Annamalai University
(Accredited with 'A' Grade by NAAC)

MARINE BIOTECHNOLOGY
(Two – Year) Programme

(Dept. of Biotechnology (DBT), New Delhi approved syllabus)

Regulations & Curriculum

2019-2020

CAS in Marine Biology
FACULTY OF MARINE SCIENCES

ANNAMALAI UNIVERSITY

REGULATIONS FOR THE TWO-YEAR POST GRADUATE PROGRAMMES UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

These Regulations are common to all the students admitted to the Two-Year Master's Programmes in the Faculty of Marine Sciences from the academic year 2019-2020 onwards.

1. Definitions and Nomenclature

1.1 **University** refers to Annamalai University.

1.2 **Department** means any of the academic departments and academic centres at the University.

1.3 **Discipline** refers to the specialization or branch of knowledge taught and researched in higher education in the Marine Sciences.

1.4 **Programme** encompasses the combination of courses and/or requirements leading to a Degree. For example, M.A., M.Sc.

1.5 **Course** is an individual subject in a programme. Each course may consist of Lectures/Tutorials/Laboratory work/Seminar/Project work/Experiential learning/ Report writing/viva-voce etc. Each course has a course title and is identified by a course code.

1.6 **Curriculum** encompasses the totality of student experiences that occur during the educational process.

1.7 **Syllabus** is an academic document that contains the complete information about an academic programme and defines responsibilities and outcomes. This includes course information, course objectives, policies, evaluation, grading, learning resources and course calendar.

1.8 **Academic Year** refers to the annual period of sessions of the University that comprises two consecutive semesters.

1.9 **Semester** is a half-year term that lasts for a minimum duration of 90 days. Each academic year is divided into two semesters.

1.10 **Choice Based Credit System** A mode of learning in higher education that enables a student to have the freedom to select his/her own choice of elective courses across various disciplines for completing the Degree programme.

1.11 **Core Course** is mandatory and an essential requirement to qualify for the Degree.

1.12 **Elective Course** is a course that a student can choose from a range of alternatives.

1.13 **Value-added Courses** are optional courses that complement the students' knowledge and skills and enhance their employability.

1.14 **Credit** refers to the quantum of course work in terms of number of class hours in a semester required for a programme. The Credit value reflects the content and duration of a particular course in the curriculum.

1.15 Credit Hour refers to the number of class hours per week required for a course in a semester. It is used to calculate the credit value of a particular class.

1.16 Programme Outcomes (POs) are statements that describe crucial and essential knowledge, skills and attitudes that students are expected to achieve and can reliably manifest at the end of a programme.

1.17 Programme Specific Outcomes (PSOs) are statements that list what the graduate of a specific programme should be able to do at the end of the programme.

1.18 Learning Objectives also known as Course Objectives are statements that define the expected goal of a course in terms of demonstrable skills or knowledge that will be acquired by a student as a result of instruction.

1.19 Course Outcomes (COs) are statements that describe what students should be able to achieve/demonstrate at the end of a course. They allow follow-up and measurement of learning objectives.

1.20 Grade Point Average (GPA) is the average of the grades acquired in various courses that a student has taken in a semester. The formula for computing GPA is given in section 11.3

1.21 Cumulative Grade Point Average (CGPA) is a measure of overall cumulative performance of a student over all the semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters.

1.22 Letter Grade is an index of the performance of a student in a particular course. Grades are denoted by letters S, A, B, C, D, E, RA, and W.

2. Programmes Offered and Eligibility Criteria

Faculty of Marine Sciences	
M.Sc. Marine Biotechnology	Under graduate Degree in Biotechnology Biochemistry, Microbiology, Industrial Microbiology, Industrial Fish and Fisheries, Agricultural Microbiology, Plant Science & Biotechnology and Animal Science & Biotechnology, Plant Biology & Plant Biotechnology, Plant Science, Zoology, Animal Science, Biotechnology & Bioinformatics, Bioinformatics, Chemistry, Animal Biotechnology, Advanced Zoology & Biotechnology, B.Tech. Biotechnology/ Genetic Engineering with a minimum of 50% marks in Part-III.

2.1 In the case of SC/ST and Differently-abled candidates, a pass is the minimum qualification for the above Programme.

3. Reservation Policy

Admission to the various programmes will be strictly based on the reservation policy of the Government of Tamil Nadu.

4. Programme Duration

4.1 The Two Year Master's Programmes consist of two academic years.

4.2 Each academic year is divided into two semesters, the first being from July to November and the second from December to April.

4.3 Each semester will have 90 working days (18 weeks).

5. Programme Structure

5.1 The Two Year Master's Programme consists of Core Courses, Elective Courses (Departmental & Interdepartmental) and Project.

5.2 Core courses

5.2.1. These are a set of compulsory courses essential for each programme.

5.2.2. The core courses include both Theory (Core Theory) and Practical (Core Practical) courses.

5.3 Elective courses

5.3.1 **Department Electives (DEs)** are the Electives that students can choose from a range of Electives offered within the Department.

5.3.2 **Interdepartment Electives (IDEs)** are Electives that students can choose from amongst the courses offered by other departments of the same faculty as well as by the departments of other faculties.

5.3.3 **Each student shall take a combination of both DEs and IDEs.**

5.4 Experimental Learning

5.4.1 Experimental Learning provides opportunities to students to connect principles of the discipline with real-life situation.

5.4.2 In-plant training / field trips / internships / industrial visits (as applicable) fall under this category

5.4.3 Experimental learning is categorised as core

5.5 Project

5.5.1 Each student shall undertake a Project in the final semester.

5.5.2 The Head of the Department shall assign a Research Supervisor to the student.

5.5.3 The Research Supervisor shall assign a topic for research and monitor the progress of the student periodically.

5.5.4 Students who wish to undertake project work in recognised institutions/industry shall obtain prior permission from the University. The Research Supervisor will be from the host institute, while the Co-Supervisor shall be a faculty in the parent department.

5.6 Value added Courses (VACs)

5.6.1 Students may also opt to take Value added Courses beyond the minimum credits required for award of the Degree. VACs are outside the normal credit paradigm.

5.6.2 These courses impart employable and life skills. VACs are listed in the University website and in the Handbook on Interdepartmental Electives and VACs.

5.6.3 Each VAC carries 2 credits with 30 hours of instruction, of which 60% (18 hours) shall be Theory and 40% (12 hours) Practical.

5.6.4 Classes for a VAC are conducted beyond the regular class hours and preferably in the II and III Semesters.

5.7 Online Courses

5.7.1 The Heads of Departments shall facilitate enrolment of students in Massive Open Online Courses (MOOCs) platform such as SWAYAM to provide academic flexibility and enhance the academic career of students.

5.7.2 Students who successfully complete a course in the MOOCs platform shall be exempted from one elective course of the programme.

5.8 Credit Distribution

The credit distribution is organised as follows:

	Credits
Core Courses	**70**
Elective courses	**2**
Project	**26**
Total (Minimum requirement for award of Degree)	**98**

**Each Department shall fix the minimum required credits for award of the Degree within the prescribed range of 94-98 credits.*

5.9 Credit Assignment

Each course is assigned credits and credit hours on the following basis:

1 Credit is defined as

1 Lecture period of one hour per week over a semester

1 Tutorial period of one hour per week over a semester

1 Practical/Project period of two or three hours (depending on the discipline) per week over a semester.

6 Attendance

6.1 Each faculty handling a course shall be responsible for the maintenance of *Attendance and Assessment Record* for candidates who have registered for the course.

6.2 The Record shall contain details of the students' attendance, marks obtained in the Continuous Internal Assessment (CIA) Tests, Assignments and Seminars. In addition the Record shall also contain the organisation of lesson plan of the Course Instructor.

6.3 The record shall be submitted to the Head of the Department once a month for monitoring the attendance and syllabus coverage.

6.4 At the end of the semester, the record shall be duly signed by the Course Instructor and the Head of the Department and placed in safe custody for any future verification.

6.5 The Course Instructor shall intimate to the Head of the Department at least seven calendar days before the last instruction day in the semester about the attendance particulars of all students.

6.6 Each student should have at least 75% attendance in the courses of the particular semester failing which he or she will not be permitted to write the End-Semester Examination. The student has to redo the semester in the next year.

6.7 Relaxation of attendance requirement up to 10% may be granted for valid reasons such as illness, representing the University in extracurricular activities and participation in NCC/NSS/YRC/RRC

7 Mentor-Mentee System

7.1 To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach certain number of students to a member of the faculty who shall function as a Mentor throughout their period of study.

7.2 The Mentors will guide their mentees with the curriculum, monitor their progress, and provide intellectual and emotional support.

7.3 The Mentors shall also help their mentees to choose appropriate electives and value-added courses, apply for scholarships, undertake projects, prepare for competitive examinations such as NET/SET, GATE etc., attend campus interviews and participate in extra-curricular activities.

8 Examinations

8.1 The examination system of the University is designed to systematically test the student's progress in class, laboratory and field work through Continuous Internal Assessment (CIA) Tests and End-Semester Examination (ESE).

8.2 There will be two CIA Tests and one ESE in each semester.

8.3 The Question Papers will be framed to test different levels of learning based on Bloom's taxonomy viz. Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation/Creativity.

8.4 Continuous Internal Assessment Tests

8.4.1 The CIA Tests shall be a combination of a variety of tools such as class test, assignment, seminars, and viva-voce that would be suitable to the course. This requires an element of openness.

8.4.2 The students are to be informed in advance about the assessment and the procedures.

8.4.3 The pattern of question paper will be decided by the respective faculty.

8.4.4 CIA Test – I will cover the syllabus of the first two Units while CIA Test – II will cover the last three Units.

8.4.5 CIA Tests will be for two to three hours duration depending on the quantum of syllabus.

8.4.6. A student cannot repeat the CIA Test-I and CIA Test-II. However, if for any valid reason the student is unable to attend the test, the prerogative of arranging a special test lies with the teacher in consultation with the Head of the Department.

8.5 End Semester Examinations (ESE)

8.5.1 The ESE for the first/third semester will be conducted in November and for the second/fourth semester in May.

8.5.2 A candidate who does not pass the examination in any course(s) of the first, second and third semesters will be permitted to reappear in such course(s) that will be held in April and November in the subsequent semester/year.

8.5.3 The ESE will be of three hours duration and will cover the entire syllabus of the course.

9 Evaluation

9.1 Marks Distribution

9.1.1. Each course, both Theory and Practical as well as Project/Internship/Field work/In-plant training shall be evaluated for a maximum of 100 marks.

9.1.2 For the theory courses, CIA Tests will carry 25% and the ESE 75% of the marks.

9.1.3 For the Practical courses, the CIA Tests will constitute 40% and the ESE 60% of the marks.

9.2. Assessment of CIA Tests

9.2.1 For the CIA Tests, the assessment will be done by the Course Instructor

9.2.2 For the Theory Courses, the break-up of marks shall be as follows:

	Marks
Test – I	10
Test – II	10
Seminar	03
Assignment	02
Total	25

9.2.3 For the Practical Courses (wherever applicable), the break-up of marks shall be as follows:

	Marks
Test – I	15
Test – II	15
Viva-voce and Record	10
Total	40

9.3 Assessment of End-Semester Examinations

9.3.1 Evaluation for the ESE is done by both External and Internal examiners (Double Evaluation).

9.3.2 In case of a discrepancy of more than 10% between the two examiners in awarding marks, third evaluation will be resorted to.

9.4 Assessment of Project/Dissertation

9.4.1 The Project Report/Dissertation shall be submitted as per the guidelines laid down by the University.

9.4.2 The Project Work/Dissertation shall carry a maximum of 100 marks.

9.4.3 CIA for Project will consist of a Review of literature survey, experimentation/field work, attendance etc.

9.4.4 The Project Report evaluation and Viva-voce will be conducted by a committee constituted by the Head of the Department.

9.4.5 The Project evaluation Committee will comprise the Head of the Department, Project Supervisor and a senior faculty.

9.4.6 The marks shall be distributed as follows:

<table>
<tr><td colspan="2">Continuous Internal Assessment (30 Marks)</td><td colspan="4">End Semester Examination (70 Marks)</td></tr>
<tr><td rowspan="3">Review-I 15</td><td rowspan="3">Review-II: 15</td><td colspan="2">Thesis Evaluation (40)</td><td colspan="2">Viva-voce (30)</td></tr>
<tr><td>Internal</td><td>External</td><td>Internal</td><td>External</td></tr>
<tr><td>20</td><td>20</td><td>15</td><td>15</td></tr>
</table>

9.5 Assessment of Value-added Courses

9.5.1 Assessment of VACs shall be internal.

9.5.2 Two CIA Tests shall be conducted during the semester by the Department(s) offering VAC.

9.5.3 A committee consisting of the Head of the Department, faculty handling the course and a senior faculty member shall monitor the evaluation process.

9.5.4 The grades obtained in VACs will not be included for calculating the GPA.

9.6 Passing Minimum

9.6.1 A student is declared to have passed in each course if he/she secures not less than 40% marks in the ESE and not less than 50% marks in aggregate taking CIA and ESE marks together.

9.6.2 A candidate who has not secured a minimum of 50% of marks in a course (CIA + ESE) shall reappear for the course in the next semester/year.

10. Conferment of the Master's Degree

A candidate who has secured a minimum of 50% marks in all courses prescribed in the programme and earned the minimum required credits shall be considered to have passed the Master's Programme.

11. Marks and Grading

11.1 The performance of students in each course is evaluated in terms Grade Point (GP).

11.2 The sum total performance in each semester is rated by Grade Point Average (GPA) while Cumulative Grade Point Average (CGPA) indicates the Average Grade Point obtained for all the courses completed from the first semester to the current semester.

11.3 The GPA is calculated by the formula

$$GPA = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i}$$

where 'C_i' is the Credit earned for the Course i in any semester;

'G_i' is the Grade Point obtained by the student for the Course i and

'n' is the number of Courses passed in that semester.

11.4. CGPA is the weighted average Grade Point of all the Courses passed starting from the first semester to the current semester.

Where GG is the Credit earned for the course G in any semester

GG is the Grade point obtained by the student for the Course G

G is the number of courses passed in that semester

G is the number of semesters

11.5 Evaluation of the performance of the student will be rated as shown in the Table.

Letter Grade	Grade Points	Marks %
S	10	90 and above
A	9	80-89
B	8	70-79
C	7	60-69
D	6	55-59
E	5	50-54
RA	0	Less than 50
W	0	Withdrawn from the examination

11.6 Classification of Results. The successful candidates are classified as follows:

11.6.1 For **First Class with Distinction:** Candidates who have passed all the courses prescribed in the Programme *in the first attempt* with a CGPA of 8.25 or above within the programme duration. Candidates who have withdrawn from the End Semester Examinations are still eligible for First Class with Distinction (See Section 12 for details)

11.6.2 For **First Class:** Candidates who have passed all the courses with a CGPA of 6.5 or above.

11.6.3 For **Second Class:** Candidates who have passed all the courses with a CGPA between 5.0 and less than 6.5

11.6.4 Candidates who obtain highest marks in all examinations at the first appearance alone will be considered for University Rank.

11.7 Course-Wise Letter Grades

11.7.1 The percentage of marks obtained by a candidate in a course will be indicated in a letter grade.

11.7.2 A student is considered to have completed a course successfully and earned the credits if he/she secures an overall letter grade other than RA.

11.7.3 A course successfully completed cannot be repeated for the purpose of improving the Grade Point.

11.7.4 A letter grade RA indicates that the candidate shall reappear for that course. The RA Grade once awarded stays in the grade card of the student and is not deleted even when he/she completes the course successfully later. The grade acquired later by the student will be indicated in the grade sheet of the Odd/Even semester in which the candidate has appeared for clearance of the arrears.

11.7.5 If a student secures RA grade in the Project Work/Field Work/Practical Work/Dissertation, he/she shall improve it and resubmit if it involves only rewriting/ incorporating the clarifications suggested by the evaluators or he/she can re-register and carry out the same in the subsequent semesters for evaluation.

12. Provision for withdrawal from the End Semester Examination

12.1 The letter grade W indicates that a candidate has withdrawn from the examination.

12.2 A candidate is permitted to withdraw from appearing in the ESE for one course or courses in **ANY ONE** of the semesters **ONLY** for exigencies deemed valid by the University authorities.

12.3. Permission to withdrawal from the examination shall be granted only once during the entire duration of the programme.

12.4. Application for withdrawal shall be considered **only** if the student has registered for the course(s), and fulfilled the requirements for attendance and CIA tests.

12.5. The application for withdrawal shall be made ten days prior to the commencement of the examination and duly approved by the Controller of Examinations. Notwithstanding the mandatory prerequisite of ten days notice, due consideration will be given under extraordinary circumstances.

12.6 Withdrawal is **not** granted for arrear examinations of courses in previous semesters and for the final semester examinations.

12.7 Candidates who have been granted permission to withdraw from the examination shall reappear for the course(s) when the course(s) are offered next.

12.8 Withdrawal shall not be taken into account as an appearance for the examination when considering the eligibility of the candidate to qualify for First class with Distinction.

13. Academic misconduct

Any action that results in an unfair academic advantage/interference with the functioning of the academic community constitutes academic misconduct. This includes but is not limited to cheating, plagiarism, altering academic documents, fabrication/falsification of data, submitting the work of another student, interfering with other students' work, removing/defacing library or computer resources, stealing other students' notes/assignments, electronically interfering with other students'/University's intellectual property. Since many of these acts may be committed unintentionally due to lack of awareness, students shall be sensitised on issues of academic integrity and ethics.

14. Transitory Regulations

Wherever there has been a change of syllabi, examinations based on the existing syllabus will be conducted three consecutive times after implementation of the new syllabus in order to enable the students to clear the arrears. Beyond that the students will have to take up their examinations in equivalent subjects, as per the new syllabus, on the recommendation of the Head of the Department concerned.

15. Notwithstanding anything contained in the above pages as Rules and Regulations governing the Two year Master's Programme at Annamalai University, the Syndicate is vested with the powers to revise them from time to time on the recommendation of the Academic Council.

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Annamalai University

Department of CAS in Marine Biology

M.Sc. Marine Biotechnology(Two Year) Programme

Programme Code: CMAB22

Programme Structure

(For students admitted from the academic year 2019-2020)

Course Code	Course Title	Hours/ Week			Marks		
		L	P	C	CIA	ESE	Total
Semester-I							
19MBTC 101	Biochemistry	3		3	25	75	100
19MBTC 102	Molecular Biology	3		3	25	75	100
19MBTC 103	Fisheries Resources, Conservation and Oceanography	4		4	25	75	100
19MBTC 104	Marine Microbiology	2		2	25	75	100
19MBTC 105	Biostatistics	2		2	25	75	100
19MBTC 106	Biophysical Principles and Analytical Techniques	2		2	25	75	100
19MBTP 107	Practical – I (Biochemistry and Analytical Techniques)		6	4	40	60	100
19MBTP 108	Practical – II (Microbiology and Experimental Methods in Fisheries)		6	4	40	60	100
19MBTP 109	Tutorial / Journal Club / Communication Skills	1		1	40	60	100
				25			
Semester-II							
19MBTC 201	Cell and Developmental Biology	3		3	25	75	100
19MBTC 202	Genetic Engineering	3		3	25	75	100
19MBTC 203	Aquaculture Bioprocessing and Marine Pharmacology	3		3	25	75	100
19MBTC 204	Fish Immunology and Health Management	3		3	25	75	100
19MBTC 205	Aquatic Environmental Biotechnology	2		2	25	75	100
19MBTP 206	Practical – III (Molecular Biology and Genetic Engineering)		6	4	40	60	100

19MBTP 207	Practical – IV (Aquaculture and Fish Immunology and Health Management)		6	4	40	60	100
19MBTP 208	Practical – V (Aquatic Environmental Biotechnology)		3	2	40	60	100
19MBTP 209	Seminar / Journal Club / Assignment		1	1	40	60	100
				25			
Semester-III							
19MBTC 301	Marine Bioprocess Technology	3		3	25	75	100
19MBTC 302	Aquaculture Biotechnology	3		3	25	75	100
19MBTC 303	Bioinformatics	2		2	25	75	100
19MBTC 304	Intellectual Property Rights, Bio-safety and Bioethics	2		2	25	75	100
19MBTC 305	Bio-entrepreneurship	2		2	25	75	100
19MBTP 306	Practical – VI (Marine Bioprocess Technology)		3	2	40	60	100
19MBTP 307	Practical – VII (Aquaculture Biotechnology)		3	2	40	60	100
19MBTP 308	Practical – VIII (Bioinformatics and Biostatistics)		3	2	40	60	100
19MBTE 309	Project Proposal Preparation and Presentation		9	2			100
				20			
Semester-IV							
19MBTC 401	Research work/ Dissertation		26	26	25	75	100
19MBTE 402	Elective-I	4		2	25	75	100
				28			
	Total Credits			**98**			
	Value Added Courses						
	On-line courses (SWAYAM, MOOC and NPTEL)						

L- Lectures; P- Practical; C- Credits; CIA- Continuous Internal Assessment; ESE- End-Semester Examination

Note:

1. Students shall take both Department Electives (DEs) and Interdepartmental Electives (IDEs) from a range of choices available.

2. Students may opt for any Value-added Courses listed in the University website.

Department Electives (DE)

S. No.	Course Code	Course Title	hours/ week		C	Marks		
			L	P		CIA	ESE	Total
1.	19MBTE309	Genetics and Proteomics (Elective-I)	4	0	2	25	75	100
2.	19MBTE310	Nano-biotechnology (Elective-I)	4	0	2	25	75	100
3.	19MBTE403	Molecular Diagnostics (Elective-II)	4	0	2	25	75	100
4.	19MBTE404	Marine Food Technology (Elective-II)	4	0	2	25	75	100
5.	19MBTE405	Stem Cell Biology (Elective-II)	4	0	2	25	75	100

Value Added Course

	Course Code	Course Title	Hours/week		C	Marks		
			L	P		CIA	ESE	Total
	19VAMS011.1	Sea Food Processing Technology	3	0	3	25	75	100

Programme Outcomes

PO1:	**Vital Assessment**: Make the students to assess themselves to proceed upon to acquire knowledge to bridge the gap between under graduation and post graduation.
PO2:	**Rational**: Interpret the themes of the curriculum to suit to ideologies and compose inferences.
PO3:	**Sampling**, **Scientific Logic and Communication**: Gather biological and environmental samples from different niches of marine and adjoining provinces during diurnal, nocturnal and prevailing seasonal conditions to comprehend the abundance of bio-materials in reference to environmental parameters. Validate the inferences with scientific reasoning to imbibe the knowledge and exhibit the skills by conversing, reading and writing.
PO4:	**Central Dogma of Being**: Gain fundamental awareness of molecular and cellular processes that

	regulates the life of an organism.
PO5:	**Harness Biology for Technology and Sophisticated tool usage**:: Categorize biological materials based on their taxonomical and environmental significance of sustainability and distinguish for utilizing them as animal model, ecological component, food, fertilizer and pharmacological product. Understand the scientific principles of devices for analyses, evaluations, processing, syntheses, determination, examination, pathology, diagnoses and product scaling up.
PO6:	**Data Processing, Computing, IPR and Bioethics**: Compile numerical output as data for processing, appreciation and understanding of scientific values through computing. Critically analyze the intellectual property rights and their implications on biological research and product development and learn bio-safety and risk assessment of products derived from biotechnology and regulation.
PO7:	**Project Outlook**: Demonstrate the knowledge by implying a novel research work for a scientific outcome.
PO8:	**Entrepreneurship and Cognition:** Acquire skills to undertake entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards. Self motivate for lifelong learning to update and practice the knowledge to the need in real time for enrolling in the scientific community.

Programme Specific Outcomes

At the end of the programme, the student will be able to

PSO1:	Build upon knowledge over the undergraduate platform on principles of Biochemistry comprising major nutrients, and factors of metabolic pathways. Gain fundamental knowledge of molecular and cellular processes: epigenetics, gene regulation, RNA transcription, protein targeting and trafficking and cell signalling.
PSO2:	Familiarize with the aquatic environment, dynamics of oceanography and aquatic living resources, besides knowledge in taxonomical features, adaptations, sustainability in relevance to the aquatic ecosystem. Identify the types of marine microbes and their habitats and sensitize the interaction with the ecosystem.
PSO3:	Quantify the marine animal population abundance in reference to the marine environmental conditions and record major fishery resources in the province. Apply the analytical tools to verify the biochemical and biophysical principles of marine ecosystem.
PSO4:	Accustom the conceptual overview of the cellular system and functioning and to get aware of the cellular development and factors regulating the process of cell growth, besides understanding the importance of stem cell biology. Analyze different types nucleases, role of nucleases, types of DNA vectors, amplification of gene of interest, strategies of cloning, selectable markers, expression of the gene, cDNA construction, gene product, protein expression, gene editing and silencing.
PSO5:	Learn culture technique of viable aquatic organisms in a defined environmental conditions for human conception. Understand the fin and shellfish immunology in order to foresee the infection caused by different pathogens and manage the health of the reared animals for sustainable aquaculture.
PSO6:	Predict aquatic environmental changes by experimental investigation and also apply biosensors for

	precise validation of the same. Utilize marine organisms for the production of high value products and understand the applications of enzyme technology in food processing by various fermentors for scaling up of product through down stream processing.
PSO7:	Apply bioinformatics tools for interpreting biological data and analyze bio-molecular assemblage through docking for drug development. Acquire knowledge in the field of IPR, biosafety and bioethics to protect our Indian subcontinent natural resources and concern holistic approaches for managing an industry.
PSO8:	Imbibe the skills to start entrepreneurship after learning the biotechnological knowhow. Build capability to critically and systematically integrate knowledge to recognize issues that must be addressed within framework of specific dissertation.

Semester-I 19MBTOC101: BIOCHEMISTRY

Credits: 3 - Hours : 3

Learning Objectives (LOS):

- To build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways.
- The students get aware of major types of nutrients, energy production, cellular molecules and their interaction.

Unit I Chemical basis of life and proteins

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

Unit II Enzyme kinetics

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

Unit III Glycobiology

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

Unit IV Lipids, DNA and RNA

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

Unit V Bio-energetics

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sourcesof glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane.

Unit VI Role of vitamins & cofactors in metabolism

Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabo-lism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomole-cules from central pathways; principles of metabolic regulation; steps for regulation; TOR (target of rapamycin) & autophagy regulation in relation to C & N metabolism, starva-tion responses and insulin signaling.

Textbooks:

1. Stryer, L. (2015). *Biochemistry* (8th ed.). New York: Freeman.
2. Lehninger, A. L. (2012). *Principles of Biochemistry* (6th ed.). New York, NY: Worth.
3. Voet, D., &Voet, J. G. (2016). *Biochemistry* (5th ed.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). *Protein Folding and Misfolding*. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). *The Protein Folding Problem*. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

Course Outcomes

On completion of this course, students will able to:

CO1: Gain fundamental knowledge in biochemistry, cellular macromolecules and assemblies

CO2: Understand the enzyme catalysis and its arithmetic principles in reaction kinetics

CO3: Describe about major fundamental nutrient molecules like sugars, glycolipids etc.

CO4: Characterize lipids, DNA and RNA

CO5: Explain the role of cellular components in energy synthesis

CO6: Acquire the facts about the vitamins and the co-factors role in metabolism

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	-	3	3	-	3	-	3	-	-	-	3	-	3	3
CO2	3	3	-	3	3	-	3	-	3	-	-	-	3	-	3	3
CO3	3	3	-	3	3	3	3	-	3	-	-	-	3	-	3	3
CO4	3	3	-	3	3	3	3	-	3	-	-	-	3	-	3	3
CO5	3	3	-	3	3	3	3	-	3	-	-	-	3	-	3	3
CO6	3	3	-	3	3	3	3	-	3	-	-	-	3	-	3	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	--	--	--	3	--	3	3
CO2	3	--	--	--	3	--	3	3
CO3	3	--	--	--	3	--	3	3
CO4	3	--	--	--	3	--	3	3
CO5	3	--	--	--	3	--	3	3
CO6	3	--	--	--	3	--	3	3
Total	**18**				**18**		**18**	**18**

Semester-I **19MBTC 102 -MOLECULAR BIOLOGY**

Credits: 3 - Hours : 3

Learning Objectives (**LOS**):

- To enrich the fundamental knowledge of molecular and cellular processes with reference to genome organization
- To understand about nucleic acids and the enzymes involved in various physiological function
- To learn the techniques in molecular biology, epigenetics, gene regulation, RNA transcription, protein synthesis, protein targeting and trafficking, and cell signaling.

Unit I DNA structure and genome organization

Structure of DNA - A,B, Z and triplex DNA; Central dogma, DNA as genetic material; Organization of bacterial genome; Structure of eukaryotic chromosomes: DNA compaction, nucleosome, 10 nm "beads-on-a-string" fiber, 30 nm chromatin fiber and metaphase chromosome; Nuclear matrix in chromosome organization and function; Heterochromatin and Euchromatin; DNA melting and buoyant density; Tm; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNase I hypersensitive regions; DNA methylation & epigenetic effects.

Unit II DNA replication, repair and recombination

Replication: initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins and mechanisms; Fidelity; Replication of single stranded circular DNA; link with cell cycle; DNA damaging agents - Physical, chemical and biological mutagens; types of damage caused by endogenous and exogenous agents; mutations- Nonsense, missense, silent and point mutations, frameshift mutations; Intragenic and Intergenic suppression. DNA repair mechanisms- direct reversal, photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, double strand break repair, SOS repair; Recombination: Chi sequences in prokaryotes; Homologous,non-homologous and site specific recombination.

Unit III RNA transcription, RNA processing and regulation in prokaryotes

Structure and function of prokaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes); Prokaryotic Transcription -RNA polymerase and sigma factors, Transcription unit, Promoters, Promoter recognition, Initiation, Elongation and Termination (intrinsic, Rho and Mfd dependent); Processing of mRNA, rRNA and tRNA transcripts; Gene regulation: Repressors, activators, positive and negative regulation, Constitutive and Inducible, small molecule regulators, operon concept: *lac, trp, his* operons, attenuation, anti-termination, stringent control, translational control, DNA re-arrangement, two component system; regulatory RNA – riboswitch, tmRNA, antisense RNA; transcriptional control in lambda phage.

Unit IV RNA transcription, RNA processing and regulation in eukaryotes

Structure and function of eukaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes). Eukaryotic transcription - RNA polymerase I, II and III mediated transcription: RNA polymerase enzymes, eukaryotic promoters and enhancers, General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); assembly of pre-initiation complex for nuclear enzymes, interaction of transcription factors with the basal transcription machinery and with other regulatory proteins, mediator, TAFs; Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing of RNAs and polyadenylation; loop model of translation; Splicing of tRNA and hnRNA; snRNPs and snoRNPs in RNA processing; Regulation of RNA processing: capping, splicing, polyadenylation; mRNA stability and degradation: degradation and surveillance pathways; RNA editing; Nuclear export of mRNA; Catalytic RNA: Group I and Group II introns splicing, Peptidyltransferase; Regulatory RNA and RNA interference mechanisms, miRNA, non-coding RNA; Silencers and insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix, homeodomain; 2C 2H zinc finger, multi cysteine zinc finger, basic DNA binding domains (leucine zipper, helix-loop-helix), nuclear receptors; Interaction of regulatory transcription factors with DNA: properties and mechanism of activation and repression including Ligand-mediated transcription regulation by nuclear receptors; Nuclear receptor; histone modifications and chromatin remodeling; Methods for

studying DNA-protein interaction: EMSA, DNase I footprinting, methylation interference assay, chromatin immunoprecipitation.

Unit V Protein translation, post translational modifications and control in prokaryotes and eukaryotes

Ribosomes; Composition and assembly; universal genetic code; Genetic code in mitochondria; Degeneracy of codons; Termination codons; Wobble hypothesis; IsoacceptingtRNA; Translational machinery; Mechanism of Translation in prokaryotes and eukaryotes; Co- and Post-translational modifications of proteins; triple helix of collagen; Translational control; Protein stability; Protein turnover and degradation.

Text Books:

1. Krebs JE, Goldstein ES and Kilpatrick ST (2014) Lewin's *Gene XI*, Jones and Barlett Publishers.
2. RF Weaver *Molecular Biology* 5th edition (2012) McGraw Hill Higher Education
3. Watson JD, Baker TA, Bell SP, Gann A, Levine M & Losick R (2014) *Molecular*
4. *Biology of the Gene*, 7th Edition, Cold Spring Harbor Laboratory Press, New York.

Course Outcomes

On completion of this course, students will able to:

CO1: Summarize the scientific principles of the molecular structure of DNA and organization of genome.

CO2: Narrate on fidelity of DNA replication and the mechanisms of its maintenance.

CO3: Explain RNA transcription and processing in prokaryotes.

CO4: Comprehend RNA transcription and processing in Eukaryotes in comparison with prokaryotic transcription

CO5: Highlight the protein translation and its post-transcriptional modification.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	3	3	-	-	-	3	-	-	3	3	-	3	3
CO2	3	3	3	3	3	3	3		3				3		3	3
CO3	3	3	3	3	3	3	3	-	3	-	-	3	3	-	3	3
CO4	3	3	3	3	3	3	3	-	3	-	-	3		-	3	3
CO5	3	3	3	3	3	3	3		3						3	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	--	--	3	3	--	3	3
CO2	3	--	--	--	3	--	3	3
CO3	3	--	--	3	3	--	3	3
CO4	3	--	--	3		--	3	3
CO5	3	--	--	--		--	3	3
Total	**15**			**9**	**9**		**15**	**15**

Semester-I 19MBTC 103 - FISHERIES RESOURCES, CONSERVATION AND OCEANOGRAPHY

Credits: 4 - Hours: 4

Learning Objectives (**LOS**):

- To evaluate marine environment and its physical features.
- To understand the marine fisheries habitat of India.
- To estimate the status and the trends of major fishery resources and their conservation.

Unit I Marine biology and ecology

Classification of marine environment, Types of aquatic habitats such as coral reefs, sand dunes, mangroves, sea grasses *etc.*, Diversity and taxonomy of marine organisms (Bacteria, Phytoplankton, zooplankton, seaweeds, sea grasses, mangroves, corals *etc.*),Species abundance, richness and diversity indices, Biogeography, Recruitment, Growth, Mortality, Culture of microalgae and invertebrates; Habitat preferences, Adaptations in marine organisms and energy transfer, Marine biomass and productivity - primary production, photosynthetic efficiency; secondary production, productivity distribution in ocean environment, Mechanism and factors affecting primary production, Assessment of impact of changing environment on biodiversity of coastal ecosystems - delineating natural and anthropogenic impacts, Ocean acidification and impacts on marine organisms, Bio-communication in oceans, Microbe-microbe interaction, Microbe-metazoa interaction, Population connectivity, Ecology of benthic organisms, Benthic biological processes and benthic biodiversity, Benthic-pelagic coupling, Bio-invasion ecology, Food web dynamics and ecosystem functioning, Microbial loop - Role of microbes in marine food web dynamics and biogeochemical processes; Bioluminescence and indicator species, Red tides.

Unit II Biodiversity and conservation of aquatic species

Principles, Importance; Fish genetic resources- survey and distribution; Marine living resources assessment - Principal methods of exploitation of marine living resources, Development of novel methods for optimization of marine aquaculture; Influencing Factors, Planning and management; IUCN criteria-Red List; Wildlife protection Act; International Treaties & conventions; Marine protected Areas, Sanctuaries and Biosphere reserves, Establishment of Marine Parks, *in situ* and *ex situ* conservation;

Cryopreservation of Gametes or Gene Banking; Institutes and societies involved in conservation; Artificial Hybridization: Heterosis, Control of fish diseases by selection; selective breeding of disease resistant fish; Marine Bio-prospecting: Mining untapped potential of living marine resources; Molecular Tools in Conservation of Fisheries Resources: Molecular Markers: development of RAPD, RFLP, AFLP, ESTs, SNPs, Micro-satellites and mini-satellites.

Unit III Oceanography

Physical Oceanography: Seawater and its properties; Air-Sea interaction; Geotrophy & large scale circulation of upper ocean; Tides, Waves, Currents, Ocean circulation and Monsoon; Chemical Oceanography: composition of sea water, including trace elements and dissolved organics, elemental and nutrient cycles, salinity & chemical transformations, Gas solubility; inorganic Characteristics of Seawater; Biological Oceanography: Living organisms of ocean: physical parameters & their effects on organisms; characteristics of organisms living in water column; Characterization of Marine Sediments - Constituents, Mass properties, Texture *etc.*; Molecular tool to study Bacterial diversity in sediments; Geographical and seasonal variation in plankton production and trophic dynamics; Indicator species.

Textbooks:

1. Carl E. Bond, (2006) *Biology of Fishes*, 2nd Edition, W.B. Saunders Company, Philadelphia
2. Levitus, (2000) *Warming the World Ocean*, Science.
3. Naskar K. and Mandal R., (1999) *Ecology and Biodiversity of Indian Mangroves*. Daya. pp 361
4. Jeffrey S. Levinton, CD (2001). *Marine Biology: Function, Biodiversity*, *Ecology* (515pp)
5. Artikeya, K., (2005) *Biodiversity: Extinction and Conservation*, (202pp).

Course Outcomes (COs):

Upon successful completion of this course, students willable to:

CO1: Understand status and trends of marine major organisms and their habitat.

CO2: Appreciate bio-communication in oceans with reference to food web dynamics and ecological function.

CO3: Accustom with factors influencing biodiversity and the need of conservation.

CO4: Appraise the factors necessitating the preservation of gametes and artificial insemination for propagation of marine life.

CO5: Acquaint the knowledge in physical, chemical and biological oceanography and their dynamics.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	-	3	-	3	-	-	3	3	-	-	-	3	3
CO2	3	3	3		3		3			3	3				3	3
CO3	3	3	3	-	-	-	3	-	-	3	3	-	-	-	3	3
CO4	3	3	3	-	3	-	3	-	-	3	3	-	-	-	3	3

CO5	3	3	3		3		3			3	3				3	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1		3	3	--	--	--	3	3
CO2		3	3	--	--	--	3	3
CO3		3	3	--	--	--	3	3
CO4		3	3	--	--	--	3	3
CO5		3	3	--	--	--	3	3
Total		**15**	**15**	**--**	**--**	**--**	**15**	**15**

Semester-I **19MBTC 104 - MARINE MICROBIOLOGY**

Credits:2 - Hours:2

Learning Objectives (LOS)

After completing this course, students should be able to -

- Explain principle features of microbial diversity in oceans;
- Describe and discuss marine microbes in terms of physiological capability and biogeochemical role;
- Synthesize microbial ecosystem function in pelagic and benthic marine habitats.

Unit I **Marine microbial ecology and diversity**

Introduction: Marine environment, Seawater, Marine sediments, Habitats for marine microorganisms; Diversity of Marine microorganisms: Archaea, Bacteria, Cyanobacteria, Algae, Fungi, Viruses, viroids and prions and actinomycetes in coastal, shallow, deep sea, hydrothermal vents, mangrove and in coral ecosystem; Marine Symbiotic Microorganisms; Ecology: Survival of indigenous organisms and fate of non-indigenous organisms in the marine environment, Predatory-prey relationship (food-web), Degradation of complex molecules, Colonisation of surfaces Chemotaxis, Attachment, Symbiotic Association; Biogeochemical Processes:Nutrient cycling, Carbon cycle, Nitrogen cycle, sulphur cycle, Iron cycling, Phophorus cycling and other cycles. Photosynthesis, Quorum sensing, Temperature dependent microbial growth, Lethal and mutagenic factors, Protection system from osmotic damage; Taxonomy of Marine Microorganisms: Prokaryotes: Phototrophs containing bacterialchlorophyll, Cyanobacteria, Prochloron, Gliding bacteria, Budding and appendaged bacteria, Aerobic gram negative rods and cocci, Facultatively anaerobic gram negative rods, Gram negative anaerobic rods and cocci, Gram negative chemolithotrophs (ammonia or nitrogen oxidizing or sulphur bacteria), Methane bacteria, Aerobic positive cocci,

Actinomycetes and related bacteria, Spirochaetes, Oceanospiralles, Magnetotactic bacteria, Bdellovibrio, Sulphur and sulphurreducing bacteria. Eukaryotes: Micro algae, Diatoms, Fungi, Yeast, Protozoa; Virus: Classification; Extremophiles.

Unit II **Techniques in marine microbiology**

Sampling: Water, Sediment and aquatic content (General Experimental Procedures and remote sensing). Direct observation and enumeration of microbes: Light and electron microscopy to study morphology and structure of microbes, Epifluorescence light microscopy - enumeration of marine microbes, confocal laser scanning microscopy - recognition of living microbes within their habitat, Flow cytometry - number and size of particles. Culture based methods for isolation and identification of microbes: Specific culture media and conditions for growth, Enrichment cultures, Phenotypic testing, Analysis of microbial components for classification and identification. Nucleic acid based methods: Sequencing of ribosomal RNA genes, Isolation of genomic DNA or RNA from the culture, PCR, Genomic finger printing, GC ratio and DNA-DNA hybridization used in taxanomy, DNA sequencing, Denaturing gradient gel electrophoresis (DGGE) and Terminal restriction fragment length polymorphism (TRFLP), Metagenomics, Fluorescent hybridization for visualization and quantification of microbes, Metatranscriptomics, Metaproteomics and Microarrays.

Unit III **Marine microbiology of organisms**

Microbiology of healthy organisms: Plants, Invertebrates and Vertebrates; Diseases of Invertebrates: Vibriosis, Shell disease, Gaffkemia, Epibiotic associations, Fungal diseases, Viral diseases, Rickettsial diseases; Diseases of Vertebrates: Bacterial pathogens, fungi, protozoa and viruses; Sea Food Microbiology: Classification of seafood: Chilled and frozen raw fish, Chilled and frozen prepared fish products, Molluscan and crustacean shellfish, Cured, smoked and Dried fish, Fermented fish. Micro flora of seafood: Initial flora, Processing and its effect on Microflora, Spoilage and causative flora, Pathogens profile, Pathogens growth and survival; Food born infection and Intoxication caused by seafood microbes: Fish and Shellfish Toxins originated from marine microbes; Microbiological standard for seafood: HACCP in seafood product and Manufacture, EU food hygiene Legislation; Marine Microbes and Biotechnology: Pharmaceutical compounds: Antibiotic, Antiviral, Antitumor compounds; Health promoting products: probiotic, prebiotic, immune-stimulants, enzymes; Other products: Biofuels, Antifouling compounds, Surfactants; Application in different fields: Aquaculture, Food Industry, Biomimetics, Nanotechnology and Bioelectronics.

Recommended Textbooks and References:

1. Munn, C. B., (2004) *Marine Microbiology: Ecology and Applications,* BIOS scientific Publishers
2. Krichman, D.L., (2000) *Microbial Ecology of the Oceans*. Wiley-liss, New York.
3. Paul, J., (2001). *Methods in Microbiology: Marine Microbiology*, Academic Press,
4. Gram, L., (2009) *Microbial Spoilage of Fish and Seafood*, Springer.
5. Pelczar M.J. Jr., Chan E.C.S. and Kreig N.R., (2001) *Microbiology,* (5th Edition), Tata McGraw Hill.
6. G Reed, Prescott and Dunn's, (2004) *Industrial Microbiology,* (4th Edition), CBS Publishers.
7. M.T. Madigan and J.M. Martinko., (2006) *Biology of Microorganisms*, 11th Edition, Pearson Prentice Hall, USA.
8. Rheinhemer, G., (1980). *Aquatic Microbiology*, Johnwiley & Sons, 235 pp.
9. Elay, A.R.(1992). *Microbial Food Poisoning*. Chapman and Hall, London, 191 pp.
10. Ford, T.E., (1993). *Aquatic Microbiology. an Ecological Approach*. Blackwell scientific publications, London, 518 pp.
11. Krichman, D.L., (2000). *Microbial Ecology of the Oceans.* Wiley-liss, New york, 542 pp.

Course Outcomes (COs):
Upon successful completion of this course, students will able to:

CO1: Explain important features of microbial diversity with reference to different niches in Oceans.

CO2: Learn techniques of microbial culture, evaluation, maintenance preservation and storing for long time use

CO3: Describe and discuss marine microbes in terms of physiological competence and bio-geochemical role

CO4: Analyze microbial eco system function in pelagic and benthic marine habitats

CO5: Validate microbial pathogenesis, host pathogens interaction, diseases diagnosis and their economic important in food industry

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	–	–	–	3	–	–	3	–	3	–	3	–	–
CO2	3	3	3	–	3	3	3	–	–	3	–	3	–	3	–	–
CO3	3	3	3	3	3	3	3	–	–	3	–	3	–	3	–	–
CO4	3	3	3	–	3	3	3	–	–	3	–	3	–	3	–	–
CO5	3	3	3	–	3	2	2	–	–	3	–	3	–	3	–	–

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1		3	-	3	--	3	--	--
CO2		3	--	3	--	3	--	--
CO3		3	--	3	--	3	--	--
CO4		3	--	3	--	3	--	--
CO5		3	--	3	--	3	--	--
Total		**15**	**--**	**15**	**--**	**15**	**--**	**--**

Semester-I **19MBTC 105 - BIOSTATISTICS**

Credits:2 - Hours:2

Learning Objectives (**LOS**):

- Apply and understand underlying principles of statistics as well as practical guidelines of utilizing a data in the following manner: "how to do it" and "how to interpret it".
- Utilize biological data for predicting population structure and their distribution pattern in real time.
- Examine a data in a graphical representation for better understanding.

Unit I Introduction

Types of biological data (ordinal scale, nominal scale, continuous and discrete data), frequency distribution and graphical representations (bar graph, histogram, box plot and frequency polygon), cumulative frequency distribution, populations, samples, simple random, stratified and systematic sampling.

Unit II Descriptive statistics

Measures of Location, Properties of the Arithmetic Mean, median, mode, range, Properties of the Variance and Standard Deviation, Coefficient of Variation, Grouped Data, Graphic Methods, Obtaining Descriptive Statistics on Computer, Case study.

Unit III Probability and distribution

Introduction to probability and laws of probability, Random Events, Events-exhaustive, mutually exclusive and equally likely (with simple exercises), Definition and properties of binomial distribution, Poisson distribution and normal distribution.

Unit IV Correlation **and regression analysis**

Correlation, Covariance, calculation of covariance and correlation, Correlation coefficient from ungrouped data Spearson's Rank Correlation Coefficient, scatter an d dot diagram, General Concepts of regression, Fitting Regression Lines, regression coefficient, properties of Regression Coefficients, Standard error of estimate.

Unit V Statistical hypothesis testing

Making assumption, Null and alternate hypothesis, error in hypothesis testing, confidence interval, one-tailed and two-tailed testing, decision making.

Unit VI Tests of significance

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

Unit VII Experimental designs

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

TEXT BOOKS:

1. Jaype Brothers, (2011), *Methods in Biostatistics for Medical Students and Research Workers* (English), 7th Edition
2. Norman T.J. Bailey, (1995), *Statistical Methods in Biology*, 3rd Edition, Cambridge University Press.
3. P. N. Arora and P. K. Malhan, (2006), *Biostatistics*, 2nd Edition, Himalaya Publishing House.
4. *Biostatistics: A Foundation for Analysis in the Health Sciences*, 7th Edition, Wiley.
5. ML Samuels, JA Witmer (2003) *Statistics for the Life Sciences*, 3rd edition. Prentice Hall.

Course outcomes (Cos):

On completion of this course, students will able to:

CO1: Understand how to summarize statistical data.

CO2: Apply appropriate statistical tests based on an understanding of study question, type of study and type of data.

CO3: Interpret results of probability correlation.

CO4: Appreciate correlation regression analysis

CO5: Describe statistical hypothesis.

CO6: Verify the significance of a data

CO7: Simulate experimental design for precise data collection.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	-	3	3	3	-	-	-	3	3	-	3	-	-
CO2	3	3	3	-	3	3	3	-	-	-	3	3	-	3	-	-
CO3	3	3	3	-	3	3	3	-	-	-	3	3	-	3	-	-
CO4	3	3	3	-	3	3	3	-	-	-	3	3	-	3	-	-
CO5	3	3	3	-	3	3	3	-	-	-	3	3	-	-	-	-
CO6	3	3	3	-	3	3	3	-	-	-	3	3	-	-	-	-
CO7	3	3	3	-	3	3	3	-	-	-	3	3	-	-	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	3	3	--	3	--	--
CO2	--	--	3	3	--	3	--	--
CO3	--	--	3	3	--	3	--	--
CO4	--	--	3	3	--	3	--	--
CO5	--	--	3	3	--	--	--	--
CO6	--	--	3	3	--	--	--	--
CO7	--	--	3	3	--	--	--	--
Total	**--**	**--**	**21**	21	--	12	--	--

Semester-I 19MBTC 106 - BIOPHYSICAL PRINCIPLES AND ANALYTICAL TECHNIQUES

Credits: 2 - Hours: 2

Learning Objectives (LOS):

- Get broad exposure to all basic techniques (Biochemical & Biophysical) used in current Modern Biology research.
- Impart basic conceptual understanding f principles of these techniques and emphasize Biochemical utility of same& underlying Biophysics.
- Understand all analytical techniques such that the barrier to implement same is abated to a great extent.

Unit I Introduction to biomolecules

Nucleic Acid, Protein-Polymer Description of Macromolecular Structure, Intermolecular and Intramolecular forces, Non Covalent Interaction; Hydrodynamic properties: Diffusion and sedimentation, determination of molecular weight from sedimentation and diffusion; Concept and application of Chemical and Physical equilibria in Biological system, Equilibrium constant and Standard Gibbs Free energies of reactants and products, Temperature dependence of equilibrium constant. Basic Concepts: Rate, order and molecularity of a reaction, First, second and third order reactions – effect of concentration on reaction rate, rate expressions and integrated form, pseudo-unimolecular and second order autocatalytic reactions, nth order reaction of a single component, effect of temperature on reaction rate – Arrhenius equation and activation energy.

Unit II Cellular and molecular mechanisms

Physical biochemistry of cell: Chemical forces translation and rotation, diffusion, directed movements, bio-molecules as machines, work, power and energy, thermal, chemical and mechanical switching of bio-molecules, Responses to light and environmental cues; Molecular recognition:

principles of specificity in biological recognition, hormone-receptor interaction, antigen--antibody interaction, transient interactions, importance of transient interaction in biology. Stochasticity in Biological systems; Overexpression and purification of protein: Bulk scale bacterial cell culture and IPTG induction for protein expression, Detection of protein by western blotting in soluble and insoluble fraction after bacterial cell lysis, Affinity purification of the protein from the soluble fraction of the bacterial cell lysate (for His-tagged protein, Ni-agarose matrix will be used), Biochemical and biophysical characterizations of the purified protein: Purified protein will be assayed for its biological activity, (Fluorescence from GFP), UV-VIS absorption and emission spectra resulting from intrinsic Tryptophan and GFP chromophores, Fluorescence quenching and polarization studies, Unfolding and refolding studies using CD and fluorescence methods, Fluorescence correlation spectroscopy experiment to measure the protein diffusion and hydrodynamic size, Atomic force microscopy of plasmid DNA.

Unit III Analytical instrumentation

Spectroscopic properties of proteins and nucleic acid: UV/Vis, Intrinsic fluorescence, Circular dichroism. Double Strand formation in nucleic acid, Ligand-protein binding, Protein denaturation and stability, Introduction of DSC and ITC; Protein folding kinetics and Biophysical methods, Misfolding and aggregation; Physical basis of conformation diseases; Introduction to basic principles of protein X-ray crystallography, protein NMR, Small Angle X-ray scattering (SAXS), and Electron microscopy (EM), cryo-EM, Graphics and structural validation, Structural databases, Other biophysical and spectroscopic techniques to understand conformations of biomolecules; Mass Spectroscopy: Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; Optical Imaging Methods: Light Microscopy: fluorescence and fluorescence microscopy: confocal microscope: scanning optical microscope, confocal principle, nonlinear microscopy: multiphoton microscopy; tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Beyond Diffraction Limit: Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM).

Textbooks:

1. Tinoco, Sauer, Wang, and Puglisi. (2013) *Physical Chemistry: Principles and Applications in the Biological Sciences*. Prentice Hall, Inc.
2. Atkins, de Paula. (2011) *Physical Chemistry for the Life Sciences* (2nd Edition). W.H. Freeman.
3. K. E. van Holde, C. Johnson, P. S. Ho (2005) *Principles of Physical Biochemistry*, 2nd Edn., Prentice Hall.
4. *Energy and Entropy Equilibrium to Stationary States*, Starzak, Michael E. 2010, XI, 303 p.
5. Branden C and Tooze J, *Introduction to Protein Structure*, Garland Science, 2017.

Supplementary Text Books:

1. Joachim Frank. (2006) *Three- Dimensional Electron Microscopy of MacromolecularAssemblies*, Academic Press.
2. A. K. Downing, Protein NMR techniques, *Methods in Molecular Biology* Volume 278, 2004.

Course Outcomes (Cos):

Co1: Students will learn how to combine previously acquired knowledge of physical chemistry and biochemistry in order to understand biochemical processes at molecular level.
Co2: Student will clarify the rate, order and molecularity of a reaction.
Co3: Student will understand the role of biomolecules and their functional analyses.
Co4: Student will acquire knowledge in analytical techniques to evaluate protein molecules.
Co5: Student will describe the principle and application of sophisticated tools of microscopy in predicting structure and function elucidation of biological molecules

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	-	-	3	3	3	-	3	3	3	3	-	-	3	3
CO2	3	3	-	-	3	3	3	-	3	3	3	3	-	-	3	3
CO3	3	3	-	-	3	3	3	-	3	3	3	3	-	-	3	3
CO4	3	3	-	-	3	3	3	-	3	3	3	3	-	-	3	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	--	--	3	3
CO2	3	3	3	3	--	--	3	3
CO3	3	3	3	3	--	--	3	3
CO4	3	3	3	3	--	--	3	3
Total	**12**	**12**	**12**	**12**	--	--	**12**	**12**

Semester-I 19MBTP 107 – Practical – I BIOCHEMISTRY AND ANALYTICAL TECHNIQUES

Credits: 4
Hours: 6

Learning Objectives (LOS):

- The objective of this laboratory course is to experiment for the evaluation of biological molecules occurrence in qualitative and quantitative aspect.
- This practical course is also meant to proof certain biochemical reactions
- Implication of analytical tools for understanding the principles

Syllabus

1. Preparing various stock solutions and working solutions that will be needed forthe course.
2. To prepare an Acetic-Na Acetate Buffer and validate Henderson-Hasselbach equation.
3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-VIS Spectrophotometer and validating the Beer- Lambert's Law.
4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
5. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of institution's choice).
    a. Preparation of cell-free lysates
    b. Ammonium Sulfate precipitation
    c. Ion-exchange Chromatography
    d. Gel Filtration
    e. Affinity Chromatography
    f. Generating a Purification Table (protein concentration, amount of total protein)
    g. Computing specific activity of enzyme preparation at each stage of purification
    h. Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis
    i. Enzyme Kinetic Parameters: Km, Vmax and Kcat.
    j. Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method
6. Experimental verification that absorption at OD260 is more for denatured DNA as compared to native double stranded DNA.
7. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments)
8. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
9. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

Course Outcomes (Cos):

Students will able to:

O1: Realize the concepts of biochemistry with easy to run experiments.

CO2: Familiarize with basic laboratory instruments and understand principle of measurements using those instruments with experiments in biochemistry.

CO3: Acquire to utilize the different types of chromatography in separation of bio-molecules like protein, lipid, carbohydrate, phenolics, terepenoids, alkaloids and other nitrogen- containing compounds.

CO4: Develop skills in utilization various laboratory tools in the isolation and evaluation of nucleic acids and protein.

CO5: Learn about the uses of different types of spectroscopy including mass spectroscopy in understanding of biomolecules and their function.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	-	3	3	3	-	3	-	-	-	-	-	-	-
CO2	3	3	3	-	3	3	3	-	3	-	-	-	-	-	-	-
CO3	3	3	3	-	3	3	3	-	3	-	-	-	-	-	-	-
CO4	3	3	3	-	3	3	3	-	3	-	-	-	-	-	-	-
CO5	3	3	3	-	3	3	3	-	3	-	-	-	-	-	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	--	--	--	--	--	--	--
CO2	3	--	--	--	--	--	--	--
CO3	3	--	--	--	--	--	--	--
CO4	3	--	--	--	--	--	--	--
CO5	3	--	--	--	--	--	--	--
Total	**15**	**--**	**--**	--	--	--	--	--

Semester-I 19MBTP 108 – Practical – II Microbiology and Experimental Methods in Fisheries

Credits: 4
Hours: 6

Learning Objectives (LOS):

- To learn fundamental microbiological and fishery biological laboratory techniques for investigating experimental problems.
- To handle different culture technique in isolation, identification and characterization of microbes
- Can able to distinguish different marine organisms like micro algae, benthos, fin and shell fishes
- Can able to analyze various water parameters
- To understand the method of using data generated in a range of experiments in relevance to theoretical concepts of the experimental outcomes.

Syllabus

Microbiology

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Preparation of media for cultivation of bacteria (differential and selective).
3. Isolation of bacteria in pure culture by streak plate method.
4. Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus, Streptococcus, etc.*
5. Preparation of bacterial smear and Gram's staining.
6. Enumeration of bacteria: standard plate count.
7. Antimicrobial sensitivity test and demonstration of drug resistance.
8. Maintenance of stock cultures: slants, stabs and glycerol stock cultures
9. Determination of phenol co-efficient of antimicrobial agents.
10. Determination of Minimum Inhibitory Concentration (MIC)
11. Isolation and identification of bacteria from soil/water samples.

Fisheries Resources, Conservation & Oceanography

1. Identification and quantification of phytoplankton (diatoms and dinoflagellates) using microscopy/FlowCAM/ HPLC
2. Qualitative and quantitative enumeration of zooplankton (microscopy/Flowcam)
3. Identification of commercially important crustaceans (prawns, Shrimps, lobsters and crabs), molluscs (pelecypods, gastropods and Cephalopods) and fishes (Cartilaginous & teleost) apart from dolphins & whales.
4. Identification of larval stages of crustaceans (prawns, shrimps, lobsters and crabs), molluscan and fish eggs and larvae.
5. Qualitative and quantitative enumeration of benthos, Sediment characterization
6. Primary productivity - measurement and new production
7. Gut content analysis for assessing food and feeding habits
8. Reproductive biology and ecology of commercially important crustaceans, molluscs and fishes

9. Introduction to basic molecular tools for evaluation of community structure – DNA extraction, PCR/Q-PCR, DGGE, cloning, sequencing
10. Crafts and gears- Principles and operation of different fishing gears.

Course Outcomes (Cos):

Student will able to:

CO1: Obey the bio-safety aspects of good laboratory practices in the culture of microbes.
CO2: Do enumeration of microbial cultures using different culture media.
CO3: Characterize microbes and their culture conditions from different sources of aquatic environment.
CO4: Utilize microscopy for evaluation of phytoplankton and zooplankton.
CO5: Validate primary productivity of different water bodies.
CO6: Distinguish different larval stages of both fin and shell fishes.
CO7: Gain the knowledge in using different crafts and gears.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-
CO2	3	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-
CO3	3	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-
CO4	3	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-
CO5	3	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-
CO6	3	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-
CO7	3	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	3	--	--	--	--	--	--
CO2	--	3	--	--	--	--	--	--
CO3	--	3	--	--	--	--	--	--
CO4	--	3	--	--	--	--	--	--

CO5	--	3	--	--	--	--	--	--
CO6	--	3	--	--	--	--	--	--
CO7	--	3	--	--	--	--	--	--
Total	**--**	**21**	**--**	--	--	--	--	--

Semester-II **19MBTC 201 - CELL AND DEVELOPMENTAL BIOLOGY**

Credits: 3

Hours: 3

Learning Objectives (**LOS**):

- To emphasize a conceptual overview of cellular system and functioning, and also to interpret on developmental patterns arise using examples from different model systems
- To highlightcellular regulatory networks involved in these processes.
- To discuss essential aspects of stem cell biology, their usage for therapeutic purposes and social implications associated with this modern technology.

Unit – I Cell architecture organization and function of organelles

Cell theory; diversity of cell size and shape: Microscope and its modifications – Light, phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunnelling and Atomic Force Microscopy, *etc.*; Membrane Structure and Function: Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo- and Exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata; Organelles: Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging; Cell cycle and control mechanisms; Mitochondria – structure, organization of respiratory chain complexes, ATP synthase, Structure-function relationship; Mitochondrial DNA and male sterility; Origin and evolution; Chloroplast– Structure-function relationship; Chloroplast DNA and its significance; Chloroplast biogenesis; Origin and evolution.

Unit – II Cellular motility

Structure and function of microbodies, Golgi apparatus, Lysosomes and Endoplasmic Reticulum; Organization and role of microtubules and microfilaments; Cell shape and motility; Actin-binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments; Extracellular matrix in plants and animals; Cellular Movements and Pattern Formation- Laying of body axis planes; Differentiation of germ layers; Cellular polarity; Model plants like*Fucus* and*Volvox*; Maternal gene effects; Zygotic gene effects; Homeotic gene effects in *Drosophila*; Embryogenesis and early pattern formation in plants; Cell lineages and developmental control genes in *Caenorhabditis*.

Unit – III Differentiation of specialized cells

Stem cell differentiation; Blood cell formation; Fibroblasts and their differentiation; Cellular basis of immunity; Differentiation of cancerous cells and role of proto-oncogenes; Phase changes in *Salmonella*; Mating cell types in yeast; Surface antigen changes in Trypanosomes; Heterocyst

differentiation in *Anabaena*; Sex determination in *Drosophila*; Plant Meristem Organization and Differentiation- Organization of Shoot Apical Meristem(SAM); Organization of Root Apical Meristem (RAM); Pollen germination and pollen tube guidance; Phloem differentiation; Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixes

Textbooks:

1. Lodish *et al.*, (2000) *Molecular Cell Biology*, (4th Edition), W.H. Freeman & Company
2. Smith & Wood, (2005) *Cell Biology,* (2nd Edition), Chapman & Hall, London
3. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; (2014). *Molecular Biology of the Gene*, 7th Edition, Benjamin Cummings Publishing Company Inc.
4. B. M. Turner, (2002) *Chromatin & Gene Regulation*, (1st Edition), Wiley-Blackwell
5. *Benjamin Lewin*, (2013) Gene XI, 11th Edition, Jones and Barlett Publishers.

Course Outcomes (Cos):

At the end of course students will able to:

CO1: Understand the major organelles and their physiological role in the maintenance of cellular architecture

CO2: Analyze macromolecular trafficking, chromatin organization and packaging,

CO3: Explain cell cycle and control mechanisms

CO4: Comprehend with cell motility and its role in functional organization of different tissues

CO5: Appreciate cell division components, the factors responsible in cell growth, embryonic development mechanisms and certain elements' role in deformities during growth.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	-	3	3	-	3	-	3	-	-	3	3	3	-	-
CO2	3	3	-	3	3	-	3	-	3	-	-	3	3	3	-	-
CO3	3	3	-	3	3	-	3	-	3	-	-	3	3	3	-	-
CO4	3	3	-	3	3	-	3	-	3	-	-	3	3	3	-	-
CO5	3	3	-	3	3	-	3	-	3	-	-	3	3	3	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	--	--	3	3	3	--	--
CO2	3	--	--	3	3	3	--	--
CO3	3	--	--	3	3	3	--	--
CO4	3	--	--	3	3	3	--	--
CO5	3	--	--	3	3	3	--	--
Total	**15**	**--**	**--**	**15**	**15**	**15**	--	--

Semester-II **19MBTC 202 - GENETIC ENGINEERING**

Credits: 3
Hours: 3

Learning Objectives (LOS):

- To acquire knowledge in restriction digestion and joining of DNA molecules
- To understand various approaches in the expression of cloned gene of our interest
- To familiarize different molecular tools for the application in biological research as well as in biotechnological industries.

Unit – I Introduction and tools for genetic engineering

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymer tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.

Unit – II Different types of Vectors

Plasmids; Bacteriophages; M13mp vectors; pUC19 and pBluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag *etc.*; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and *Pichia* vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

Unit – III Different types of PCR techniques

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR

products; T - vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

Unit – IV cDNA Analysis

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein - DNA interactions: electrophoretic mobility shift assay; DNase I footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit – V Gene silencing and genome editing technologies

Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs 23 xenopus), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials; Cloning genomic targets into CRISPR/Cas9 plasmids; electroporation of Cas9 plasmids into cells; purification of DNA from Cas9 treated cells and evaluation of Cas9 gene editing; *in vitro* synthesis of single guide RNA (sgRNA); using Cas9/sgRNA complexes to test for activity on DNA substrates; evaluate Cas9 activity by T7E1 assays and DNA sequence analysis; Applications of CRISPR/cas9 technology.

Textbooks:

1. Brown, T. A. (2006). *Genomes* (3rded.). New York: Garland Science Pub
2. S. Primrose, R. Twyman, B. Old, and G. Bertola (2006). *Principles of Gene Manipulation and Genomics*, Blackwell Publishing Limited; 7th Edition
3. Green, M. R., &Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
4. Selected papers from Scientific Journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab*etc.*

Course Outcomes (Cos):

After qualifying in this course student will able to:

CO1: Acquire knowledge in utilizing the tools (i.e., DNA polymerases, nucleases, ligases, phosphorylases, labeled DNA/RNA markers, vector constructs selectable markers etc.,) of genetic engineering.

CO2: Gain facts on types of DNA vectors, strategies of cloning, expression of the gene, screening and isolation of the cloned gene

CO3: Know the method of specific gene amplification using PCR and the techniques involved in disease diagnosis

CO4: Learn the principles involved in cDNA construction, gene product evaluation and protein expression substantiation.

CO5: Learn gene silencing and gene editing technologies for the use in clinical and pharmacological applications.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	-	3	3	-	3	-	3	-	-	-	3	-	-	-
CO2	3	3	-	3	3	-	3	-	3	-	-	-	3	-	-	-
CO3	3	3	-	3	3	-	3	-	3	-	-	-	3	-	-	-
CO4	3	3	-	3	3	-	3	-	3	-	-	-	3	-	-	-
CO5	3	3	-	3	3	-	3	-	3	-	-	-	3	-	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	3	--	--	3	--	--	--
CO2	--	3	--	--	3	--	--	--
CO3	--	3	--	--	3	--	--	--
CO4	--	3	--	--	3	--	--	--
CO5	--	3	--	--	3	--	--	--
Total	**--**	**15**	**--**	--	**15**	--	--	--

Semester-II 19MBTC 203 - AQUACULTURE BIOPROCESSING AND MARINE PHARMACOLOGY

Credits: 3

Hours: 3

Learning Objectives (LOS):

- To appreciate different types aquaculture methods for growing different types of cultivable aquatic algal organisms
- To learn feed formulation

- To understand bioprocess methods required for obtaining essential components from marine organisms of pharmacological importance.

Unit – I Microbial and micro-algal technologies in aquaculture

Bio-floc technology; Aquaponics; Zero water exchange aquaculture system; Aquamimicry; Hydroponics; Raceway system of aquaculture; Bioremediation in Aquaculture systems: Genetically modified organisms in waste water treatment; Bioremediation for soil and water quality improvement; Probiotics: Preparation and applications; Micro-algae- indoor and mass-culture methods, Biotechnological approaches for production of important microalgae. Single cell protein from *Spirulina*; vitamins, minerals and Omega-3 fatty acids from micro-algae; enrichment of micro-algae with micro-nutrients; cell wall polysaccharides of micro-algae; micro algae biomass for removal of heavy metals; Biofuel production from microalgae; metabolic engineering of microalgae for biofuel production.

Unit – II Industrial aquaculture technology

Fish Feed Technology: Types of feed, conventional feed *vs* functional feeds; Principles of feed formulation and manufacturing, diets suitable for application in different aquaculture systems; feed formulation ingredients; Use of natural and synthetic carotenoids; feed additives; Role of additives; Feed processing: Gelatinization, extrusion Technology, pellet dressing with heat liable nutrients; Feed evaluation; Feeding schedule to different aquatic organisms, check tray operation and feed management, Biomass calculation based on feed intake; Post-harvest Biotechnology: Fundamental aspects of freezing, methods of freezing; Delaying of spoilage; Detection of toxic substances and pathogenic microbes; biosensors for toxin detection; Natural biomaterial used for preservation of fish, Antibiotic residual analysis techniques, detection of human pathogenic bacteria by PCR methods, Microbial and enzymatic standards of different fishery products.

Unit – III Marine Pharmacology

Principles & mechanisms of drug action; Pharmacokinetics & pharmacodynamics; Marine derived pharmaceuticals: Marine bio-resources, secondary metabolites, marine proteins and lipids & molecular biology approaches; Marine actinobacterial metabolites & their pharmacological potential; Potential pharmaceuticals from soft and hard corals; pharmaceutical potential of marine sponges; metagenomic strategies for natural product discovery; marine biotoxins and potential pharmacological uses of phyco-toxins.

Unit – IV Important marine products

Green fluorescent protein (GFP) & red fluorescent protein (RFP) characteristics and their applications; Green mussel adhesive protein; Chitosan and its applications; ornamental fishes.

Textbooks:

1. Se-kwon Kim, (2015) *Handbook of Marine Biotechnology,* Springer,
2. Pelczar M.J. Jr., Chan E.C.S. and Kreig N.R., (2001) *Microbiology*, (5th Edition), Tata McGraw Hill.
3. Felix, S., (2010) *Handbook of Marine and Aquaculture Biotechnology*, AGROBIOS INDIA.
4. Gautam, N.C., (2007) *Aquaculture Biotechnology*, Shree Publishers and Distributors.
5. Lakra, W.S. (2008) *Fisheries Biotechnology*, Narendra Publishing House.

Course Outcomes (Cos):

After qualifying in this course student will able to:

CO1: Different methodologies in culture of micro-algae and their importance in aquaculture.

CO2: Learn the techniques involved in the processing of feed formulation for cultivable aquatic organisms.

CO3: Understand the techniques employed to get bioactive compounds from marine living resources

CO4: Gain knowledge in marine pharmacology.

CO5: Know about important marine sources for valuable products.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	-	-	3	3	3	3	3	3	3	-	3	-	-	-
CO2	3	3	-	-	3	3	3	3	3	3	3	-	3	-	-	-
CO3	3	3	-	-	3	3	3	3	3	3	3	-	3	3	-	-
CO4	3	3	-	-	3	3	3	3	3	3	3	-	3	3	-	-
CO5	3	3	-	-	3	3	3	3	3	3	3	-	3	3	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	--	3	--	--	--
CO2	3	3	3	--	3	--	--	--
CO3	3	3	3	--	3	3	--	--
CO4	3	3	3	--	3	3	--	--
CO5	3	3	3	--	3	3	--	--
Total	15	15	15	--	15	9	--	--

Semester-II 19MBTC 204 - FISH IMMUNOLOGY AND HEALTH MANAGEMENT

Credits: 3
Hours: 3

Learning Objectives (LOS):

- To comprehend basic principles of fish and shell immunology and their types
- To know the various types of diseases and their causative agents
- To quarantine the aquatic organisms and the essential principles in their health management

Unit – I Defense mechanism in fish and shellfish

Non-specific defense mechanisms: Surface barriers, gastrointestinal tract; Non-specific humoral factors: Growth inhibitors, Enzyme inhibitors, Precipitins and agglutinins; Non-specific cellular factors; Adaptive and Innate immunity: cells, factors and mechanisms, Specific defense mechanism; Antibody molecule; Antibody effector mechanisms; Factors affecting immune response: intrinsic and extrinsic factors; Cellular components of crustacean immunity: Non-self recognition mechanisms, Innate immediate immune reactions; Mechanisms of cellular defense in crustaceans - Phagocytosis, Nodule formation, Encapsulation, Cytotoxicity, Cell adhesion; Humoral components of crustacean immunity: Lectins, ProPO activating system; Antimicrobial compounds; Serine proteinase inhibitors, Clotting reaction; Maternal transmission of immunity to white spot syndrome associated virus (WSSV) in shrimp (Penaeusmonodon) Broad antiviral activity in tissues of crustaceans; Circulating haemocytes and haematopoiesis; Toxins as defense mechanism.

Unit – II Fish and shellfish diseases and diagnostic techniques

Significance of fish diseases in relation to Aquaculture; Disease development process in fish; Infectious diseases of cultured finfish and shellfish: Bacterial, viral, fungal diseases of fish and shellfish; Parasitic diseases of fish and shellfish; zoonotic and OIE listed notifiable diseases; non-infectious diseases; Antibody Based Disease diagnostics: Antibodies, sources of antibodies; Basis of antibody based diagnostics; Conventional Antibody based Tests-Neutralisation Test, agglutination Test; Advanced antibody based Tests: ELISA, ELISPOT assay, Immunodot Assay, Western blotting; Molecular Diagnostics: PCR, RT-PCR, LAMP, Real Time PCR, Micro-Array and Probe based techniques in fish disease diagnosis; Cell culture based Diagnostics: Cell culture media & supplements, Primary cell culture, Passaging of cell culture for routine maintenance, Fish cell lines; Isolation and Identification of viruses using cell culture.

Unit – III Health Management

Drugs, chemicals, antibiotics and probiotics used in aquaculture and their mode of action; Preventive strategies; Principles and methods of vaccine production and fish immunization; DNA and RNAi vaccines; Quarantine and health certification in aquaculture; Crop rotation, Immunostimulants, bioremediation and polyculture as strategies for health management. Probiotics; Quarantine and health certification; Bioremediators and Other prophylactic measures; Pharmacology: Terms and Definitions; Drugs, chemicals, antibiotics, probiotics and their mode of action.

Textbooks:

1. Edward J.Noga, (2010). *Fish Disease: Diagnosis and Treatment*, Wiley Blackwell.
2. Ronald J. Roberts, (2012) *Fish Pathology*, (4th Edition), Wiley-Blackwell.
3. R. LanFroshney, *Culture of Animal Cells*, (3rd edition), Wiley-Liss.
4. Thanwal, R., (2014) *A Handbook of Fish Diseases*, Astha publishers & Distributors.
5. Bullock, G.L., (2014) *Diseases of Fishes.* Narendra Publishing House.

6. Inglis, V., (2013) *Bacterial Diseases of Fish*, Wiley Publications.

Course Outcomes (Cos):

On completion of this course, students will able to:

O1: Recognize immunological nature of shell and fin fishes in marine environment
CO2: Evaluate the humoral components of invertebrate immunity.
CO3: Learn about the techniques on early diagnosis of diseases and identification of causative agent.
CO4: Understand the importance of animal cell culture in the field of immunology
CO5: Progress in enduring health management strategies.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	-	-	3	3	3	-	3	3	-	-	3	3	-	-
CO2	3	3	-	-	3	3	3	-	3	3	-	-	3	3	-	-
CO3	3	3	-	-	3	3	3	-	3	3	-	-	3	3	-	-
CO4	3	3	-	-	3	3	3	-	3	3	-	-	3	3	-	-
CO5	3	3	-	-	3	3	3	-	3	3	-	-	3	3	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	--	--	3	3	--	--
CO2	3	3	--	--	3	3	--	--
CO3	3	3	--	--	3	3	--	--
CO4	3	3	--	--	3	3	--	--
CO5	3	3	--	--	3	3	--	--
Total	**15**	**15**	**--**	--	**15**	**15**	--	--

Semester-II 19MBTC 205 - AQUATIC ENVIRONMENTAL BIOTECHNOLOGY

Credits: 2
Hours: 2

Learning Objectives (LOS):

To learn about:

- Marine organisms and their niches in making an ecosystem
- Necessity of tackling environmental issues like pollution, fouling pertaining to marine biodiversity
- Biotechnological approaches for remedial measures

Unit – I Marine Organisms and environment interaction

Types of marine environment - Physical, Chemical and Biological aspects and their interaction with marine life; Air – Sea interaction; Greenhouse gases (CO2 and Methane); Marine pollution-major pollutants (heavy metal, pesticide, oil, thermal, radioactive, plastics, litter and microbial) & sources; Biological indicators (Marine microbes, algae and crustaceans) as a tool for assessment of aquatic environment: Protein biomarkers; Biosensors and biochips; eutrophication; red tides & pesticide kills; immune responses of aquatic animals in bio-unsafe environment; Bioaccumulation and impact on aquatic fauna; Microbial Pollution: Types of aquatic microbes; autotrophs, heterotroph, saprotrophs and necrotrophs.

Unit – II Biomaterial interaction

Biofilm formation; Biofouling; Marine fouling and boring organisms - their biology, adaptation; Biosensor in pollution detection; Unculturable bacteria- occurrence, characteristics, characterization and exploitation; Factors influencing settlement of macrofoulers; Antifouling and Anti boring treatments; Corrosion Process and control of marine structures.

Unit – III Biotechnology in pollution management

BOD, COD; Marine pollution & its control; genetically modified microbes for wastewater treatment; Biosensors-types & applications; Biomolecules; membrane and transducer; Bioaugmentation- estimation of microbial load; Methods of Inorganic and Organic waste removal; treatment of Oil pollution at sea; Biodegradation; Bioremediation & Phytoremediation; Biodegradation of natural and synthetic waste materials; methods in determining bioaugmentation & biomagnification; Separation, purification and bio removal of pollutants; fermented products and Biogas from wastes; utilization of aquatic slurry for salt-resistant paddy cultivation.

Textbooks:

1. Milton fingerman*et al.* (1999) *Recent Advances in Marine Biotechnology* Volume 3.
2. Pawan, B., Zaki, M.S.A., (2014) *Aquatic Ecology and Biotechnology*, Discovery Publishing House Pvt. Ltd,
3. Olguni, E.J. *et al.* (2000) E*nvironmental Biotechnology and Cleaner Bioprocess.*
4. Gareth M.Evams*et al.*, (2003) *Environmental Biotechnology*.
5. S. Mahesh*et al.*, (2003) *Biotechnology, Recombinant DNA Technology, Environmental Biotechnology*.

Course outcomes (Cos):

On completion of this course, students will able to:

CO1: Identify interaction between marine organisms and environment
CO2: Categorize different types of pollutants and their effect on marine organisms.
CO3: Appreciate in developing biomarkers for different pollutants.
CO4: Recognize various type of biological materials causing fouling and their relevance to environment
CO5: Employ biotechnological management to come up with solutions against growing marine pollution

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	-	3	3	3	-	-	3	3	-	-	-	-	-
CO2	3	3	3	-	3	3	3	-	-	3	3	-	-	-	-	-
CO3	3	3	3	-	3	3	3	-	-	-	3	-	-	3	-	-
CO4	3	3	3	-	3	3	3	-	-	-	3	-	-	3	-	-
CO5	3	3	3	-	3	3	3	-	-	-	3	-	-	3	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	3	3	--	--	--	--	--
CO2	--	3	3	--	--	--	--	--
CO3	--	--	3	--	--	3	--	--
CO4	--	--	3	--	--	3	--	--
CO5	--	--	3	--	--	3	--	--
Total	**--**	**6**	**15**	--	--	9	--	--

Semester-II 19MBTP 206 – Practical – III MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Credits: 4
Hours: 6

Learning Objectives (LOS):

- To handle different molecular tools in the isolation of DNA/RNA molecules for subjecting them for genetic engineering.

Syllabus

1. Concept of lac-operon:
   a) lactose induction of â-galactosidase.
   b) Glucose Repression.
   c) Diauxic growth curve of *E. coli*.
2. UV mutagenesis to isolate amino acid auxotroph.
3. Phage titre with ë phage/M13.
4. Genetic Transfer-Conjugation, gene mapping.
5. Plasmid DNA isolation and DNA quantitation.
6. Restriction Enzyme digestion of plasmid DNA.
7. Agarose gel electrophoresis.
8. Polymerase Chain reaction.
9. DNA Ligation.
10. Preparation of competent cells.
11. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency.
12. Confirmation of the insert by Colony PCR and Restriction mapping
13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in*E.coli*, SDS-PAGE analysis
14. Purification of His-Tagged protein on Ni-NTA columns
    a) Random Primer labeling
    b) Southern hybridization.

Course Outcomes (Cos):

On completion of this course, students will able to:

CO1: Apprehend the concept of operon model for predicting the use in genetic engineering.
CO2: Use PCR for gene amplification.
CO3: Gain hands-on experience on gene insertion, transformation and screening for recombinant clone.
CO4: Experiment the gene and protein expression
CO5: Understand the principles of His-taq expression of protein for column purification.
CO6: Learn hybridization technique to confirm the selection of precise clone.

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	–	3	3	3	–	–	3	3	–	–	3	–	–
CO2	3	3	3	–	3	3	3	–	–	3	3	–	–	3	–	–

CO3	3	3	3	–	3	3	3	–	–	–	–	–	–	3	–	–
CO4	3	3	3	–	3	3	3	–	–	–	–	–	–	3	–	–
CO5	3	3	3	–	3	3	3	–	–	–	–	–	–	3	–	–
CO6	3	3	3	-	–	–	–	–	–	–	–	–	–	3	–	–

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	3	3	--	--	3	--	--
CO2	--	3	3	--	--	3	--	--
CO3	--	--	--	--	--	3	--	--
CO4	--	--	--	--	--	3	--	--
CO5	--	--	--	--	--	3	--	--
CO6	--	--	--	--	--	3	--	--
Total	--	**6**	**6**	--	--	18	--	--

Semester-II 19MBTP 207 – Practical – IV -AQUACULTURE AND FISH IMMUNOLOGY AND HEALTH MANAGEMENT

Credits: 4
Hours: 6

Learning Objectives (LOS):

- To execute basic immunological techniques for disease diagnosis
- To learn histological techniques
- To analyze host pathogen interaction
- To carryout cell culture technology

Syllabus

1. Sampling of fish and shellfish for disease diagnosis
2. Histology techniques
3. Identification of bacteria- staining techniques and biochemical techniques
4. Observation of cellular components of Fish blood and shrimp hemolymph
5. Isolation and characterization of Fungi from fish & slide culture of fungi

6. Identification of fish parasites
7. Antibiotic sensitivity test
8. Bacterial agglutination test
9. Agar gel precipitation test
10. Antibody titre by ELISA, SDS-PAGE, immunoblotting and dot-blotting Nucleic acid Isolation, PCR, RT-PCR
11. Hybridoma technology and monoclonal antibody production
12. Cell culture and passaging
13. Isolation of virus using cell culture.
14. Identification of fish pathogens using various techniques.

Course Outcomes (Cos):

On completion of this course, students will able to:

CO1: Dissect and display the marine fin and shell fishes

CO2: Demonstrate the type of blood cells from the circulatory body fluids of marine animals.

CO3: Evaluate the pathology of cells by histology and explain host pathogen interaction.

CO4: Conduct experiments for specific antigen antibody reaction using different immune-assays

CO5: Perform cell culture and understand the principles of monoclonal antibody production.

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	–	3	3	–	–	–	3	3	–	–	–	–	–
CO2	3	3	3	–	3	3	–	–	–	3	3	–	–	–	–	–
CO3	3	3	3	–	3	3	–	–	–	–	–	–	–	3	–	–
CO4	3	3	3	–	3	3	–	–	–	–	–	–	–	3	–	–
CO5	3	3	3	–	3	3	–	–	–	–	–	–	–	3	–	–

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	3	3	--	--		--	--
CO2	--	3	3	--	--		--	--

CO3	--	--	--	--	--	3	--	--
CO4	--	--	--	--	--	3	--	--
CO5	--	--	--	--	--	3	--	--
Total	--	**6**	**6**	--	--	9	--	--

Semester-II 19MBTP 208 – Practical – V - AQUATIC ENVIRONMENTAL BIOTECHNOLOGY

Credits: 2
Hours: 3

Learning Objectives (LOS):

- To acquire basic skills in aquatic environmental biotechnology for environmental protection and remediation.

Syllabus

1. Estimation of dissolved oxygen, salinity, H_2S, BOD and COD
2. Estimation of heavy metals (Cu, Cd, Pb, Hg)
3. Demonstration – estimation of pesticide residues, petroleum hydrocarbons using GC
4. Experiment on heavy metal removal using biosorbent
5. Microscopic studies of biofilm using test panels
6. Identification of organisms involved in fouling and boring
7. Methods of isolation of viable and unculturable bacteria from the sea
8. Recombinant DNA technology to construct biosensor
9. Detection of sea food associated pathogens using multiplex PCR
10. Metagenomic DNA isolation from coastal water
11. Bacterial diversity by 16S rDNA amplification of metagenomic DNA.

Course Outcomes (Cos):

Student will able to

CO1: Assess water quality parameters in relevance to aquatic organisms dwelling in the niche

CO2: Assess economic loss caused by fouler and borers

CO3: Employ environmental management technologies to validate different kind of marine pollution.

CO4: Understand the usage of biosensors in evaluating environmental parameters

CO5: Utilize molecular tools in assessing the aquatic environment microbial diversity.

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6	PS O7	PS O8
CO1	3	3	3	–	3	3	3	–	–	–	–	–	–	3	–	–
CO2	3	3	3	–	3	3	3	–	–	–	–	–	–	3	–	–
CO3	3	3	3	–	3	3	3	–	–	–	–	–	–	3	–	–
CO4	3	3	3	–	3	3	3	–	–	–	–	–	–	3	–	–
CO5	3	3	3	–	3	3	3	–	–	–	–	–	–	3	–	–

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	3	--	--
CO2	--	--	--	--	--	3	--	--
CO3	--	--	--	--	--	3	--	--
CO4	--	--	--	--	--	3	--	--
CO5	--	--	--	--	--	3	--	--
Total	--	--	--	--	--	18	--	--

III SEMESTER COURSE: 19MBTC301 MARINE BIOPROCESS TECHNOLOGY

Credits: 3
Hours: 3

Learning Objectives (LOS):

- Students acquire about fundamental concepts of bioprocess technology and its related applications,
- Prepare to meet challenges of new and emerging areas of biotechnology industry.

Unit I Biochemical engineering

Basic principles of Biochemical engineering: Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics; Stoichiometry and Models of Microbial Growth: Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

Unit II Bioprocess Technology

Bioreactor Design and Analysis: Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation *vs*biotransformations; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters; Downstream Processing and Product Recovery: Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging; Fermentation Economics: Isolation of microorganisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

Unit III Enzyme Technology in food processing

Applications of enzyme technology in food processing: Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing; Applications of Microbial Technology in food process operations and production, biofuels and biorefinery: Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery.

Textbooks:

1. Shuler, M. L., &Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (1997). *Principles of Fermentation Technology.* Oxford: Pergamon Press.
3. Blanch, H.W., & Clark, D.S. (1997). *Biochemical Engineering*. New York: M. Dekker.
4. Bailey, J. E., &Ollis, D. F. (1986). *Biochemical Engineering Fundamentals.* New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology.* Boca Raton: CRC/Taylor & Francis.

Course Outcomes (Cos):

On completion of this course, students will able to:

CO1: Understand the principles of biochemical engineering.
CO2: Appreciate relevance of micro-organisms in bioprocessing technology.
CO3: Carry out stoichiometric calculations and specify models of their growth
CO4: Give an account of design and operations of various bioreactors.
CO5: Present unit operations together with fundamental principles for basic methods in production technique for bio-based products
CO6: Calculate yield and production rates in biological production process, and also interpret data.
CO7 Calculate the need for oxygen and oxygen transfer in bio-production process
CO8: Critically analyze any bioprocess from an economics/market point of view
CO9: Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Outcome Mapping

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	-	3	3	-	3	3	3	-	-	-	3	3	-	-	-	-
CO2	-	3	3	-	3	3	3	-	-	-	3	-	-	-	-	-
CO3	-	3	3	-	3	3	3	-	-	-	3	-	-	3	-	-
CO4	-	3	3	-	3	3	3	-	-	-	3	-	-	3	-	-
CO5	-	3	3	-	3	3	3	-	-	-	3	-	-	3	-	-
CO6	-	3	3	-	3	3	3	-	-	-	-	-	-	3	-	-
CO7	-	3	3	-	3	3	3	-	-	-	-	-	-	3	-	-
CO8	-	3	3	-	3	3	3	-	-	-	-	-	-	3	-	-
CO9	-	3	3	-	3	3	3	-	-	-	-	-	-	-	-	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	3	--	--	--	--	--
CO2	--	--	3	--	--	--	--	--
CO3	--	--	3	--	--	3	--	--
CO4	--	--	3	--	--	3	--	--
CO5	--	--	3	--	--	3	--	--
CO6	--	--	--	--	--	3	--	--
CO7	--	--	--	--	--	3	--	--
CO8	--	--	--	--	--	3	--	--
CO9	--	--	--	--	--	--	--	3
Total	**--**	**--**	**15**	--	--	18	--	3

III SEMESTER **COURSE: 19MBTC302 - AQUACULTURE BIOTECHNOLOGY**

Credits: 3
Hours: 3

Learning Objectives (LOS):

- Recognize aquatic animal resources and the breeding behavior
- Understand basic requisite for the culture of both fin and shell fish culture from the larval stage to adult stage
- Utilize biotechnological approaches for scaling up of aquaculture production

Unit I Fish and Shellfish biology and breeding

Male and female of finfish and shellfish; Primary and secondary sex characters; Process of Oogenesis & Spermato-genesis, metabolic changes during gametogenesis; neuroendocrine system in crustacean & molluscs & its role in control of reproduction; mechanism of hormone synthesis, release, transport & action; Pheromones & reproductive behaviour; environmental factors influencing reproduction; Advances in Fish Breeding: Hypophysation, evaluation of carp milt and egg, cryopreservation technique, Genetic basis of determination of sex; chromosome manipulation: ploidy induction, sex reversal; gyno- genesis and androgenesis; Broodstock management; Application of Cross breeding in aquaculture; Selective breeding: qualitative and quantitative traits for selection, methods of

selection; Inbreeding and heterosis in various economic characters; hormone induced ovulation; Synthetic hormones for induced breeding- GnRH analogue structure and function.

Unit II Culture systems and hatchery techniques

Importance of coastal aquaculture; Aqua farms; Design and construction; Criteria for selecting cultivable species; Culture systems and management practices – extensive, semi intensive and intensive culture practices Seed production in controlled condition; Types; Design and management of hatchery – induced spawning; Mass production of seeds; feed formulation; Artificial insemination - *in vitro* fertilization; Culture of Live food organisms: Candidate species of phytoplankton & zooplankton as live food organisms of freshwater & marine species; biology & culture requirements of live food organisms: green algae, diatoms, rotifers, infusoria, tubifex, brine shrimp and earthworms.

Unit III Advanced techniques in aquaculture management

Fish Cell culture Techniques: Tissue culture, cell lines, primary and secondary culture, cell culture based vaccines, organ and histotypic cultures; measurement of cell death; apoptosis; Cell Hybridization: Somatic cell fusion, hybridoma technology, Production and Application of monoclonal antibodies; Transgenic production of fishes : definition, transgenic fish, Methods of gene transfer in fishes, single gene traits, detection of transgenes, screening for transgenics, site of integration, applications; Evaluation of GFP transgenics; Genetically modified Fish Production- Prospects and Problems.

Textbooks:

1. Felix, S., (2010) *Marine and Aquaculture Biotechnology*, AGROBIOS INDIA.
2. Bradach, J.E., H.H. Ryther and W.D. MC Larney, (1972) *Aquaculture, Farming and Husbandry and Fresh and Marine Organisms*, Wiley lnterscience, New York.
3. Lakra, W. S., (2008). *Fisheries Biotechnology*. Narendra Publishing House, Delhi.
4. Naha, S., Philopose, P.M., (2014). Dominant Publishers & Distributors Pvt. Ltd.
5. Gautam, N.C., (2007) *Aquaculture Biotechnology*, Shree Publishers and Distributors.

Course Outcomes (Cos):

On completion of this course, students will able to:

CO1: Explain fundamental principles of aquaculture.

CO2: Troubleshoot in resolving aquaculture issues.

CO3: Apply biotechnological methods in high yield aquaculture produce.

CO4: Acquire self-employability skills to start own farm or hatchery.

CO5: Identify role of aquaculture-biotechnology in societal development.

Outcome Mapping

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	3	-	-	3	3	3	-	-	-	-	3	-	-	-
CO2	3	3	3	-	-	3	3	3	-	-	-	-	3	-	-	-
CO3	3	3	3	-	-	3	3	3	-	-	-	-	3	3	-	-
CO4	3	3	3	-	-	3	3	3	-	-	-	-	3	3	-	-
CO5	3	3	3	-	-	3	3	3	-	-	-	-	-	-	-	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	3	--	--	--
CO2	--	--	--	--	3	--	--	--
CO3	--	--	--	--	3	3	--	--
CO4	--	--	--	--	3	3	--	--
CO5	--	--	--	--	--	--	--	3
Total	**--**	**--**	**--**	--	12	6	--	3

III SEMESTER COURSE: 19MBTC 303 - BIOINFORMATICS

Credits: 2
Hours: 2

Learning Objectives (LOS):

- Proper utilization of computational tools in acquiring biological information.
- Application and evaluation of system biology.
- Understanding of cellular talk and molecular interaction of biological molecules

Unit I Biological databases

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

Unit II Sequence alignment and database searching

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

Unit III Phylogenetic analysis

Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD).

Unit IV Structural biology

3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules; External coordinates and Internal Coordinates, Molecular Mechanics, Force fields *etc.* Secondary structure elucidation using Peptide bond, phi, psi and chi torsion

angles, Ramachandran map, anatomy of proteins – Hierarchical organization of protein structure –like CATH (class, architecture, topology, homology), SCOP (Structural Classification of Proteins), FSSP (families of structurally similar proteins).

Unit V Classification and comparison of 3D structures

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

Unit VI Applications in drug design

Chemical databases like NCI/PUBCHEM; Fundamentals of Receptor-ligand interactions; Structure-based drug design: Identification and Analysis of Binding sites and virtual screening; Ligand based drug design: Structure Activity Relationship – QSARs &Pharmacophore; *Insilico* predictions of drug activity and ADMET.

Unit VII Analysis of microarray data

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

Unit VIII Biological algorithms

Comparison with computer algorithms, string structures, Introduction to programming in computational biology through C/ Perl / Java.

Unit IX Systems biology

System-level understanding of biological systems, use and integration of data from transcriptomics, proteomics and metabolomics; concepts in glycomics, interactomics and fluxomics.

Textbooks:

1. A.D. Baxevanis and B.F.F. Ouellette (Eds). (2002), *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*, John Wiley and Sons.
2. D.W. Mount, (2001), *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbor Laboratory Press.
3. Jones &Peuzner, (2004); *Introduction to Bioinformatics Algorithms*; Ane Books, India.
4. DovStekel, (2003); *Microarray Bioinformatics*; Cambridge University Press.

Course Outcomes (Cos):

On completion of this course, students will able to:

CO1: Basic theory and practical usage of computational tools\
CO2: Biological data analyzing skills
CO3: Phylogenetic positioning of a species
CO4: Drug designing strategies
CO5: Reasoning of cellular physiological changes

CO6: Targeting specific molecular interaction

CO7: Appreciate their relevance for investigating specific contemporary biological questions

CO8: Identification of species and their systematic position

Outcome Mapping

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	3	-	-	3	3	-	-	-	-	3	-	-	3	3
CO2	3	3	3	-	-	3	3	-	-	-	-	3	-	-	3	3
CO3	3	3	3	-	-	3	3	-	-	-	-	3	-	-	3	3
CO4	3	3	3	-	-	3	3	-		-	-	3	-	-	3	3
CO5	3	3	3	-	-	3	3	-	3	-	-	3	-	-	3	3
CO6	3	3	3	-	-	3	3	-	3	-	-	3	-	-	3	3
CO7	3	3	3	-	-	3	3	-		3	-	3	-	-	3	3
CO8	3	3	3	-	-	3	3	-		3	-	3	-	-	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--		--	3	--	--	3	3
CO2	--		--	3	--	--	3	3
CO3	--		--	3	--	--	3	3
CO4	--		--	3	--	--	3	3
CO5	3		--	3	--	--	3	3
CO6	3		--	3	--	--	3	3
CO7	--	3	--	3	--	--	3	3
C08		3		3				
Total	**6**	**6**	**--**	24	--	--	21	21

III SEMESTER COURSE: 19MBTC 304 INTELLECTUAL PROPERTY RIGHTS, BIOSAFETY AND BIOETHICS

Credits: 2
Hours: 2

Learning Objectives (LOS):

- To understand basic knowledge on intellectual property rights and their implications in biological research and product development
- To become familiar with India's IPR Policy;
- To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products;
- To comprehend the ethical issues in biological research and focus consequences of biomedical research technologi

Unit I Introduction to IPR

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

Unit II Patenting

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

Unit III Biosafety

Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation

of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops *vs*cisgenic plants or products derived from RNAi, genome editing tools.

Unit IV National and International regulations

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

Unit V **Bioethics**

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

Textbooks:

1. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy.* New Delhi: Tata McGraw-Hill Pub.
2. *Complete Reference to Intellectual Property Rights Laws.* (2007). Snow White Publication Oct.
3. Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.
4. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants, 2008.
5. Alonso, G. M. (2013). *Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments.*

Course Outcomes (Cos):

On completion of this course, students will able to:

CO1: Analyze the rationale of IPR and understand the importance of patents.
CO2: Understand IPR Policy of India and be familiar with broad outline of Patent regulations.
CO3: Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents.
CO4: Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations.
CO5: Comprehend ethical aspects related to biological, biomedical, health care and biotechnology research.

Outcome Mapping

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	-	-	-	-	3	-	-	-	-	-	-	-	3	-

CO2	3	3	-	-	-	-	3	-	-	-	-	-	-	-	3	-
CO3	3	3	-	-	-	-	3	-	-	-	-	-	-	-	3	-
CO4	3	3	-	-	-	-	3	-	-	-	-	-	-	-	3	-
CO5	3	3	-	-	-	-	3	-	-	-	-	-	-	-	3	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	--	3	--
CO2	--	--	--	--	--	--	3	--
CO3	--	--	--	--	--	--	3	--
CO4	--	--	--	--	--	--	3	--
CO5	--	--	--	--	--	--	3	--
Total	**--**	**--**	**--**	--	--	--	15	--

III SEMESTER COURSE: 19MBTC 305 BIOENTREPRENEURSHIP

Credits: 2
Hours: 2

Learning Objectives (LOS):

- Acquiring the knowledge of scientific scholar to do promising business.
- Developing life science industry with thorough understanding of science & technology.
- Imbibing entrepreneurship skillsfor identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

Unit I Innovation and entrepreneurship in bio-business

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs*. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development

programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit II Bio-markets: business strategy and marketing

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

Unit III Finance and accounting

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

Unit IV Technology management

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

Textbooks:

1. Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences.* Bloxham: Scion.
2. Shimasaki, C. D. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies.* Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., &Zucchella, A. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge.* Routledge.
4. Jordan, J. F. (2014). *Innovation, Commercialization and Start-Ups in Life Science*s. London: CRC Press.
5. Desai, V. (2009). *The Dynamics of Entrepreneurial Development and Management.* New Delhi: Himalaya Pub. House.

Course outcomes (Cos):

Students can able to:

On completion of this course, students will able to:

CO1: Gain entrepreneurial skills.

CO2: Evaluate the various operations involved in venture software creation,

CO3: Identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies.

CO4: Acquire the knowledge pertaining to management

CO5: Build up a strong network within the industry.

Outcome Mapping

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO 6	PO7	PO 8	PSO 1	PS O 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1			-	-	-				-	-	-	-	-	-	-	

	3	3				3	3	3								3
CO2	3	3	-	-	-	3	3	3	-	-	-	-	-	-	3	-
CO3	3	3	-	-	-	3	3	3	-	-	-	-	-	-	3	3
CO4	3	3	-	-	-	3	3	3	-	-	-	-	-	-	-	3
CO5	3	3	-	-	-	3	3	3	-	-	-	-	-	-	-	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	--	--	3
CO2	--	--	--	--	--	--	3	--
CO3	--	--	--	--	--	--	3	3
CO4	--	--	--	--	--	--	--	3
CO5	--	--	--	--	--	--	--	3
Total	**--**	**--**	**--**	--	--	--	6	12

Semester-III 19MBTP 306 – Practical – VI - MARINE BIOPROCESS TECHNOLOGY

Credits: 2
Hours: 3

Learning Objectives (LOS):

- Experience hands-on training to students in upstream and downstream unit operations.

Syllabus

1. Basic Microbiology techniques
   a) Scale up from frozen vial to agar plate to shake flask culture
   b) Instrumentation: Microplate reader, spectrophoto- meter, microscopy
   c) Isolation of microorganisms from soil samples
2. Experimental set-up
   a) Assembly of bioreactor and sterilization
   b) Growth kinetics
   c) Substrate and product inhibitions
   d) Measurement of residual substrates
3. Data analysis

a) Introduction of Metabolic Flux Analysis (MFA)

4. Fermentation (acids, alcohols, antibiotics)
   a) Batch
   b) Fed-batch
   c) Continuous
5. Unit operations
   a) Microfiltrations: Separation of cells from broth
   b) Bioseparations: Various chromatographies and extractions
6. Bioanalytics
   a) Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates.

Course Outcomes (Cos):

On completion of this course, students will able to:

CO1: Appreciate utilization of micro-organisms for industrial use.

CO2: Carry out stoichiometric calculations and specify models of their growth.

CO3: Give an account of design and operations of various fermenters.

CO4: Calculate yield and production rates in biological production process, and also interpret data.

CO5: Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

CO6: Use of bio-analytics for evaluating the quality of the product.

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	–	–	–	3	3	3	–	–	–	–	–	–	–	3
CO2	3	3	–	–	–	3	3	3	–	–	–	–	–	–	3	–
CO3	3	3	–	–	–	3	3	3	–	–	–	–	–	–	3	3
CO4	3	3	–	–	–	3	3	3	–	–	–	–	–	–	–	3
CO5	3	3	–	–	–	3	3	3	–	–	–	–	–	–	–	3
CO6	3	3	–	–	–	–	–	2	–	–	–	–	–	–	–	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	--	--	3
CO2	--	--	--	--	--	--	3	--
CO3	--	--	--	--	--	--	3	3
CO4	--	--	--	--	--	--	--	3
CO5	--	--	--	--	--	--	--	3
CO6	--	--	--	--	--	--	--	3
Total	--	--	--	--	--	--	6	15

Semester-III 19MBTP 307 – Practical – VII - AQUACULTURE BIOTECHNOLOGY

Credits: 2
Hours: 3

Learning Objectives (LOS):

- To learn aquaculture biotechnology including identification of various organisms and tissue culture techniques for maintenance of aquatic cell lines.

Syllabus

1. Dissection and location of testis and ovary in fishes
2. Dissection and location of 'x' and 'y' organs in shrimps
3. Hypophysation technique in fish
4. Maturity stages of ovary in crustaceans and finfish
5. Identification of phytoplankton and zooplankton
6. Mass culture of Live feed organisms
7. Chromosome manipulation – androgenesis, gynogenesis, triploidy, tetraploidy
8. Induced breeding of carps
9. Development of fish cell culture
10. Maintenance of fish cell lines (Passaging)
11. Methods of gene transfer.

Course Outcomes (Cos):

Student will able to:

CO1: Dissect and display various fish organs
CO2: Carryout artificial fertilization
CO3: Understand the stages of maturation

CO4: Acquire the knowledge of starting an aquaculture industry

CO5: Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	–	–	–	3	3	3	–	–	–	–	–	–	–	3
CO2	3	3	–	–	–	3	3	3	–	–	–	–	–	–	–	–
CO3	3	3	–	–	–	3	3	3	–	–	–	–	–	–	–	3
CO4	3	3	–	–	–	3	3	–	–	–	–	–	–	–	–	3
CO5	3	3	–	–	–	3	3	–	–	–	–	–	–	–	–	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	--	--	3
CO2	--	--	--	--	--	--	--	--
CO3	--	--	--	--	--	--	--	3
CO4	--	--	--	--	--	--	--	3
CO5	--	--	--	--	--	--	--	3
Total	**--**	**--**	**--**	--	--	--	--	12

Semester-III 19MBTP 308 – Practical – VIII - BIOINFORMATICS AND BIOSTATISTICS

Credits: 2
Hours: 3

Learning Objectives (LOS):

- Attain practical training in bioinformatics and statistical methods including accessing major public sequence databases.

Syllabus

1. Using NCBI and Uniprot web resources.

2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.
15. Use of Statistical packages like SPSS (Statistical Package for the Social Sciences)/SAS (Statistical Analysis System) & Maple
16. MATLAB (Matrix Laboratory)
17. Performing various statistical analysis like T-test, ANOVA, Regression, Chi-square, PLS (Partial Least Squares) and PCA (Principle Component Analysis).

Course Outcome (Cos):

Student will able to:

CO1: Describe contents and properties of important bioinformatics databases, perform text- and sequence-based searches, analyze and discuss results in light of molecular biology knowledge.

CO2: Explain major steps in pairwise and multiple sequence alignment, explain its principles and execute pairwise sequence alignment by dynamic programming.

CO3: Predict secondary and tertiary structures of protein sequences.

CO4: Perform and analyze various statistical tools available to analyze the data.

CO5: Organize different modern statistic packages precisely for specific data appreciation.

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	–	–	–	–	3	3	3	–	–	–	–	–	–	3	3
CO2	3	–	–	–	–	3	3	3	–	–	–	–	–	–	3	–
CO3	3	3	–	–	–	3	3	3	–	–	–	–	–	–	3	3
CO4	3	3	–	–	–	3	3	–	–	–	–	–	–	–	–	3
CO5	3	3	–	–	3	3	3	–	–	–	–	–	–	–	–	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	--	3	3
CO2	--	--	--	--	--	--	3	--
CO3	--	--	--	--	--	--	3	3
CO4	--	--	--	--	--	--	--	3
CO5	--	--	--	--	--	--	--	3
Total	--	--	--	--	--	--	9	12

Semester-III 19MBTP 309 – PROJECT PROPOSAL PREPARATION AND PRESENTATION

Credits: 2
Hours: 9

Learning Objectives (LOS):

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

Project Proposal Preparation

Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven.

Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.

Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, *etc.*
Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

Poster Presentation

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

Oral Presentation

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

Course Outcomes (Cos):

Students will able to demonstrate the following abilities to:

CO1: Formulate a scientific question.
CO2: Have scientific approach to solve a problem.
CO3: Interpret, discuss and communicate scientific results in written form.
CO4: Gain experience in writing a scientific proposal.
CO5: Learn to present and explain their research findings to the audience effectively.

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	–	–	–	–	3	3	3	–	–	–	–	–	–	3	–
CO2	3	–	–	–	–	3	3	3	–	–	–	–	–	–	3	–
CO3	3	–	–	–	–	3	3	3	–	–	–	–	–	–	3	3
CO4	3	–	–	–	–	3	3	3	–	–	–	–	–	–	–	3
CO5	3	–	–	–	3	3	3	3	–	–	–	–	–	–	–	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	--	3	-
CO2	--	--	--	--	--	--	3	--
CO3	--	--	--	--	--	--	3	3
CO4	--	--	--	--	--	--	--	3
CO5	--	--	--	--	--	--	--	3
Total	--	--	--	--	--	--	9	9

Semester-IV 19MBTC 401 – Dissertation

Credits: 26
Hours: 26

Learning Objectives (LOS):

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

Planning Performing experiments

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

Thesis writing

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

Course outcomes (Cos):

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

CO1: In-depth knowledge of the chosen area of research.
CO2: Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
CO3: Competence in research design and planning.
CO4: Capability to create, analyze and critically evaluate different technical solutions.
CO5: Ability to conduct research independently.
CO6: Ability to perform analytical techniques/experimental methods.
CO7: Project management skills.
CO8: Report writing skills.
CO9: Problem solving skills.
CO10: Communication and interpersonal skills.

DEPARTMENT ELECTIVES

ELECTIVE 1: 19MBTE 402 GENOMICS AND PROTEOMICS

Credits: 2
Hours: 4

Learning Objectives (LOS):

- This course is to provide introductory knowledge concerning genomics & proteomics and their applications.

Unit I Basics of genomics and proteomics

Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.

Unit II Genome mapping

Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.

Unit III Genome sequencing projects

Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.

Unit IV Comparative genomics

Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand the evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.

Unit V Proteomics

Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.

Unit VI Functional genomics and proteomics

Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in the genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.

Textbooks:

1. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
2. Liebler, D. C. (2002). *Introduction to Proteomics: Tools for the New Biology.* Totowa, NJ: Humana Press.

3. Campbell, A. M., &Heyer, L. J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics.* San Francisco: Benjamin Cummings.

Course outcomes (Cos):

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

CO1: Students will able to acquire knowledge and understanding of the fundamentals of genomics and proteomics,

CO2: Student will describe basic aspects transcriptomics and metabolomics and their applications in various applied areas of biology.

CO3: Student will understand basic principles of genome project, comparative genome and functional genomics and proteomics

Outcome Mapping

CO/ PO	PO 1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-	-
CO2	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-	-
CO3	3	3	-	3	3	3	-	-	3	-	-	-	-	-	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	--	--	--	--	--	--	--
CO2	3	--	--	--	--	--	--	--
CO3	3	--	--	--	--	--	--	--
Total	**9**	**--**	**--**	--	--	--	--	--

ELECTIVE 2: NANOBIOTECHNOLOGY

Credits: 2
Hours: 4

Learning objectives (LOS):

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

Unit I Introduction to nanobiotechnology

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

Unit II Nano - films

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

Unit III Nano - particles

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

Unit IV Applications of nano-particles

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

Unit V Nano - materials

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

Unit VI Nano - toxicity

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

Textbooks:

1. GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials,* Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004);*Bionanotechnology: Lessons from Nature*, Wiley-Liss

3. Neelina H. Malsch, *Biomedical Nanotechnology,* CRC Press
4. Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.

Course outcomes (Cos):

On successful completion of this course, students will able to:

CO1: Describe basic science behind the properties of materials at the nanometer scale.
CO2: Appreciate the princi-ples behind advanced experimental and computational techniques for studying nano-materials.
CO3: Understand the preparation of nano-particles.
CO4 Acquire the knowledge in the application of nano-particles.
CO5 Realize the effect of nano-particle toxicity.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-
CO2	3	3	-	-	-	-	3	-	-	-	-	-	-	-	3	-
CO3	3	3	3	-	3	3	3	3	-	-	-	-	-	-	3	-
CO4	3	3	3	-	3	3	3	3	-	-	-	-	-	-	3	-
CO5	3	3	3	-	3	3	3	3	-	-	-	-	-	-	3	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	--	3	-
CO2	--	--	--	--	--	--	3	--
CO3	--	--	--	--	--	--	3	--
CO4	--	--	--	--	--	--	3	--
CO5	--	--	--	--	--	--	3	--
Total	--	--	--	--	--	--	15	--

ELECTIVE 3: MOLECULAR DIAGNOSTICS

Credits: 2
Hours: 4

Learning objectives (LOS):

- This course is to sensitize students about recent advances in molecular biology and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including the pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

Unit I Basic molecular diagnostics

Historical perspective of clinical diagnosis and molecular diagnostics; Nucleic acid based diagnosis: Extraction of Nucleic acids: sample collection, methods of extraction from various diagnostic materials, assessment of quality, storage: Nucleic acid hybridization: Blotting Techniques and their interpretations: Southern and Northern Blotting methods and applications in clinical diagnosis: Polymerase Chain Reaction: Principle, components, optimization and analysis of PCR products: PCR based methods for mutation detection and gene expression: real Time PCR, ARMS, QF-PCR, OLA and primer Extension: Electrophoresis: PAGE and Capillary Electrophoresis: Application of electrophoresis I DNA Diagnosis-SSCP, heteroduplex analysis, denaturing gradient gel, detection of mismatched nucleotides /RNA-DNA duplexes; RFLP and DNA sequencing in the clinical diagnostics.

Unit II Advanced Techniques in molecular diagnosis

Testing DNA variation for Disease association: SNPs; Methods of typing: Traditional approaches (PCR-Sequencing), Microchips (Affymetrix) and Taqman : Microarray in analysis of gene expression; DNA microarray platforms: cDNA analysis, oligonucleotide arrays: Introduction to SAGE, CGH, array CGH and SNP arrays: Analysis of DNA methylation : Methylation in health and disease; Principle and inheritance; DNA methylation in pathology and cancer: PCR based methods in detection of methylation; Bisulfite modification and methylation specific PCR and Restriction analysis; real Time PCR methodologies (MethyLight), Profiling and arrays: Primer Designing for MSPs; Application of DNA methylation in disease diagnosis: cancer (malignancies)and imprinting disorders.

Unit III Cytogenetic techniques

Flow Cytometry and LCM: Principle; Clinical applications: enumeration of peripheral; blood cells in HIV infection and Immunophenotype Characterization in various blood disorders; Laser Capture Microdissection and separation of normal and aberrant cells: application and perspective in molecular diagnostics; Molecular Cytogenetic: Chromosomal abnormalities and indications of chromosomal evolution; Fluorescence *in situ* Hybridization; General procedures of FISH, M-FISH, SKY and CGH; Clinical applications of FISH: Correlation with the pathobiology of disease, disease prognosis and monitoring, correlation with molecular data; protein based molecular diagnostics: Immunoproteomics and detection methods based on Antigen-Antibody interactions; ELISA; western Blotting and Far Western Blotting applications and perspectives; Immunohistochemistry and Immunocytochemistry: Methods and interpretations: application in tumour diagnosis and infectious diseases; correlation with molecular data.

Unit IV Quality assurance in molecular diagnostics

Quality assessment, pre-analytic, analytic and post analytic phases; Verification of Molecular Assays: Standards and Standardization of Molecular Diagnostics; Laboratory development of molecular diagnostics : Implementation, validation, verifications(analytical and clinical), quality control and quality assurance of the testing process; Examples of molecular diagnostics of some common genetic and non-genetic diseases (Trinucleotide Repeats: Fragile X syndrome, DMD, Endocrine disorders-Diabetes mellitus, Cystic Fibrosis, Chronic Myeloid Leukemia, Human HIV-1.

Unit V **Immunogenetic techniques and genetic counselling**

HLA Typing: HLA/MHC genetic; Molecular methods of HLA typing; PCR –Sequence specific Primers; Sequence Specific Oligonucleotide probe Hybridization, Forensic Diagnosis: DNA typing : Overview; Techniques for human identification; Evidence collection and sample preparation; PCR amplification of STR loci: Electrophoresis and data analysis: Molecular Diagnosis and Genetic Counselling :Clinical genetic services; Uses of genetic testing; components of genetic counselling process; Genetic Counselling and Genetic testing; Ethical, social and legal issues related to molecular genetic testing; Informed consent for clinical testing and research; Confidentiality and Discrimination; Gene patenting.

Textbooks:

1. WB. Coleman and GJ.Tsongalis, (2006) *Molecular Diagnosis for the Clinical Laboratories*, 2nd Edition, Human Press.
2. Lankowski and Polak, (1996) *Clinical Gene Analysis and Manipulation: Tools, Techniques and Trouble shooting*, 1st Edition, Cambridge University press.
3. Francesco Falciani, (2007), *Microarray Technology through Applications*, Taylor & Francis.
4. Darby &Hewiston, (2006). *In Situ Hybridization Protocols*, (3rd edition), Human press.
5. Sharpe & Carter, (2006). *Genetic Testing, Care, Consent & Liability*, Wiley-Liss.
6. Jochen Decker, *Molecular Diagnosis of Infectious Diseases*, Human press.

Course outcomes (Cos):

On successful completion of this course, students will able to:

CO1: Understand various facets of molecular procedures for Diagnosis
CO2: Learn the use of modern molecular tools like micro-array for precise diagnostics
CO3: Utilize of cytogenetic techniques
CO4 Verify quality and quantum of the result
CO5 Apply immunogenic tools for early diagnosis and prognosis of human diseases.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	-	3	3	3	3	-	-	-	3	-	-	-	-	-
CO2	3	3	-	3	3	3	3	3	-	-	3	-	-	-	-	-
CO3	3	3	-	3	3	3	3	3	-	-	-	-	3	-	-	-
CO4			-	-					-	-	-	-		-	-	-

	3	3			3	3	3	3					3			
CO5	3	3	-	-	3	3	3	3	-	-	-	-	3	-	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	3	--	--	--	--	-
CO2	--	--	3	--	--	--	--	--
CO3	--	--	--	--	3	--	--	--
CO4	--	--	--	--	3	--	--	--
CO5	--	--	--	--	3	--	--	--
Total	**--**	**--**	**6**	--	9	--	--	--

ELECTIVE 4: MARINE FOOD TECHNOLOGY

Credits: 2
Hours: 4

Learning objectives (LOS):

- This course is to teach the principles of food preservation, processing and packaging and quality management practices for food of marine origin.

Unit I Food preservation and processing

Preservation and processing – chilling methods, phenomena of rigor mortis, spoilage changes – causative factors; Drying – conventional methods; Salt curing, pickling and smoking; Freezing and cold storage, Canning procedures; Role of preservatives in processing.

Unit II Food packaging

Packing – handling fresh fish, frozen packs, individually quick frozen (IQF), layered and shatter packs; Fishery by-products, cannery waste, feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizer.

Unit III Seafood microbiology

Seafood microbiology – factors influencing microbial growth and activity; Seafood borne pathogens – bacteria, fungi, viruses; Spoilage factors in seafood; Toxins influencing food spoilage; Microbes as food – single cell protein (SCP), microbial neutraceuticals.

Unit IV Quality management

Quality management – concepts, planning, system, quality control, quality assurance, quality improvement; Certification standards – ISO and HACCP; Principles of quality related to food sanitation, contamination, pest control, human resource and occupational hazards; Novel product development, marketing and sea food export – Marine Products Export Development Authority (MPEDA), marketing, government policies, export finance, economic importance; Novel products – nutrition promotion, consumer studies qualitative and quantitative research methods.

Textbooks:

1. Fereidoon Shahidi*et al.*, (2014). *Seafood Safety, Processing and Biotechnolgy*. Taylor and Francis. A CRC press book
2. K.C. Badapanda (2012). *Fish Processing and Preservation Technology*. Vol IV. NPH Narendra Publishing House, New Delhi
3. Ioannis S. Boaziaris (2014). *Seafood Processing: Technology, Quality and Safety*Wiley Blackwell
4. Sachindra NM & Mahendrakar(2015). *Fish Processing Byproducts: Quality Assessment & Aplications*. Studium Presss LLC, USA.
5. K.P. Biswas, (2014). *Fish Processing and Preservation.* Daya Publishing House, New Delhi.

Course outcomes (Cos):

On completion of this course, students will able to:

CO1: Acquire practical knowledge of food technology for marine foods.

CO2: Understand the importance of food packaging.

CO3: Know about microbial food technology.

CO4 Assess the quality of packed food.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	-	-	3	-	3	3	-	-	-	-	-	3	-	-
CO2	3	3	-	-	3	-	3	3	-	-	-	-	-	3	-	-
CO3	3	3	-	-	3	-	3	3	-	-	-	-	-	3	-	-
CO4	3	3	-	-	3	-	3	3	-	-	-	-	-	3	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	3	--	-
CO2	--	--	--	--	**--**	3	--	--
CO3	--	--	--	--	--	3	--	--
CO4	--	--	--	--	--	3	--	--
Total	**--**	**--**	**--**	--	**--**	12	--	--

ELECTIVE 5: STEM CELL BIOLOGY

Credits: 2
Hours: 4

Learning Objectives (LOS):

- The aim of course is to bring together cellular, biochemical, anatomic, histological, physiological and evolutionary medical views to a coherent picture of stem cells in an experimental and clinical context.

Unit I Introduction to stem cells

Definition, classification and source of stem cells.

Unit II Embryonic stem cells

Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology; Stem cell differentiation; Stem cells cryopreservation.

Unit III Application of stem cells

Overview of embryonic and adult stem cells for therapy, Neurodegenerative diseases; Parkinson's, Alzheimer, Spinal Cord injuries and other Brain Syndromes; Tissue systems Failures; Diabetes; Cardiomyopathy; Kidney failure; Liver failure; Cancer; Hemophilia *etc.*

Unit IV Human embryonic stem cells and society

Human stem cells research: Ethical considerations; Stem cell religion consideration; Stem cell based therapies: Pre clinical regulatory consideration and Patient advocacy.

Textbooks:

1. Ann A. Kiessling, (2003) *Human Embryonic Stem Cells: an Introduction to the Science and Therapeutic Potential*, Jones and Bartett.
2. Peter J. Quesenberry (1998), *Stem Cell Biology and Gene Therapy*, (1st Edition), Willy-Less.
3. Robert Lanja, (2006) *Essential of Stem Cell Biology,* 2nd Edition, Academic Press.
4. A.D. Ho., R.Hoffiman, (2006) *Stem Cell Transplantation Biology Processes Therapy*, Willy-VCH.
5. C.S.Potten, (2006) *Stem Cells*, Elsevier.

Course outcomes (Cos):

On completion of this course, students will able to:

CO1: Account for basics of stem cell function.
CO2: Explain about embryonic stem cells.
CO3: Discuss the usage of stem cells.
CO4 Appreciate the role of stem cell in medical field.

Outcome Mapping

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8
CO1	3	3	-	-	-	3	-	-	-	-	-	-	-	3	-	-
CO2	3	3	-	-	-	3	-	-	-	-	-	-	-	3	-	-
CO3	3	3	-	-	-	3	-	-	-	-	-	-	-	3	-	-
CO4	3	3	-	-	-	3	-	-	-	-	-	-	-	3	-	-

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	--	--	--	--	--	3	--	-
CO2	--	--	--	--	--	3	--	--
CO3	--	--	--	--	--	3	--	--
CO4	--	--	--	--	--	3	--	--
Total	--	--	--	--	--	12	--	--

CO-PO MAPPING SCORES

Courses Impact	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
1	**18**	**--**	**--**	**--**	**18**	**--**	**18**	**18**
2	**15**	**--**	**--**	**9**	**9**	**--**	**15**	**15**
3	--	15	15	**--**	**--**	**--**	**15**	**15**
4		15		15		**15**		
5			21	21		**12**		
6	12	12	12	12			**12**	**12**
7	15			15	15	**15**		
8		15			15			
9	15	15	15		15	**9**		
10	15	15			15	**15**		
11		6	15			**9**		
12			15			**18**		**3**
13					12	**6**		**3**
14	6	6		24			**21**	**21**
15							**6**	**12**
Total Score	96	99	93	96	99	**99**	**87**	**99**