanced diagnostic applications.

Course Outcome

1	Develops working knowledge of principles and procedures of serology. Candidates know in detail about various advanced immunological techniques.
2	Helpful to explore the students to clinical diagnostic laboratory techniques. Students will be aware of immunization and their benefits.
3	Explores the students to analytical instruments like ELISA, Flow cytometry etc. Explore the students in the field of immunohistochemistry.
4	Students will get knowledge to apply in their future research field.
5	Helps the students to succeed in today's modern laboratories.

Content	PSQA Level
1. Selection of animals, Preparation of antigens, Immunization and methods of bleeding, Serum separation and Storage.	K1 & K2
2. Antigen-Antibody reaction by Agglutination test (Blood Grouping, WIDAL test)	K1 & K2
3. Antigen-Antibody reaction by ELISA method (Demonstration)	K3, K4 & K5
4. Double diffusion, Immuno-electrophoresis and Radial Immunodiffusion	K3, K4 & K5
5. Complement fixation test.(Theory)	K3, K4 & K5
6. SDS-PAGE	K3, K4 & K5
7. Immunoblotting	K3, K4 & K5
8. Dot blot assays	K3, K4 & K5
9. Blood smear identification of leukocytes by Leishman staining	K3, K4 & K5
10. Phagocytosis (Theory)	K1, K2 & K3
11. Separation of mononuclear cells by Ficoll - Hypaque (Theory)	K1, K2 & K3
12. Flow cytometry, identification of T cells and their subsets (Theory)	K1, K2 & K3
13. Hybridoma technology and monoclonal antibody production (Theory)	K1, K2 & K3
14. Immunodiagnostics using commercial kits-Hand on	K3, K4 & K5

15. Lymphoid organs from fishes and mammals (Theory)	K1, K2 & K3

Mapping with Programme Outcomes

Course Code 25LC5	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	S	S
CO 3	S	S	S	S	S
CO 4	S	S	S	S	S
CO 5	S	S	S	S	S
S-Strong; M-Medium; L-Low					

References

1	Oxford Handbook of Clinical Immunology and Allergy: II Edn, 2006, Gavin Spickett, Oxford University.
2	Oxford Handbook of General Practice: 2010, Chantal Simon, Hazel Everitt, Francoise van Dorp, Oxford University Press.
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5	Hand Book of Practical and Clinical Immunology : 2006, Gupta Talwar.
6	Cellular and Molecular Immunology: 2017, Abul K Abbas., Andrew H. Lichtman., Shiv Pill.
7	Principles of Immunology Student's Compendium: 2007, Basant Kumar Sinha
8	Manual of Molecular and Clinical Lab Immunology: 2016, Barbara Detrick, Robert G. Hamilton, John L. Schmitz.
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11	www.austincc.edu/mlt/hem/Lab4Blood%20Smear%20Prep%20and%20Stain_08.doc.
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Title of the Paper: Genetic Engineering (Lab Course)
Subject Code: 25 LC 6

Course Objectives

1	Improve the practical skills in Genetic Engineering.
2	To know how to isolate Genomic and Plasmid DNA and characterize them by Agarose Gel Electrophoresis.
3	To know how to design the primer.
4	To know how to do gene amplification using PCR.
5	To know about restriction digestion and ligation and selection of clones.

Course Outcome

1	Students will be able to gain knowledge in genetic engineering.
2	Helps to know the isolation of plasmid DNA and genomic DNA.
3	Helps to learn primer designing and PCR techniques.
4	Helps to study about restriction digestion and ligation.
5	Helps to get employment in biotechnology laboratory and industries

Content	PSQA Level
1. Isolation of Genomic DNA - Microorganism / Fish/ Blood	K3, K4 & K5
2. Isolation of Plasmid DNA	K3, K4 & K5
3. Agarose Gel Electrophoresis (DNA /Plasmid)	K3, K4 & K5
4. Primer designing	K3, K4 & K5
5. Gene amplification-PCR	K3, K4 & K5
6. Restriction Digestion	K3, K4 & K5
7. Ligation	K3, K4 & K5
8. Selection of clones (Blue and White colonies)	K3, K4 & K5
9. Southern blotting – hybridization – autoradiography (Theory only)	K1 & K2

Mapping with Programme Outcomes

Course Code 25LC6	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	S	S
CO 3	S	M	S	M	S
CO 4	S	S	S	S	M
CO 5	S	S	M	S	S
S-Strong; M-Medium; L-Low					

References

1	Molecular cloning - A Laboratory manual (Vol - 1, 2, 3): 3rd Edn, 2001, Sambrook J and Russell DW, Cold Spring Harbor Laboratory.
2	Medical Microbiology: 5th Edn, Patric R. Murray, Ken S. Rosenthal & Michael A. Pfaller.,

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SEMESTER IV

Title of the Paper: Self Study
Subject Code: 25 CC 9

Course Objectives

1	To encourage independent learning, critical thinking and foster a culture of continuous improvement.
2	To reinforce the understanding of concepts and identify knowledge gaps.
3	To boost confidence in the abilities, leading to a greater motivation and better performance.
4	To allow for in-depth inquiry and improvement by encouraging self awareness.
5	To demonstrate ethical consideration, problem solving and independent research learning.

Course Outcome

1	The students developed their own study strategies in learning and critical thinking.
2	Developed self awareness, self confidence and Problem solving ability.
3	Providing opportunity to identify their field of interest
4	Brings desirable changes in student way of understanding and identifying the gaps.
5	Uphold self-confidence leading to better performance and better career.

Mapping with Programme Outcomes

Course Code 25CC9	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	S	S
CO 3	S	S	S	S	S
CO 4	S	S	S	S	S
CO 5	S	S	S	S	S
S-Strong; M-Medium; L-Low					

Title of the Paper: Project Work
Subject Code: 25 PW

Course Objectives

1	Develop a comprehensive understanding of Industrial Biotechnology, focusing on the process of identifying and implementing innovative solutions for real-world challenges.
2	Explore the technical and biological aspects of microbial utilization for the sustainable production of valuable metabolites in a project-based context.
3	Learn and apply various strategies of immobilized techniques in the design and execution of bioprocess projects.
4	Cultivate the ability to work effectively in diverse laboratory environments, fostering adaptability and practical problem-solving skills.
5	Foster an entrepreneurial mindset among students, encouraging them to apply their knowledge and skills towards the development of practical solutions and projects.

Course Outcome

1	Acquire practical, hands-on experience in all facets of biotechnology through the execution of real- world projects, preparing students for a successful professional career.
2	Apply and demonstrate proficiency in various chromatographic separation techniques through project-based activities conducted in collaboration with reputable institutes and laboratories.
3	Implement and run an aquaculture farm as part of the project work, gaining practical insights into the application of biotechnological principles in aquaculture settings.
4	Collaborate effectively within a research team, applying gained hands-on experience to contribute meaningfully to ongoing research projects/ develop how to write a research proposal, thesis writing, paper writing, etc.
5	Develop the knowledge and skills required to pursue entrepreneurial ventures, enabling students to apply biotechnological concepts in the development of innovative and commercially viable projects.

Mapping with Programme Outcomes

Course Code 25CC9	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	S	S
CO 3	S	S	S	S	S
CO 4	S	S	S	S	S
CO 5	S	S	S	S	S
S-Strong; M-Medium; L-Low					

VALUE ADDED COURSES

Title of the Paper: Good Laboratory Practices
Subject Code: 25 VAC 1

Course Objectives

1	To know about basic skill and knowledge supposed to every Biology students before entre in to the laboratory.
2	To be useful for Food & Feed sector, Pharmaceutical sector, Drink sector and other Biotechnology sectors.
3	To learn about handling Chemicals and Safety of the same.
4	To inculcate knowledge about different types of medium know the basis of any Microbial culture.
5	To get consistent result and reliability of cultures, Different method of sterilization are focused. To impart knowledge about the Waste disposal.

Course Outcome

1	This course may help the students to know more detail in Cloning strategies by which they may imply Cloning techniques in their Research area.
2	Apply Quality Assurance techniques to ensure the Reliability and Accuracy of Laboratory data.
3	Exhibit a strong awareness of Laboratory Safety Protocols and Regulatory compliance. Implement measures to create a safe and compliant laboratory environment.
4	Develop effective Documentation skills, including proper recording of Procedures, Observations, and Outcomes.
5	Exhibit a strong awareness of Laboratory safety protocols, Regulatory compliance, and Waste management. Implement measures to create a Safe and Compliant Laboratory Environment, including proper Disposal of Waste.

UNIT–I:Types of chemical constituents of lab wares and cleaning	
Content	**PSQA Level**
Types of glass wares- (Glass, Polypropylene, Plastic, Quartz) Burettes, Culture tubes, Dishes and culture bottles, Pipettes, Serological tubes, Slides and cover glasses, Petriplates, Beaker, Cuvettes. Properties of Glassware - Physical, Chemical, Optical properties.	K1&K2
Cleaning Solution- Detergent, Soap solution, Chromic acid preparation. Washing Methods-Soaking, Washing, Drying and Sterilization.	

UNIT–II:Types of chemicals and storage	
Types of Chemicals- Flammable, Toxic, Corrosive, Carcinogens,etc.	K1&K2
Safety recommendations and guidelines of Storage of Chemicals-Symbols, Labelling and Packaging of Chemicals- Emergency management of Chemical injuries.	

UNIT–III: Culture Media and Nutritional types	
Phototrophs, Autotrophs, Heterotrophs, Chemotrophs, Lithotrophs, Obligate parasites; Culture media–Definition, Physical parameters and Chemical constituents.	K1, K2 & K3

Classification (types) of media– Solid, Semi-solid, Liquid media, Preservation media; Various–Defined media, Complex media, General purpose / Basic media, Enriched media, Selective media, Differential / Indicator media, Resuscitation media, Auxotrophic media etc.	
General characteristics for Media for Cell culture, Bacteria and Fungi; Industrial Growth media – criteria to be followed, General characteristics of Industrial media.	

UNIT–IV: Statistics	
Principles of experimental design, collection, assembly, analysis and interpretation of experimental data. Data presentation: Tabular, Graphical and Diagrammatic representation of Data.	K1, K2 & K3
Statistical applications in research averages-standard deviation, standard error, analysis of variance, regression, coefficient of variation. Levels of significance, Chi- square test, students test (t), ANOVA and Duncan's new multiple range test.	

UNIT–V: Waste Disposal	
Waste– Types of wastes, Liquid, Solid.	K1&K2
Hazardous waste – Radioactive waste-Biological waste- Sharps. Waste Collection and Segregation – Colour codes.	

UNIT–VI: Current contours
Discussion on new events and innovations in Molecular Biology and Microbial Genetics and their related researches. Recent innovation of Advanced Molecular Biology Techniques to be discussed via blent method of teaching.
*Blended Learning topics,**Group discussion topics

Mapping with Programme Outcomes

Course Code 25VAC1	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	L	L	L
CO 2	S	M	M	L	L
CO 3	S	M	M	M	L
CO 4	S	S	S	M	L
CO 5	S	S	S	M	S
S-Strong; M-Medium; L-Low					

References	
1.	Good Laboratory Practice: Nonclinical Laboratory Studies Concise Reference, (2010) Book by Mindy J. All port-Settle, Pharmalogika,
2.	Good Laboratory Practice Standards: Applications for Field and Laboratory Studies, 2013 (ACS Professional Reference Book) 1st Edition, Eds. Willa Y. Garner, Maureen S. Barge, James P. Ussary.
3.	Handbook: Good laboratory practice (GLP): quality practices for regulated non-clinical

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4.	Good Laboratory Practices and Compliance Monitoring: (2024).,TruptiPatil-Dongare, PharmaMed Press / BSP Books.
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Title of the Paper: Biomolecules Separation Techniques
Subject Code: 25 VAC 2

Course Objectives

1	This is an interdisciplinary course for graduate and postgraduate students and Research Scholars in Chemical Engineering, Biomedical Engineering, Biotechnology, Chemistry, Microbiology, and various Life Science speciality.
2	The objective of this course is to familiarize the student with fundamental principle and hands-on practical training for the advanced molecular separation techniques of Electrophoresis and Chromatography.
3	There will be a laboratory demonstration for both Gas Chromatography and High Performance Liquid Chromatography to help explain the Chromatographic concepts presented in the lectures.
4	Also a hands-on training will be given for electrophoretic separation both Native and SDS-PAGE separation to gain independent laboratory skill.
5	To instigate an appreciation for the interdisciplinary nature of Biomolecule separation techniques, fostering collaboration among students from diverse backgrounds.

Course Outcome

1	Get update Laboratory skill on Molecular separation techniques.
2	Prepare Chemical solutions and Buffers flawlessly for the appropriate to the task
3	Execute Hands-on experience on difficult Separation techniques independently
4	Understand and interpret the results, properly so that future experiments can be planned flawlessly.
5	Showcase adept troubleshooting skills for overcoming challenges in molecular separation experiments, ensuring adaptability in the laboratory.

UNIT–I: Chromatography

Content	PSQA Level
Principle and Modes – Paper, Thinlayer, Column Chromatography Gel filtration(Size-exclusion),Adsorption, Ionexchange, Affinity chromatography	K1,K2&K3

UNIT–II: Gas Chromatography

Content	PSQA Level
Principle & Detectors (Thermal conductivity detector(TCD), Flame ionization detector (FID));	K1,K2&K3
Gas Chromatography Mass Spectrometry	
Laboratory Demonstration: Separation of compounds(organic) using Flame ionization detector;	
Laboratory Demonstration: Separation Gas molecules (inorganic) using thermal conductivity detector;	

UNIT–III: HPLC

Content	PSQA Level
Principle & application, various detectors	K1,K2&K3
A brief note on FPLC	
Laboratory demonstration: Separation of Compounds using PID detector	

UNIT–IV: Electrophoresis	
Content	**PSQA Level**
Definition, General principle; Moving boundary electrophoresis and Zone electrophoresis; types of Gels- Agar, Agarose, Starch, Paper, Cellulose acetate membrane, PAGE, Capillary Electrophoresis.	K1,K2,K3 &K4
Buffer system: Continuous& discontinuous	
Gel condition: Dissociating (SDS-PAGE) & Non-dissociating (NATIVE-PAGE) buffer system.	
Hands on training on both SDS-PAGE and Native gel electrophoresis	

UNIT–V:Types of Electrophoresis and their techniques	
Content	**PSQA Level**
Agarose gel electrophoresis, Pulse field Gel electrophoresis	K1,K2&K3
Isotachophoresis, Iso-electrophoresis (IEF), Two-Dimensional (2D-Gel) Gel Electrophoresis	

Mapping with Programme Outcomes

Course Code 25VAC2	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	M	S	M	L
CO 2	S	M	S	M	L
CO 3	S	M	S	S	L
CO 4	S	S	S	S	L
CO 5	S	S	S	S	L
S-Strong; M-Medium; L-Low					

References

1. Lundanes, E., Reubsaet, L., & Greibrokk, T. (2013). Chromatography: basic principles, sample preparations and related methods. John Wiley & Sons.
2. Grob,R.L., & Barry,E.F.(Eds.).(2004).Modern practice of Gas chromatography. JohnWiley& Sons.
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Title of the Paper: Ornamental Fish Culture
Subject Code: 25 VAC 3

Course Objectives

1	Understand about the basics of ornamental fishes and their varieties and habitats
2	Gain knowledge on Aquarium designing and construction
3	Acquire knowledge on management of water quality in aquariums
4	Acquire knowledge on breeding methods and disease management in aquarium fishes
5	Understand the transportation methods and marketing of ornamental fishes

Course Outcome

1	Understood the basics of ornamental fish culture and the varieties of Exotic and Indigenous fishes and their habitats
2	Acquired knowledge on designing and needs for construction of an aquarium
3	Gained knowledge on the water quality management system in ornamental fish aquariums
4	Acquired knowledge on breeding techniques and disease management of ornamental fishes
5	Understood the methods of transportation and marketing strategies of ornamental fishes.

UNIT–I: Introduction to Ornamental fish culture

Content	PSQA Level
Basics of Aquaculture- History, Definition and Scope.	K1&K2
Varieties and habitats of Exotic and Indigenous fishes.	
Common fresh water ornamental fishes. Common marine water ornamental fishes	

UNIT–II: Aquarium Design and Construction

Content	PSQA Level
Aquarium plants and their propagation methods.	K1,K2 & K3
Aquarium accessories and decorative: Aerators, Filters, Lighters and Heaters.	
Setting up a Fresh water aquarium, Setting up a marine and reef aquarium.	

UNIT–III: Water Quality Management

Content	PSQA Level
Water quality needs: Water filtration system- biological, mechanical and chemical	K1,K2 & K3
Water quality management for fresh water aquariums.	
Water quality management for marine water and reef aquariums	

UNIT–IV: Breeding and Disease control

Content	PSQA Level
Aquarium fish feeds: Dry, Wet and Dry feeds	K1,K2 & K3
Breeding and rearing of ornamental fishes, Brood stock management	
Common diseases of aquarium fishes, diagnosis, treatment and control	

UNIT–V: Transportation and Marketing

Content	PSQA Level
Conditioning, Packing and transport of fishes.	K1,K2,K3 &
Applications of genetics and biotechnology for producing quality strains	

Trade regulations and Marketing Strategies	K4

Mapping with Programme Outcomes

Course Code 25VAC3	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	S	S	S	S	S
CO 2	S	S	S	S	S
CO 3	S	S	S	S	S
CO 4	S	S	S	M	S
CO 5	S	S	S	S	M
S-Strong; M-Medium; L-Low					

References	
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