Curriculum Framework

M.Sc. Marine Biotechnology

Center for Marine Science and Technology

Manonmaniam Sundaranar University

2022-2023

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Programme: MSc Marine Biotechnology

Vision of the University

- To empower learners with wholesome knowledge through progressive innovation in training, research and development which will render students a unique learning experience and a transformation impact on the society

Mission of the University

- To Impart value-based higher education and technical knowledge with uncompromising strides of an outstanding quality
- To be a Centre of Excellence in skill development in emerging technologies in accordance with industrial trends.
- To make the students formulate and implement strategy for a desired career path.
- Make a positive difference to society through technical education.
- To provide quality / inclusive education, especially for the rural and un-reached segments of economically downtrodden students including women, socially oppressed and differently abled.

PREAMBLE

Marine Biotechnology is the application of molecular and cellular biology to marine and fresh water organisms for the purpose of identifying, developing, and enhancing products derived from these organisms. During the course the candidates are introduced to a variety of aspects such as Fundamentals of Oceanography, Cell Biology and Genetics, Marine Biology, Genetic Engineering, Applications of Immunology and the like. The duration of the course is two years and its syllabus is divided into four semesters. The Master degree course is valuable and career providing in nature.. Biotechnology as a field of science is the most application oriented field where the knowledge gained in this course has direct and immediate application in the real world, be it pharmaceutical industry, food industry, diagnostics, personalized medicine, genetically modified crops and animals, bioprinting of organs, bioinformatics or clinical research.

After passing the Master degree course they can have marine biotechnologists. The growing use of marine products in the food, cosmetic, and agriculture industries has created a current demand that we can barely meet.the candidates can be employed in the areas of planning, production and management of bio-processing industries. It also necessitates the incorporation of cutting-edge information and new technology in order to meet society's evolving needs. The course is unique in that it requires 6 months of research projects. Students have the option to work at nationally and internationally renowned research institutes and enterprises throughout this time. As a result, professional human resources are produced in accordance with societal needs. Other research parts of the course include scientific writing, research proposal writing, publication preparation, and research poster preparation for conferences, and the entire process also produces new minds to work as scientists.

1. Introduction: In the increasingly globalized society, it is important that the younger generation especially the students are equipped with knowledge, skills, mindsets and behaviors which may enable them to perform their duties in a manner so that they become important contributors to the development of the society. This will also help them to fully utilize their educational training for earning a decent living so that the overall standard of their families and surroundings improve leading to development of welfare human societies. To achieve this goal, it is imperative that their educational training is improved such that it incorporates the use of newer technologies, use of newer assessment tools for mid-course corrections to make sure that they become competitive individuals to shoulder newer social responsibilities and are capable of undertaking novel innovations in their areas of expertise. In the face of the developing knowledge society, they are well aware about the resources of self-development using on-line resources of learning which is going to be a major component of learning in the future. The learning should also be a continuous process so that the students are able to re-skill themselves so as to make themselves relevant to the changing needs of the society.

2.Structure of M.Sc., (Marine Biotechnology) LOCF degree program:

The overall structure of the course to be implemented from the academic year 2022-2023 onwards is as follows.

A. The Master of Science in Marine Biotechnology programme will last two years. The syllabus for Biotechnology for the total four semesters is meticulously designed so as to make students understand the principles behind the complex biological processes and their applications in the real world. The syllabus evolves from semester I to semester IV with basics and essential biological concepts explained earlier and the advanced and the current techniques towards the last semester. In the postgraduate curriculum there is a full paper on Research methodologies. We also have the topic of Entrepreneurship as a full paper in the curriculam, this helps to enhance the entrepreneurial skills of our students.

B. Four categories of courses will be offered: Core Courses: Include theoretical as well as practical courses, Elective courses: Include theoretical courses, its department specific courses. The students must opt for three courses for the semesters 1, 2 and 3 out of six courses offered by the department, two courses for each semester. Open Elective: For the 1^{st}, 2^{nd}, 3^{rd} and 4^{th} semester, students may opt for any one open elective offered through swayam portal (e-PG pathasala-INFLIBNET) and MOOCs. Skill Enhancement Elective Course: A separate project training-based course that leads to a dissertation worth nine credits is also one of the core courses.

C. Candidates must appear for four core obligatory theory papers, one elective theory paper, and one theory paper from e-PG pathasala-INFLIBNET in semester I. The candidate must finish two practical courses as specified in the syllabus for semester I. Practical examinations for Practical Courses 1 and 2 will be held at the end of the semester. In semester 2, the candidate must take four core obligatory papers, one core elective paper, and one MOOC-based paper. Two practical courses will be held in semester II, as specified in the curriculum, and practical examinations for practical courses 3 and 4 will be held at the end of the semester.

D. There will be four core obligatory papers, two practical courses, one elective paper, and one elective paper from MOOCs in Semester III. The practical examinations for practical courses 5 and 6 will be held at the end of the semester III. Semester IV is devoted exclusively to project/dissertation work, as well as one elective paper from e-PG pathasala-INFLIBNET. The elective paper will have a theory examination at the end of semester IV.

E. The entire M.Sc. in Marine Biotechnology course will be covered in 19 theory papers. Each practical course will be covered in two four-hour practical turns per week. As a result, the students will work for each practical on two days of the week.

F. One entire semester of PG practical course work is dedicated to internship in any of the research institutions, academic institutes or industry. This gives our students an exposure to work away from the campus in the industrial set up, research set up, production set up or pharmaceutical or health care organizations and they get acquainted with the real world projects and processes. These projects also help the students to directly get employment in the field of their choice or help them get research experience useful for their future research career.Students will be required to complete an internship programme (major project with dissertation) in order to learn about research technique and work presentation. The internship (major project/dissertation) will be worth a total of 100 points. The students will work on their projects, completing the experimental work in the fourth semester and the writing portion of the project within the time frame provided.

3. PROGRAMME OUTCOMES

1. **PO1 Disciplinary Knowledge**

   In our post graduate syllabi the most advanced and relevant subjects such as nanotechnology, Genomics, IPR, Bioprocess Technology, Bioinformatics, Developmental biology have been incorporated. These will make the students ready for both industry as well as research oriented endeavors.

2. **PO2 Communication Skills**

   Emerge as a Centre of Excellence inculcating skill development in recent technologies in accordance with industrial trends and communicate the scientific findings and analysing them through publication, writing, project.assignments, etc.

3. **PO3 Critical Thinking**

   Foster analytical and critical thinking abilities to find out the problems and can work meticulously on that aspect.

4. **PO4 Problem Solving**

   Inculcate innovative thinking to address a problem or solution to the research community.

5. **PO5 Analytical Reasoning**

The practicals related to covering biodiversity, isolation, analysis and interpretation of marine environment and arriving valid conclusions in marine biotechnology.

6. **PO6 Research Related Skills**

One semester marine science research based project involves ability to define problem, formulate the hypothesis, draw conclusions and report the results is included in the students' curriculum.

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7. **PO7 Co-operation / Team Work**

Demonstrate the ability to work on research projects to establish marine based work, ornamental fish breeding, live-feed culture and assignments in the teams of students coming from different academic disciplines, diverse cultures and ethnicities.

8. **PO8 Scientific Reasoning**

The programme offers analysis of microbiology based data, its critical evaluation and reasoning.

9. **PO9 Reflective Thinking**

Develop reflective thinking in Microbiology, drug from microbes, resource utilization and management for the benefit of the society.

10. **PO10 Information / Digital Library**

Almost all the course in Marine biotechnology teaching is based on knowledge dissemination involving ICT. For the project data analysis appropriate analysis is recommended.

11. **PO11 Self-directed Learning**

Marine based project works, practicals and group works makes a self-directed approach among the student community.

12. **PO12 Multicultural Competence**

Marine based field visits, interaction with coastal people, sample collection to coastal areas, visit to national organization, and participation of international webinars create the multi-cultural competence among students.

13. PO13 Moral & Ethical Awareness / Reasoning

Create the ability to identify ethical issues related to recombinant DNA technology, genetic engineering, animals handling, intellectual property rights, biosafety and handling of sensitive experiments; awareness about the difference between data beautification and data manipulation/scientific misconduct. Create moral and ethical practices in project oriented data collection, presentation of results and marine entrepreneurship.

14. PO14 Leadership Readiness / Qualities

Demonstrate the ability to take initiative, set direction, design strategy, and build social cohesion not only in research labs but also in social contexts.

15. Life-long Learning

Demonstrate conceptual learning through systematic thinking and self-study and life-long learning that helps to solve scientific problems with well-defined solutions. Establishment of marine research forum, invitation of alumni and exchange of knowledge among students creates life-long learning among students.

4.PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1:

To demonstrate and apply their knowledge of cell biology, biochemistry, microbiology and molecular biology to solve the problems related to the field of biotechnology The structure and functions of the cell, as well as the molecular biology of prokaryotic cellular structure, were covered. Learn basic Biotechnology, Microbiology laboratory skills, techniques, and competence in the use of

research tools, clinical approaches, and observation analysis. Understanding the importance of Biostatistics in Biology and applying it in the analyze and interpretation of data manually and using statistical softwares

PSO2:

Distinguish between various phyla of the Bacteria,fungi and algal kingdoms based on their characteristics and attain knowledge to Compare and contrast the differences in morphology and anatomy in Angiosperms.

PSO3:

knowledge of the structure and function of the cells and organs of immune systems of marine animals and get Familiarized with various techniques involved in Immunology and also acquire clear idea about the immune based diagnosis kit for aquaculture, isolation, culture and feeding of marine live feeds.

PSO4:

Understand the functions of several enzymes and vectors used in genetic engineering. Acquaint to the versatile tools and techniques employed in recombinant DNA technology. Explain the construction of DNA & c DNA library. Acquire skills on techniques of plasmid isolation To gain hands on experience in gene cloning, protein expression and purification which would enable them to begin a career in industry that engages in genetic engineering as well as in research laboratories conducting fundamental research, to work in the interdisciplinary and multidisciplinary areas of modern biotechnology and its applications.

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PSO5:

To explore marine environment for natural products as medicines for various human and animal diseases and pesticides ,Understand basic ecological concepts, various pollution, its measurements & remediation.

PSO6:

Understanding the importance of general safety measures in laboratories and biosafety guidelines and applying them in the synthesis ,characterization, processing, preservation and storage of biomaterials/nanomaterials from marine organisms. Acquire knowledge about the marine nanopharmaceuticals and drug delivery. Acquire the principles, regulation of IPR and patents in marine based research and marine based product development.

5. QUALIFICATION DESCRIPTION:

The following may serve as the important qualification descriptors for a PG degree in Marine Biotechnology:

- Candidates who have completed Bachelor's degree in science in Microbiology / Biochemistry / Biotechnology / Zoology with Botany ancillary / Botany with Zoology ancillary / Plant Science and Biotechnology / Advanced Zoology and Animal Biotechnology / Biology / Life Science / Home Science / Nutrition and Dietetics / Chemistry with Zoology ancillary / B F.Sc., or any other degree that may be considered as equivalent top by the Manonmaniam Sundaranar University are eligible for admission

6. SEMESTERWISE COURSE DISTRIBUTION AND COURSE CREDITS

Subject Type	Code	Subject Title	Hrs./week	L	T	P	C	Maximum Marks			
				Hrs/week	Hrs/week	Hrs/week	Credits	Exam hours	Internal Assessment	External Assessment	Total
SEMESTER I											
Core Compulsory Theory											

Core -1		Biodiversity Conservation & Biosystematics	4	4	-	-	4	3	25	75	100
Core-2		Biochemistry & Biochemical Techniques	4	4	-	-	4	3	25	75	100
Core-3		Molecular Cell Biology	4	4	-	-	4	3	25	75	100
Core-4		Microbiology & Microbial Physiology	4	4	-	-	4	3	25	75	100
Core Compulsory Practical Course											
Major Practical -1		Practical I: Core -1 & Core-2	4	-	-	4	2	3	50	50	100
Major Practical –2		Practical II: Core -3 & Core-4	4	-	-	4	2	3	50	50	100
Core Elective Theory – Any one from the following											
Elective -1		Biostatics & Computer Application	3	3	-	-	3	3	25	75	100
		Biophysics									
Open elective											
ePG-Pathsala		To be selected latter	3	3	-	-	3	3	25	75	100
		Sub-Total	**30**	**22**	**-**	**8**	**26**		**200**	**600**	**800**
SEMESTER II											
Core Compulsory Theory Courses											
Core -5		Developmental biology	4	4	-	-	4	3	25	75	100
Core-6		Genomics & Bioinformatics	4	4	-	-	4	3	25	75	100
Core-7		Immunology	4	4	-	-	4	3	25	75	100
Core-8		Marine biomaterials	4	4	-	-	4	3	25	75	100
Core Compulsory Practical Courses											
Major Practical -3		Practical 3: Core-5 & Core-6	4	-	-	4	2	3	50	50	100
Major Practical - 4		Practical 4: Core-7 & Core-8	4	-	-	4	2	3	50	50	100

Core Elective Theory Courses – Any one from the following											
Elective 2		Marine Natural products	3	3	-	-	3	3	25	75	100
		Biosafey, Bioethics & IPR									
Open Elective Course											
MOOCs on line course			3	3	-	-	3	3	25	75	100
		Sub-Total	**30**	**22**	**-**	**8**	**26**		**200**	**600**	**800**
SEMESTER III											
Core Compulsory Theory Courses											
Core -9		Genetics	4	4	-	-	4	3	25	75	100
Core-10		Aquaculture Biotechnology	4	4	-	-	4	3	25	75	100
Core-11		Environmental Biotechnology	4	4	-	-	4	3	25	75	100
Core-12		Bioprocess technology	4	4	-	-	4	3	25	75	100
Core Compulsory Practical Courses											
Practical 5		Practical 5: Core-9 & Core-10	4	-	-	4	2	3	50	50	100
Practical 6		Practical 6: Core-11 & Core-12	4	-	-	4	2	3	50	50	100
Core Elective Theory Courses – Any one from the following											
Elective 3		Extremophiles	3	3	-	-	3	3	25	75	100
		Research Methodology									
Open Elective Course											
MOOCs on-line course			3	3	-	-	3	3	25	75	100
		Sub-Total	**30**	**22**	**-**	**8**	**26**		**200**	**600**	**800**
SEMESTER IV											
Open Elective Course											
ePG-Pathsala			3	3	-	-	3	3	25	75	100
Project		Project & Viva voce	-	-	-	-	9		50	50	100
		Sub-Total					**12**		**75**	**125**	**200**

		93	**69**	**-**	**24**	**90**		**675**	**1925**	**2600**

DISTRIBUTION OF MARKS WITHIN EACH PAPER

INTERNAL ASSESSMENT (Theory Courses - 25 marks) :

Each course has three internal assessments, each worth 15 marks. The average of the two best results from each of the three tests would be considered. Regarding the internal assessment, 25 marks are allocated in the following manner.

Component	**Marks**
The average of the best two tests from the 3 compulsory tests	**15 marks**
Assignment	**05 marks**
Seminar	**05 marks**
Total	**25 marks**

EXTERNAL ASSESSMENT (Theory Courses - 75 marks):

QUESTION PAPER PATTERN AT THE END OF EACH SEMESTER-UNIVERSITY EXAMINATION PATTERN

Sub. Code:

Title of the course

Semester: **Max. Marks : 75**

Time : 3 hrs

Section–A (10 X 1 mark =10 marks)

Answer all the questions in one or two sentences

Section – B (5 X 5 marks = 25 marks)

Answer all the questions (minimum 200 words) by selecting either ‘a’ or ‘b’

Section – C (5 X 8 marks = 40 marks)

Answer all the questions (minimum 500 words) by selecting either ‘a’ or ‘b’

7.COURSE LEVEL OUTCOMES OUTCOMES

CORE PAER 1
BIODIVERSITY CONSERVATION AND BIOSYSTEMATICS

Semester	**I Semester**				
Course Type	**Core Paper**				
Title of the Course	**BIODIVERSITY CONSERVATION AND BIOSYSTEMATICS**				
Course Code					
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**				
	BIODIVERSITY CONSERVATION AND BIOSYSTEMATICS	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: The student should have a basic knowledge on Biodiversity and its management					
CODE:	**BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	• To give an overview of marine environment and its living and nonliving resources in support of marine biotechnology and marine biodiversity conservation.				
Module 1	**DEFINITION AND BASIC CONCEPTS**			**12 hours**	

Definition and basic concepts of Biosystematics – importance and applications of Biosystematicsin biology; Material basic of biosystematics – different attributes; Trends inbiosystematics – Concepts; Conventional and new aspects-Chemotaxonomy; cytotaxonmy and molecular taxonomy.		
Module 2	**CLASSIFICATION TAXONOMIC CHARACTERISTICS**	**12 hours**
Dimensions of speciation and taxonomic characters; evalution of biodiversity indices – Shannon – Weiner index, dominance index, similarity and dissimilarity indices; association index – Diversity and ecosystem process; theory, achievements and future directions. Taxonomic procedures – (ICZN) its operative principles.		
Module 3	**FUNDAMENTALS OF MARINE BIOLOGY**	**12 hours**
Bioenergetics: Fundamentals of Marine Biology: Biological divisions of the sea- estuaries and backwaters, lagoons, mangroves, coastal waters, inshore, offshore, deep sea/oceanic; Biodiversity of the oceans; marine flora and fauna; Plankton - diversity and their role in the food chain; Plankton blooms and impact on fisheries; Harmful algal blooms; Nekton – abundance, distribution, geographic ranges and patterns of migration; diversity and distribution of Marine reptiles, birds and mammals; Benthos – intertidal and subtidal zones; Marine boring and fouling organisms; Concept of food chain and food web; ecological efficiency; Methods of estimation of marine productivity. amino acid oxidation; Metabolic fate of amino groups: role of glutamate and glutamine, urea cycle: reactions and regulation, Biosynthesis of amino acids, Regulation of amino acid biosynthesis, genetic defects in amino acid metabolism, metabolic diseases related to amino acid metabolism.		
Module 4	**MARINE BIODIVERSITY**	**12 hours**
Ttypes of biodiversity – species, ecosystem and Genetic biodiversity, Importance of Marine Biological Diversity – products from marine life: Food,Medicine and raw materials – seaweeds, seagrass, factors creating biodiversity, significance ofthree dimensional structures of mangrove plantation – Primary productivity – Ecosystem services from sea.		
Module 5	**CONSERVATION OF BIODIVERSITY**	**12 hours**
Conservation of biodiversity: areas of diversity, species and areas to be protected, larval and nursery grounds. Threats to biodiversity, Risk factors for Population: demography –sex ratio, anthropogenic uncertainty, low recruitment, mortality. Tools for the conservation of Biodiversity – Knowledge base, Planning, action plan, Regulating threats, Economic tools, Protecting areas, Recovering population.		

ReferenceBooks	1 1. Chapman, V.J., 1976, Mangrove Vegetation, J.Gramer, Berlin. 2. McRoy, C.P., and G. Helfferich, 1977, Seagrass Ecosystems: A Scientific Perspective. Marcel Dekker Inc., New York. 3. Yale Dawson, E., 1966, Marine Botany: An Introduction. Holt, Reinhart and Winston Inc., New York. 4. Kaestner, A., 1968, Invertebrate Zoology Vols. I to III, Interscience Publishers, New York, London, and Sydney. 4. Carl E. Bond, 1979, Biology of Fishes. W.B. Saunders Company, Philadelphia. 6. King M., 1995, Fisheries Biology, Assessment and Management. Fishing News Books, Oxford. 7. Miller, R.I., 1994. Mapping the Diversity of Nature, Chapman & Hall.

Course Outcomes (COs):

Course Outcome	**After the Completion of the Course, the student will be able to –**	**CognitiveLevel**
CO1	Get a deep knowledge on biodiversity richness in global scale and biogeography of India..	K1, K2
CO2	Know about diversity specification,Taxonomic and classification systems of .marine animals	K2, K3
CO3	Knowledge on Taxonomic procedures – (ICZN) its operative principles.	K3, K4
CO4	Analyze various threats to our biodiversity and able to suggest measures for conservation Strategies.Trained effectively and scientifically to convey the message of sustainable use of resources and conservation of biodiversity to the public and young generation	K5,K4 K5 K6
CO5	Assess the dynamics and types of ecosystem. Gain knowledge about population and community.Gain	K4, K5, K6

	knowledge about the global climate change and its impact Skill to evaluate soil and water quality and the basic concepts of global frame work, acts and policies in natural resource management	

K1- Remember; K2- Understand; K3- Apply; K4- Analyze; K5- Evaluate; K6- Create.

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	M	H	M	M	M	M	L	L	H	M	H	L	H	L
CO2	H	H	M	H	H	M	M	L	L	M	H	H	L	H	L
CO3	H	L	H	L	M	H	L	L	L	M	M	H	L	H	L
CO4	H	M	M	L	M	L	L	M	L	H	L	H	L	H	L
CO5	H	L	L	L	M	L	M	M	M	H	L	H	M	H	L

MAPPING WITH PSO

COs	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	L	M	L	H
CO2	H	H	L	M	L	M
CO3	H	M	L	L	L	M
CO4	H	M	L	M	M	M
CO5	H	M	M	L	M	M

CORE PAPER 2: BIOCHEMISTRY& BIOCHEMICAL TECHNIQUES

Semester	**I Semester**

Course Type	**Core Paper**				
Title of the Course	**BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES**				
Course Code					
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**				
	BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: The student should have a basic knowledge on chemistry and biomolecules					
CODE:	**BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	• To understand the basic principles of chemistry & physics related to biology • To understand the structures and functions of bio-molecules • To provide an depth knowledge of metabolic pathways in the living systems • To provide an in-depth knowledge on enzymes and bioenergetics • To provide an advanced understanding of the core principles and applications of various techniques used in biology/biotechnology				
Module 1	**BIOCHEMISTRY IN GENERAL**				**8 hours**
Structure of atoms, molecules and chemical bonds. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). Stabilizing interactions (Vander Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.); Composition, nature of bonds/linkages.					
Module 2	**CLASSIFICATION AND FUNCTIONS OF BIOMOLECULES**				**12 hours**
Classification, structure, physiological and biochemical functions of carbohydrates, amino acids, proteins, lipids, nucleic acids, vitamins, minerals and hormones.					
Module 3	**BIOENERGETICS, CARBOHYDRATE, LIPID & AMINOACID METABOLISM**				**16 hours**

Bioenergetics: Bioenergetics-basic principles; Equilibria and concept of free energy; common biochemical reactions; Phosphoryl group transfers and ATP; biological high energy compounds; Biological oxidation –reduction reactions and its importance in electron transfer, coupled reactions. **Metabolism:** General Introduction, types. ***Carbohydrate metabolism*** - Glycolytic pathway; Gluconeogenesis; Reciprocal regulation of Glycolysis and gluconeogenesis, Pentose phosphate pathway; Pyruvate Dehydrogenase Complex, its mechanism of action and regulation, Kreb's cycle; Electron Carriers, Electron transport and Oxidative phosphorylation; Photophosphorylation; Synthesis of glycogen, glycogenolysis, metabolic diseases related to carbohydrate metabolism. ***Lipid metabolism*** - Mobilization and transport of lipids, Oxidation of lipids: beta, alpha & omega oxidation, oxidation of saturated fatty acids, Oxidation of unsaturated fatty acids, and oxidation of odd chain fatty acids; Formation and oxidation of Ketone bodies; Biosynthesis of saturated fatty acids; synthesis of odd chain and unsaturated fatty acids, regulation of fatty acid biosynthesis; Biosynthesis of triglycerols; Biosynthesis of cholesterol and its regulation, metabolic diseases related to lipid metabolism. ***Amino acids metabolism*** - Amino acid degradation: deamination and transamination reactions; alpha ketoglutorate, succinate, fumarate and oxaloacetate pathways of amino acid oxidation; Metabolic fate of amino groups: role of glutamate and glutamine, urea cycle: reactions and regulation, Biosynthesis of amino acids, Regulation of amino acid biosynthesis, genetic defects in amino acid metabolism, metabolic diseases related to amino acid metabolism.		
Module 4	**NUCLEIC ACID METABOLISM & BIOCATALYSTS**	**15 hours**
Nucleic acid metabolism - *De novo* synthesis of purine and pyrimidine nucleotides; Catabolism of purine and pyrimidine; Disorders of purine and pyrimidine metabolism; Integration of metabolism. ***Biocatalysts*** - general principles of catalysis; Enzyme characteristics and classifications; monomeric and oligomeric enzymes; Specificity of enzymes; Active sites and binding site of enzymes, energy considerations, enzyme activity and its measurements, factors affecting enzyme activities; Enzyme kinetics: methods for investigating enzyme kinetics, Michaelis-Menton equation; regulatory enzymes, allosteric enzymes and their regulation; Mechanisms of enzyme catalysis: acid-base catalysis and covalent catalysis; Enzyme inhibition and its types, Enzyme activation; Reaction mechanism of enzymes: chymotrypsin, lysozyme, Structure function relationship of enzymes		
Module 5	**BIOCHEMICAL TECHNIQUES**	**9 hours**
Principle, working and applications of centrifugation, filtration; chromatography – Paper, TLC, ion exchange, sizeexclusion, affinity, adsorption, GLC, HPLC; Electrophoresis – Agarose, PAGE – SDS; Spectrophotometric techniques- UV, Visible, IR, NMR and MASS		
ReferenceBooks	1. Rodwell, V., Bender, D., Anthony Weil, P., Kennelly, P., Botham, K., 2015,	

	Harpers Illustrated Biochemistry, 30th Edition, LANGE. 2. Donald Voet, Judith G. Voet, 2011, Biochemistry, 4th Edition, Willey Science. 3. Jain, J.L., Sunjay Jain, Nitin Jain, 2016, Fundamentals of Biochemistry, 7th Edition, S. Chand & Company Pvt Ltd. 4. Cooper. T.G., 2011, The Tools of Biochemistry, Wiley India Pvt. Ltd. 5. Donald Voet, Judith G. Voet, 2018, Biochemistry, Willey Science. 6. Keith Wilson, John Walker, 2012, Principles and Techniques of Biochemistry and Molecular Biology, 7th edition, Cambridge University Press. 7. Nelson, D.L., and Cox, M.M., 2017, Lehninger Principles of Biochemistry, 7th Edition, MacMillan International Edition. 8. Reginald H. Garrett, Charles M. Grishm, 2013, Biochemistry, 4th Edition, Saunders College Publishers. 9. Rodwell, V., Bender, D., Anthony Weil, P., Kennelly, P., Botham, K., 2018, Harpers Illustrated Biochemistry, 31st Edition, LANGE. 10. Satyanarayana, U., 2017, Biochemistry, 5th Edition, Books and Allied Pvt. Ltd., Kolkata. 11. Trevor Palmer, 2008, Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, 5th Edition, Horwood Publishing Limited.
Web References	1. https://www.ncbi.nlm.nih.gov/books/NBK21139/ (Carbohydrates) 2. https://www.ncbi.nlm.nih.gov/books/NBK173989/ (vitamins) 3. nature.com/scitable/topicpage/protein-structure-14122136/ (proteins) 4. https://www.sciencedirect.com/topics/neuroscience/enzymes (Enzymes) 5. https://www.britannica.com/science/hormone (hormones)

At the end of the course the students can

Course Outcomes	**Cognitive**
CO1: Understand the fundamental concepts of chemistry, biology, physics and basic concepts about biochemistry at the atomic level (U)	K1, K2
CO2: Explain the classification, and function of biomolesules like carbohydrates, lipids, proteins, nucleic acids (Ap)	K1, K2
CO3: Identify the different classes of polymeric biomolecules and their monomeric building blocks, analyze and study the chemical	K1, K2, K3, K4, K5

and biochemical properties of biomolecules and also understand the relationships between biological molecules (An)	
CO4: Understand concepts of enzyme kinetics in living system (An)	K1, K2, K3, K4
CO5: Critically analyze and interpret the results obtained from biological experiments and understanding of solving biological problems using various techniques (An, Sk)	K1, K2, K3, K4

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	H	M	M	M	L	L	M	L	H	L	L	L	L	M
CO2	H	H	M	M	M	L	L	M	L	H	L	L	L	L	M
CO3	H	H	M	M	M	L	L	M	L	H	L	L	L	L	M
CO4	H	H	M	M	H	L	L	M	L	H	L	L	L	L	M
CO5	H	H	M	M	H	H	M	M	M	H	L	M	M	L	H

MAPPING WITH PSO

COs	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	M	M	H	H	H
CO2	H	M	M	H	H	M
CO3	H	M	M	H	H	M

CO4	H	M	M	H	H	M
CO5	H	M	M	H	H	M

CORE PRACTICAL COVERING 1 AND 2

Semester	**I Semester**				
Course Type	**Practical I**				
Title of the Course	**BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES**				
Course Code					
Teaching Hours					
	BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES	**Credits: 4**	**Max. Marks:**		
Course Prerequisites: The student should have basic practical knowledge on chemistry					
CODE:	**BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES**	**L**	**T**	**P**	**C**
			-	**-**	
Course Objectives	• To inculcate/impart skills to perform various tests/assays and experiments. • To provide qualitative & quantitative analysis of the macromolecules in the given sample and analyze the results. • To provide students with a deep insight of the various biochemical reactions and cellular processes through quantitative and qualitative				

	analysis of the samples provided.
Course Outcomes	After completing this course, student is expected to learn the following: CO1: Improved skills to perform various tests/assays and experiments. CO2: Design and analyze the experiments related with the different molecules and use of the various techniques the kinetics and rationale behind each phenomenon CO3: Use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a research project, collect and analyze data, and interpret results
1. Qualitative analysis of protein, carbohydrate, lipid and nucleic acids 2. Quantification of total carbohydrate 3. Quantification of aminoacids by ninhydrin method 4. Quantification of protein by Lowry's method 5. Quantification of RNA by Orcinol method 6. Quantification of DNA by diphenyl amine method 7. Analysis of DNA by Agarose gel electrophoresis (Demonstration) 8. Separation of any biomolecule by Thin Layer Chromatography	

CORE PAPER/Ppr-3: MOLECULAR CELL BIOLOGY

Semester	**I Semester**
Course Type	**CORE PAPER**
Title of the Course	**MOLECULAR CELL BIOLOGY**
Course Code	**……..**

Teaching Hours	**60 Hours/ Semester: 4 Hours/ week**

……..	**MOLECULAR CELL BIOLOGY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should possess basic knowledge on general aspects about cell and its various organelles. They may have the brief knowledge on the functions of the cell in the body like transcription, translation, genetic codes etc.

CODE: ……..	**MOLECULAR CELL BIOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To understand the molecular components of plasma membrane, their arrangements and role in making the cell live. ➢ To give a clear knowledge on the transport of nutrients in and out of cells by various mechanisms. ➢ To impart knowledge on the cytoskeleton of cells and their contribution in cell cycle, cell adhesion and communication between cells. ➢ To give a knowledge on chromosomal DNA and its role in gene expression and regulation.				
Module I	**INTRODUCTION TO PLASMA MEMBRANE**				**12 hours**
Experimental systems in Cell Biology. Bio-membranes - Molecular composition and arrangement functional consequences - Transport across cell membrane- Diffusion, active transport and pumps and uniports, symports and antiport - Membrane potential - Co-transport by symports or antiporters - Transport across epithelia.					
Module II	**CYTOSKELETON**				**12 hours**
Microfilaments and microtubules-structure and dynamics - Microtubules and mitosis - Cell movements-intracellular transport, role and kinesin and dynein, signal transduction mechanisms Cilia and flagella - Cell-cell signaling - Cell surface receptors - Second messenger system - MAP kinase pathways - Signaling from plasma membrane to nucleus.					
Module III	**CELL-CELL ADHESION AND COMMUNICATION**				**12 hours**

Ca^{++} dependent homophilic cell-cell adhesion - Ca^{++} independent homophilic cell-cell adhesion- Gap junctions and connexons - cell matrix adhesion – integrins – collagen - Non-collagen components - cell cycle - mitosis and meiosis - cyclins and cyclin dependent kinases - regulation of CDK- cyclin activity.		
Module IV	**GENOME ORGANIZATION**	**12 hours**
Hierarchy in organization - chromosomal organization of coding and non-coding DNA – regulation of gene expression - mobile DNA - morphological and functional elements of eukaryotic chromosomes - Genetic analysis in Cell Biology		
Module V	**INTRACELLULAR PROTEIN TRAFFIC**	**12 hours**
Protein synthesis on free and bound polysomes - uptake into ER - membrane proteins, Golgi sorting, post-translational modifications - biogenesis of mitochondria, and nuclei - trafficking mechanisms - biology of cancer - biology of aging - apoptosis-definition, mechanism and significance.		
ReferenceBooks	1. De Robertis, E.D.P. and E. M. F. De Robertis, 1995, Cell and Molecular Biology,8th Edition, B.I. Waverly Pvt. Ltd. 2. Lodish, H., A. Berk, P. Matsudaira, C.A Kaiser, M. Krieger, M.P. Scott, S. L. Zipursky and J. Darnell, 2004. Molecular Cell Biology, 5th Edition, W.H. Freeman and Company. 3. Watson, J. D., N. H. Hopkins, J.W Roberts, J. A. Steitz and A.M Weiner, 1987, Molecular Biology of the Gene, 4th Edition, Benjamin / Cummings. 4. Lewin, B., 2004. Genes, 8th Edition, Peasrson Prentice Hall. Karp, G., 1996, Cell and Molecular biology: Concepts and Experiments, John Wiley & Sons. 5. Ajoy Paul, 2011, Text Book of Cell and Molecular Biology, , Books and Allied Pvt. Ltd., Kolkata. 6. Aberts, B., Bray, D., Lewis, J, Ratf, M., Roberts, K., and Watson, J.D., Molecular Biology of the Cell, Garland Publishing Inc., New York.	

Web Source:	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Understand and analyze the molecular components of plasma membrane of a cell and their arrangement , their role in transport of micro and macromolecules between its internal and external environment.	K1, K2. K4
CO2	Know about microtubules and microfilaments in making the cytoskeleton of a cell and how they help in the transport of molecules needed for cell cycle. Also, know about the cell surface receptors and how they work in cell signaling through signal transduction pathway.	K1, K2
CO3	Acquire knowledge on adhesion molecules and structures that make contact between two adjacent cells; know about the fact lying behind on the growth of cells by mitosis and meiosis and the factors involved in cell cycle regulation.	K3, K4, K5
CO4	Know the facts behind the gene organization of chromosomes and how the genes get expressed and regulated. Know about the use of genes in genetic analyses.	K2, K3, K5
CO5	Understand the process of translation and how the translated protein is getting segregated and reach their respective organelles for their suitable function.	K1, K2.

K1- Remember; K2- Understand; K3- Apply; K4- Analyze; K5- Evaluate; K6- Create.

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	H	M	M	M	L	L	M	L	H	M	L	M	L	M
CO2	H	H	M	M	M	L	L	M	L	H	M	L	L	L	M
CO3	H	H	M	M	M	L	L	M	L	H	L	L	L	L	M
CO4	H	H	M	M	H	L	L	M	L	H	L	L	L	L	M
CO5	H	H	M	M	H	H	M	M	M	H	L	M	M	L	H

Mapping with PSO:

COs	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	H	L	M	L	H
CO2	H	H	L	M	L	M
CO3	H	M	L	L	L	M
CO4	H	M	L	M	M	M
CO5	H	M	M	L	M	M

(H-High, M-Medium, L-Low)

Core paper 4 MICROBIOLOGY & MICROBIAL PHYSIOLOGY

Semester	**I Semester**		
Course Type	**Core Compulsory Paper - 4**		
Title of the Course	**MICROBIOLOGY & MICROBIAL PHYSIOLOGY**		
Course Code			
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	MICROBIOLOGY & MICROBIAL PHYSIOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**

Course Prerequisites:
The student should have a basic knowledge on microbiology

CODE:	**MICROBIOLOGY & MICROBIAL PHYSIOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**

Course Objectives

- To inculcate knowledge on fundamentals of microorganisms
- To learn the structural organization, morphology and reproduction of microbes
- To develop a sufficient background to students about the growth of Microbes
- To learn the microbial metabolism

Module 1	**History and Scope of Microbiology**	**12 hours**

Generation theory – Contribution of Leuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Joseph Lister, Winogradsky, Waksman and John Tyndall. Classification of microorganisms - Haeckel's three kingdom concept, Whittaker's five kingdom concept, Carl Woes three domain system, Bacterial classification (outline) according to Bergey's manual of systemic Bacteriology. Morphological types, Cell wall of Gram negative, Gram positive bacteria and halophiles. Cell wall synthesis. Capsule composition and function.Cell membranes in Eubacteria, archaebacteria and cyanobacteria, Cell membrane functions. Periplasmicspace.Structure and function of flagella, cilia and pili, gas vesicles, chlorosomes, carboxysomes, magnetosomes and phycobilisomes. Reserve food materials – polyhydroxybutyrate, polyphosphates, cyanophycin and sulphur inclusions. General

account on mycolpasma.		
Module 2	**General Characteristics**	**12 hours**
Classification, Structure and Reproduction of Algae: Chlorophyta (Green algae), Diatoms, Rhodophyta (Red algae), Fungi: Cell wall – chemical composition and functions, membranes and their functions, nutritional strategies of fungi. Structure and life cycle of fungi Ascomycetes (*Aspergillus*), Zygomycetes (*Mucor*), Basidiomycetes (*Agaricus*) and Protozoa. Discovery, distinctive properties, morphology and ultra-structure of Virus, Classification, Cultivation and Purification assay of virus. Bacteriophages - structural organization and life cycle - lytic, lysogenic. Viral related agents - viroid and prion.		
Module 3	**Growth of Bacteria**	**12 hours**
Phases of growth, Growth kinetics - batch culture, continuous culture and synchronous culture - induction of synchrony. Factors affecting growth - nutrition, aeration, temperature and pH. Physiological adaptation to extreme environmental conditions. Nutritional types and metabolic diversity - types based on carbon, energy and electron sources		
Module 4	**Bacterial Photosynthesis**	**12 hours**
Historical background. General types of microbial photosynthesis - oxygenic and anoxygenic. Structure of photosynthetic pigments – chlorophylls, bacteriochlorophyll, carotenoids and phycobilins. Photosynthetic bacteria - green sulphur and purple. Mechanism of photosynthesis - non-cyclic and cyclic electron transport. Photophosphorylation. Carbon assimilation - calvin, reverse citric acid cycle and hydroxyl propionate cycle.		
Module 5	**Nitrogen Metabolism**	**12 hours**
Nitrogen cycle - ammonification, nitrification, denitrification and nitrogen fixation.Nitrogenase enzyme, physiology of nitrogen fixation in symbiotic and free living bacteria. Genetics of nitrogen fixation, acetylene reduction assay. Transamination and deamination.		
ReferenceBooks	1. Atlas, R.A. and Bartha, R., 2000, Microbial Ecology, Fundamentals and Application, Benjamin Cummings, New York. 2. Dubey, R.C. and Maheswari, D.K., 2013, A Text Book of Microbiology, Revised Edition, S. Chand and Company Ltd, New Delhi. 3. Madigan, M.T., Martinka, M., Parker, J. and Brock, T.D., 2000, Biology	

of Microorganisms, 12th Edition, Prentice Hall, New Jerry.
4. Mark Wheelis, 2010, Principles of Modern Microbiology, Jones & Bartlett India Pvt. Ltd., New Delhi.
5. Pelczar, M.J., Schan, E.C. and Kreig, N.R., 2010, Microbiology – An Application Based Approach, 5th Edition, Tata McGraw Hill Publishing Company Limited, New Delhi.
6. Prescott, L.M., Harley, J.P. and Helin, D.A., 2008, Microbiology, 5th Edition, McGraw Hill, New York.
7. Schlegal, H.G., 1995, General Microbiology, 7th Edition, Cambridge Univeristy Press.
8. Stanier, R., Lingraham, Y., Wheelis, M.L. and Painter, R.P., 1986, General Microbiology, 5th Edition, Macmillan, London.
9. Stryer, L. 2010, Biochemistry, 7th Edition, W.H. Freeman and Company, New York.
10. Tortora G.J., Funke, B.R. and Case, C.L., 2009, Microbiology, 9th Edition, Dorling Kindersely (India) Pvt. Ltd., Noida.

After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
CO1: Got an idea about the history of microbiology, classification and ultrastructure of microbes	K1, K2
CO2: Acquire knowledge on the structure and reproduction of algae, fungi, protozoa, virus, bacteriophages	K1, K2
CO3: Got an idea about the growth kinetics and the factors affecting the growth of bacteria	K1, K2, K3
CO4: Understand about the mechanism of microbial photosynthesis, structure of photosynthetic pigments	K2, K3
CO5: Understand about the nitrogen metabolism and their genetics in microbes	K2, K3

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

MAPPING WITH PO

	PO1	PO2	PPO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	M	L	L	L	M	L	L	L	M	M	L	L	M	M
CO2	H	M	L	L	M	L	L	L	L	M	M	L	L	M	M
CO3	H	M	L	L	M	L	L	L	L	M	M	L	M	M	M
CO4	H	M	L	L	L	L	L	L	L	M	M	L	M	M	M
CO5	H	L	M	L	M	M	L	M	L	L	L	L	L	M	L

MAPPING WITH PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	M	H	M
CO2	H	M	M	H	M	M
CO3	H	M	L	M	M	L
CO4	M	H	M	M	H	L
CO5	H	M	M	M	H	M

PRACTICAL COVERING CORE PAPERS 1 AND 2

Semester	**I Semester**
Course Type	**Core Compulsory Course Practical - 1**
Title of the Course	**BIODIVERSITY CONSERVATION & BIOSYSTEMATICS AND BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES**
Course Code	

Teaching Hours	60 hours/semester: 4 hours/week		
	BIODIVERSITY CONSERVATION & BIOSYSTEMATICS AND BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES	**Credits: 2**	**Max. Marks: 100 (Internal: 50; External: 50)**

Course Prerequisites:
The students should know the basics of biochemistry & knowledge on the biodiversity of marine organisms

		L	T	P	C
CODE:	**BIODIVERSITY CONSERVATION & BIOSYSTEMATICS AND BIOCHEMISTRY & BIOCHEMICAL TECHNIQUES**	**-**	**-**	**4**	**2**

Course Objectives	• To inculcate/impart skills to perform various tests/assays and experiments. • To provide qualitative & quantitative analysis of the macromolecules in the given sample and analyze the results. • To provide students with a deep insight of the various biochemical reactions and cellular processes through quantitative and qualitative analysis of the samples provided.

1. Estimation of primary productivity in a sea weed
2. Study of sandy, muddy and rocky shore fauna with special reference to adaptation to environment
3. Identification of important marine invertebrates
4. Identification of important vertebrates
5. Identification of important marine plants
6. Qualitative analysis of protein, carbohydrate, lipid and nucleic acids
7. Quantification of total carbohydrate
8. Quantification of aminoacids by ninhydrin method
9. Quantification of protein by Lowry's method
10. Quantification of RNA by Orcinol method
11. Quantification of DNA by diphenyl amine method
12. Analysis of DNA by Agarose gel electrophoresis (Demonstration)
13. Separation of any biomolecule by Thin Layer Chromatography

PRACTICAL COVERING CORE PAPERS 3 AND 4

Semester	**I Semester**				
Course Type	**Practical II**				
Title of the Course	**MOLECULAR CELL BIOLOY&MICROBIOLOGY AND MICROBIAL PHYSIOLOGY**				
Course Code					
Teaching Hours					
	MOLECULAR CELL BIOLOY&MICROBIOLOGY AND MICROBIAL PHYSIOLOGY	**Credits: 4**	**Max. Marks:**		
Course Prerequisites: The student should have basic practical knowledge on microbiology and cell biology					
CODE:	**MOLECULAR CELL BIOLOY&MICROBIOLOGY AND MICROBIAL PHYSIOLOGY**	**L**	**T**	**P**	**C**
			-	-	
Course Objectives	• The candidate will gain hands-on knowledge and acquire adequate skill required to sterilize media and to prepare, inoculate observe and distinguish bacteria, fungi and their growth patterns in different media. • The student will also get a thorough input to analyse end evaluate the difference between different microorganisms. • Experiments relating to chromosomes study and identifying the phases of cell division are explained.				
Course Outcomes	After completing this course, student is expected to learn the following: CO1: Understand various physical and chemical means of sterilization - Sterilization techniques ,competently prepare various types of media CO2:Understanding,Knowledge and Skill to isolate, analyse and differentiate between different types of Microorganisms based on their chemical characteristics				

	CO3:skilled to perform the extraction and characterization of chromatin and techniques for studying its modifications,

LIST OF PRACTICALS

1. 1. Principle and methods of sterilization
2. Preparation of media: nutrient broth, nutrient agar plate, soft agar
3. Pure culture techniques: streak plate, spread plate and pour plate
4. Motility determination – Hanging drop method
5. Isolation and enumeration of bacteria from different environmental samples
6. Enumeration of bacteria - viable count (plate count) and total count (Haemocytometer count) Direct microscopic observation of fungal spores and mycelium
7. Staining method: simple, negative, Gram's staining and spore staining
8. Fungal slide culture
9. Measurement of growth rate and generation time by turbidometry method
10. Measurement of cell size by micrometry
11. Identification of mitotic phases from onion root tip.
12. Identification of meiotic phases from grass hopper testis
13. Observation of Giant Chromosomes (Polytene-Chirnomous larva)
14. Identification of Sex Chromatin (Barr Body) from human epithelial cell

ELECTIVE PAPER 1a: BIOSTATSTICS AND COMPUTER APPLICATION

Semester	**I Semester**
Course Type	**ELECTIVE PAPER 1a**
Title of the Course	**BIOSTATSTICS AND COMPUTER APPLICATION**
Course Code	**NMYEA**
Teaching Hours	**45 Hours/ Semester : 4 Hours/ week**

NMYEA	**BIOSTATSTICS AND COMPUTER APPLICATION**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
The student should possess basic knowledge on general aspects about Biostatistics, statistical data representations, statistical measures and analysis of biological data, as well as to know the available statistical tools and interpretation of statistical data through computer software.

CODE: NMYEA	BIOSTATISTICS AND COMPUTER APPLICATION	L	T	P	C
		3	-	-	3
Course Objectives	➢ To know the basic concepts of biostatistics like history & growth of statistics and statistical methods ➢ To understand about data, their types, and methods involved in collection of data and presentation of data through various modalities. ➢ Enable to understand the statistical measures through determination of averages, deviations, test of significance, hypothetical analysis, correlation & Regression analysis, etc. ➢ To understand about basic computer application in relation with analysis of biological data by using various computer software technique.				
Unit I	**STATSTICAL INTRODUCTION**				**9 hours**
Definition of statistics, History and growth of statistics, Statistical methods, Types of biological data, Population, Samples from populations and Random sampling.					
Unit II	**DATA INTERVAL AND REPRACENTATION**				**9 hours**
Collection, organization and tabulation of data, Diagrammatic representation of data, Types of diagrams and Graphical representation of data.					
Unit III	**STATSTICAL MEASURES**				**9 hours**
Measures of Central Tendency- mean, median and mode, Measures of dispersion and variability – range, dispersion measured with quartiles, mean deviation, variance and standard deviation, Comparison of means and variances.					

Unit IV	STATISTICAL HYPOTHESIS AND ANALYSIS	9 hours
Proportion of data – Examples of proportion data, Statistical treatment of proportion of data, Chi square test and goodness of fit, Application of Chi square test, Sampling and Hypothesis: One and Two sample hypothesis, Test of Significance, Analysis of Variance: One way and Two way ANOVA classification, Regression and Correlation analysis.		
Unit V	**INTRODUCTION TO COMPUTER**	**9 hours**
Basic computer application: Purpose of computer, types of computer, Hardware and Software, Programming language, Commercial software: Windows, MS Word, Excel, Power point, Statistical packages: Sigma stat, SPSS-Intra and Internet, Email, Website Creation, Database in Biology: Pub Med, Sequence Analysis, Genome and Protein database genome research.		
ReferenceBooks	1. Gupta, S.P., 2010, Practical Statistics, S. Chand and Company, New Delhi. 2. Bliss, C.I.K., 1967, Statistics in Biology, Vol. I, Mc Graw Hill, New York. 3. Campbell, R.C., 1974, Statistics for Biologists, Cambridge University Press, New York. 4. Lutz, W., 1967. Statistics Methods as Applied to Immunological data, app. In : D.M. Weir (ED). 5. Hand Book of Experimental Immunology, Blackwell Publications Ltd., Oxford. 6. Jerrold H. Zar, 2009, Biostatistical Analysis, 5th Edition, Pearson Publications, India. 7. David Baskeen, 2008, Introduction to Computer Application and Concept, Cengage Learning Public, UK. 8. Bhose, S.B., 2011, Text book of Computer Application and Biostatistics, Trinity publishing House, India.	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Understand about the basic concepts of Biostatistics, its history and development, meaning of data, different types of statistical data, etc.	K1, K2

CO2	Know about how to collect biological data and its presentation by following various methodologies like tabulation, diagrammatic and graphical representations.	K2, K3
CO3	Interpret and determine the biological data through some basic statistical measures like measures of Central tendency, Dispersion and variation analysis.	K3, K4, K5
CO4	Test and Analyse the biological data through hypothetical assumption or creation by following some statistical treatments with Chi square test, students 't' test, ANOVA test, Correlation and Regression analysis	K4, K5, K6
CO5	Know about computer application in statistical data analysis, study about available basic software's & hardware's and statistical packages related to data base in biology.	K3, K4, K6

K1- Remember; K2- Understand; K3- Apply; K4- Analyze; K5- Evaluate; K6- Create.

MAPPING CO WITH PO

	PO1	**PO2**	**PPO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	H	M	H	H	M	H	M	L	H	L	L	L	L	M
CO2	H	H	L	H	M	M	H	L	L	H	L	L	L	L	M
CO3	H	M	L	H	H	H	H	L	L	H	L	L	L	L	M
CO4	H	M	L	H	H	M	H	L	L	H	L	L	L	L	H
CO5	H	M	M	M	M	L	L	H	M	H	M	M	L	L	H

ELECTIVE PAPER 1b: BIOPHYSICS

Semester	**I Semester**		
Course Type	**Core Elective Paper – 1 b**		
Title of the Course	**BIOPHYSICS**		
Course Code			
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**		
	BIOPHYSICS	**Credits: 3**	**Max. Marks: 100**

			(Internal: 25, External 75)

Course Prerequisites:
The student should have a basic knowledge on physics and biology

CODE:	**BIOPHYSICS**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**

Course Objectives	• To get an idea about the physics behind the biological materials	
Module 1	**Introduction of Biophysics**	**9 hours**
Historical overview, connections with physics, biology and medicine – Physical phenomena and processes in the living organisms. The possibilities to study physical process in biological systems. Reductionism in life sciences, its consequences and limits. Electromagnetic waves, their characteristics and their classification. Physical characteristics of light, light spreading, reflection, refraction, absorption, interference, diffraction, optical properties of lenses.		
Module 2	**Radioactivity and X-rays**	**9 hours**
X-rays, their properties, sources of X-radiation, applications of X-rays to biology and medicine. Radioactivity and radioactive isotopes, characteristics of radioactivity, radioactive radiations and their classifications, effect of radioactive radiations on living organisms, measurement of radiations, applications of radioactivity in medicine.		
Module 3	**DNA**	**9 hours**
Basis of Waston Cricks original model, base pairing schemes – biological implication of Watson Crick base pairing scheme – fibre X-ray diffraction studies – single crystal X-ray diffraction, and NMR studies on mono- and oligo-nucleotides, DNA polymorphism, spectroscopic study of DNA polymorphism, interactions, structure of RNA, basic differences between DNA and RNA structures		
Module 4	**Stability of Protein Structures**	**9 hours**
Flexibility, reversible folding and unfolding, pH titration, chemical modification predication of protein structures: circular dichroism, NMR methods, structure – function relationship.		
Module 5	**Structure of Biological Membranes**	**9 hours**

Modern membrane theories, the Singer –Nicolson, Fluid – Mosaic membrane model. The transport processes through biological membranes, membrane models, membrane as a selective barrier for different substances, the contribution of lipid bilayer and membrane proteins (channels and transporters) to the biological transport processes. Active and passive forms of the membrane transport. Use of liposomes for membrane models and drug delivery systems.	
ReferenceBooks	1. Available in web: Biophysics Textbook online. http://www.biophysics.org 2. Rob Phillips, Jane Kondev, Julie (Eds.), 2011, Biological Physics – Energy, Information, W.H. Freenan company. 3. Rob Phillips, Jane Kondev, Julie Thriot, Hernan G. Garcia (Eds), 2011, 2nd Edition, Physical Biology of Cell, Illustrated by Nigel Orme 4. William Bailek (Ed.), 2012, Biophysics-Searching for Principes, Princteon University Press 5. Voet, D., & Voet, J.G., 1995, Biochemistry, 2nd Edition, John Wiely & Sons.

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Get an idea about the physical factors involved in life sciences	K1, K2
CO2	To get an idea and knowledge of radioactivity and X-ray	K2, K3, K4
CO3	To get an idea about the techniques involved in the study of nucleic acids – DNA and RNA	K2, K3, K4
CO4	To get an idea about the techniques involved in the study of proteins	K2, K3, K4
CO5	To get an idea about the physical factors involved in the biological membranes	K1, K2, K3

K1- Remember; K2- Understand; K3- Apply; K4- Analyze; K5- Evaluate; K6- Create.

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15

CO1	H	M	H	H	H	L	L	M	L	L	L	H	H	L	L
CO2	H	L	H	M	H	M	L	M	L	L	M	H	H	L	L
CO3	H	M	M	M	H	L	L	L	L	M	L	L	M	L	L
CO4	H	M	L	M	L	M	L	M	L	M	M	L	H	L	L
CO5	H	M	M	M	M	L	M	H	M	M	M	M	M	L	M

CORE 5 DEVELOPMENTAL BIOLOGY

CORE PAPER/Ppr-3: DEVELOPMENTAL BIOLOGY

Semester	**II Semester**
Course Type	**CORE PAPER**
Title of the Course	**DEVELOPMENTAL BIOLOGY**
Course Code	**……..**
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**

……..	**DEVELOPMENTAL BIOLOGY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should possess basic knowledge on male and female gametes, fertilization and embryo development. They may have the cellular events taking place in fertilized egg like cleavage, blastulation and gastrulation. May have knowledge on types of reproduction including sexual and asexual reproduction.

CODE:	**DEVELOPMENTAL BIOLOGY**	**L**	**T**	**P**	**C**
……..		**4**	**-**	**-**	**4**

Course Objectives	➢ To give the basic knowledge on the various concepts of embryo development. ➢ To understand the sequential changes from cellular grade of organization to organ grade of organization in the multicellular organisms. ➢ To make understand the existence of indirect development among animal groups and how they develop through metamorphosis. ➢ To highlight the reproductive aspects of human beings and the importance of Assisted Reproductive Technologies and to make aware of contraceptive methods in birth control.	
Module I	**HISTORY AND BASIC CONCEPTS OF DEVELOPMENT**	**12 hours**
Definition and Scope of Gametogenesis – Spermatogenesis – Oogenesis – Vitellogenesis - Structure of Sperm and Egg. Fertilization: Pre and Post fertilization events – significance; Parthenogenesis.		
Module II	**STAGES OF DEVELOPMENT**	**12 hours**
Zygote – Blastula, Gastrula, Neurula - Cell fate commitment – Potency – Concept of embryonic stem cells – Lineages of 3 germ layers – fate map – Germ cell speciation and migration – Eg. Chick / Frog / Zebrafish.		
Module III	**EARLY DEVELOPMENT OF EMBRYO**	**12 hours**
Cleavage- Gastrulation – Axis specification – Dorsoventral and Anterior-posterior, Body plan patterning		
Module IV	**LATE DEVELOPMENT OF EMBRYO**	**12 hours**
Organogenesis – Eg. Rat. Development of eye, ear, heart and brain. Metamorphic events in frog and its hormonal regulation.		
Module V	**HUMAN EMBRYOLOGY**	**12 hours**

Implantation of embryo in humans, placenta in humans and its function, manipulation of reproduction in humans – infertility (Male and Female), IUI , IVF, Artificial insemination , test tube babies, Amniocentrosis. Birth control, contraceptive devices- surgical and hormonal methods.	
ReferenceBooks	1. Balinsky, B.J.Introduction to Embryology, W.B.Saunders, Philadelphia,USA. 2. Developmental Biology: R.M.Twyman. Bios scientific publishers, Ltd. New Delhi (2001). 3. Gilbert. Developmental Biology, ANE Books India, Avantika Niwas, 19, Doraiswamy Road, T.nager, Chennai-600 017. 4. Goel,S.C. Principles of Animal Developmental Biology, Himalaya Publishing House,Ramdoot,Dr.Bhalerao Marg (Kelewadi)Girgaon,Mumbai – 400 004. 5. Rao, K.V. Developmental Biology. A Modern Synthesis. Oxford & IBH Publishing company Private Limited, S-155 Panchshila Park, New Delhi 110017. 6. Sastry.K.V. and Vineeta Shukal, Developmental Biology Rastogi Publications Gangotri, Shivaji Road, Meerut-250 002. 7. Verma.P.S. and V.K. Agarwal. Chordate Embryology (10 ^{h} Edition).S. Chand & Company Ltd.7361 Ram Nagar,Qutab Road,New Delhi – 110055.

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Understand the basic concepts of development like gametogenesis, vitellogenesis and post fertilization events and also acquire knowledge on parthenogenetic development.	K1, K2.
CO2	Know and analyze the stages of development of zygote in to an adult by observing the sequential development stages	K1, K2, K4

	in Zebra fish embryo. Understand the concepts of embryonic stem cells, germinal layers and their migration.	
CO3	Understand about the different developmental processes starting from cleavage of zygote, blastulation, gastrulation and how the germinal layers take part in body plan patterning.	K1, K2.
CO4	Acquire knowledge on the development of organs like eye, ear, heart and brain and the regulation of their development. Know about indirect development that leads to the formation of an embryonic stage, the larva and its development in to adult through metamorphosis.	K2, K3, K4.
CO5	Know about human embryo development with special reference to implantation and placental development understand the significance of Assisted Reproductive Technologies (ART) in case of barren couples and the causes leading to ART. Know about the various contraceptive methods in birth control.	K1, K2.

K1- Remember; K2- Understand; K3- Apply; K4- Analyze; K5- Evaluate; K6- Create.

MAPPING WITH PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	M	H	H	H	L	L	M	L	L	L	H	H	L	L
CO2	H	L	H	M	H	M	L	M	L	L	M	H	H	L	L
CO3	H	M	M	M	H	L	L	L	L	M	L	L	M	L	L
CO4	H	M	L	M	L	M	L	M	L	M	M	L	H	L	L
CO5	H	M	M	M	M	L	M	H	M	M	M	M	M	L	M

CORE PAPER 6 GENOMICS AND BIOINFORMATICS

Semester	**I Semester**

Course Type	**Core Compulsory Paper - 6**		
Title of the Course	**GENOMICS & BIOINFORMATICS**		
Course Code			
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	GENOMICS & BIOINFORMATICS	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**

Course Prerequisites:
The student should have a basic knowledge on gene organization and bioinformatics

CODE:	**GENOMICS & BIOINFORMATICS**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**

Course Objectives

- To get an idea about the genome organization, marine genomics and techniques involved in genome study
- To get a basic knowledge on bioinformatics, different bioinformatics search engines and sequence similarity alignment using various bioinformatic tools

Module 1	**Introduction to Genomics**	**12 hours**

Genes and genomes, Genes within a Genome, Eukaryotic and prokaryotic molecular molecular genome organization and evolution. Chromatins, Histones, Exons, Introns, Minisatellites, Microsatellites, Telomere, Transposons, Promoters, Enhancers, Chloroplasts and Mitochondrial genome. Human Genome Project.

Module 2	**Marine Genomics**	**12 hours**

Metagenomics, Population genomics, Environmental genomics analysis and applications. Functional genomics in models animals - fugu, Medaka, Zebra fish. Transcription Regulatory sequence, Transcriptiomics – gene expression analysis by transcript profiling, genome wide functional analysis. Genome perspectives in molecular clock.

Module 3	**Methods in Genomics**	**12 hours**

Isolation and purification of DNA (genomic and plamid), Agarose gel electrophoresis, molecular cloning of DNA fragments in bacterial and eukaryotic systemes; expression of recombinant proteins

using bacterial vectors; isolation of specific nucleic acid sequences; generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors; gene knock out in bacterial and eukaryotic organisms; DNA analysis of gene expression at RNA and protein level, RFLP, RAPD and AFLP techniques.		
Module 4	**Bioinformatics**	**12 hours**
Introduction to Bioinformatics: Definition and history of Bioinformatics, Internet and Bioinformatics, Information Networks, EMBney-, Intranet and Internet Packages, Basics, WWW, HTML, URLs Browsers, applications of Bioinformatics, DNA sequence Databases, Protein Sequence Databases.		
Module 5		**12 hours**
Basic concepts of sequence similarity, pairwise sequence alignments, Needleman & Wuncsh, Smith & Waterman algorithms, Scoring matrices PAM and BLOSUM Matrices, BLAST and FASTA algorithm, multiple sequence alignments (MSA), Importance of MSA, Clustal W and Pileup, Definition and description of phylogenetic trees and various types of trees, methods and programs for Phylogenetic tree construction.		
ReferenceBooks	1. Arthur M. Lesk, 2003, Introduction to Bioinformatics, Oxford University Press, New Delhi. 2. Attwood, T.K., 2003, Introduction to Bioinformatics, Pearson Education, Ltd., New Delhi. 3. Benjamin Lewin, 2007, Genes 9, 9th Revised Edition, Jones and Bartlett Publishers, Inc. 4. Brown, T.A., 2006, Genomes, 3rd Edition, Garland Science. 5. Chris Town, 2002, Functional Genomics, 1st Edition. 6. Edgar Jacoby, 2006, 1st Edition, Chemogenomics: Knowledge Based Approaches to Drug Discovery, Imperial College Press. 7. Higgins, D., and Taylor, W., 2000, Bioinformatics – Sequence, Structure and Data Banks, Oxford University Press, New Delhi. 8. Julio Licino (Ed.), Ma-Li Wong (Ed.), 2002, Pharmacogenomics: The Search for Individualized Therapies, 1st Edition, Wiley-Blackwell. 9. Werner Kalow, U.A. Meyar, Rachel F. Tyndal, 2005, Pharmacogenomics, 2nd Edition, CRC Press.	

After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
CO1: Understand the components of genome organization and human genome project	K1, K2
CO2: Get an idea about the marine organisms genomics with model animals	K1, K2
CO3: Acquire knowledge on different involved in the genome analysis	K2, K3, K4
CO4: Obtain knowledge on basic bioinformatics like introduction, history different types of bioinformatics databases	K2, K3, K4, K5
CO5: Get an idea and skill on the different methods adopted to find the sequence similarity	K2, K3, K4, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

	PO1	PO2	PPO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	M	H	L	M	M	M	M	M	M	L	L	L	L	L
CO2	H	M	H	L	M	M	M	H	M	M	L	L	L	L	L
CO3	H	M	H	H	H	H	M	H	H	M	M	M	M	L	M
CO4	L	M	H	H	H	H	M	H	H	M	H	H	H	L	H
CO5	L	M	H	H	H	H	M	H	H	M	H	H	H	L	H

PRACTICAL COVERING CORE PAPER 5 AND 6

Semester	**II Semester**		
Course Type	**Practical II**		
Title of the Course	**DEVELOPMENTAL BIOLOGY&GENOMICS AND BIOINFORMATICS**		
Course Code			
Teaching Hours			
	DEVELOPMENTAL	**Credits: 4**	**Max. Marks:**

	BIOLOGY&GENOMICS AND BIOINFORMATICS		

Course Prerequisites:
The student should have basic practical knowledge on microbiology and cell biology

CODE:	**DEVELOPMENTAL BIOLOGY&GENOMICS AND BIOINFORMATICS**	**L**	**T**	**P**	**C**
			-	-	

Course Objectives	• Name, describe and order the main stages of development common to most multicellular organisms. • Describe the main anatomical changes that occur during development • To gain knowledge on various techniques, algorithms and tools employed in DNA sequencing, assembly and its applications in Next Generation Sequencing. • Describe about the various techniques, algorithms and tools used for Phylogenetic Analysis
Course Outcomes	After completing this course, student is expected to learn the following: CO1: Be able to discuss the critical contributions of the sperm and the egg to the zygote, and how structure informs function CO2: To get exposed to various tools and methodologies used in multiple sequence alignment, phylogenetic analysis and genetic diversity analysis observed in biological sequences CO3: To gain knowledge about various Biological databases that provide information about nucleic acids and protein. CO4:skilled to perform the mounting of different organs,

LIST OF PRACTICALS

1. Observation of gonads in fish.
2. Mounting of live sperms and eggs of fish / crustaceans.
3. Induced ovulation in fish.
4. Temporary mounting of chick blastoderm.
5 Developmental stages of shrimp and Artemia.
6. Isolation of metagenomic DNA from sediments / seawater.

7. PCR amplification and sequencing of 16S rRNA gene.
8. Expression of haemolysin gene from aquatic bacterial pathogens.
9. BLAST analysis.
10. Multiple sequence alignment by Clustal X analysis.
11. Construction of phylogenetic tree by different methods.
12. SWISS PROT analysis, Conserved domain analysis, MOTIFS and Waterman algorithm

CORE PAPER 7 IMMUNOLOGY

Semester	**II Semester**		
Course Type	**Core Compulsory Paper – 7**		
Title of the Course	**IMMUNOLOGY**		
Course Code			
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	IMMUNOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**
Course Prerequisites: The student should have a basic knowledge on immunology			

CODE:	IMMUNOLOGY	L	T	P	C
		4	-	-	4
Course Objectives	To provide knowledge on immunity system and fish immunology To understand the mechanism of antigen antibody reaction				
Module 1	Innate and Acquired Immunity:			12 hours	
Phlogeny and Ontogeny of immune system - organization and structure of lymphoid organs. Cells of the immune system and their differentiation - Lymphocyte traffic - Nature of immune response. Nature of Antigens: Antigenicity and immunogenicity - Factors influencing immunogenicity - Epitopes and haptens - Superantigens - Structure and Functions of Antibodies - Classes and subclasses - Gross and fine structure - Antibody mediated effector functions - Antigen- Ab interactions *in vitro* and *in vivo*.					
Module 2	COMPLEMENT SYSTEM			12 hours	
Components, control proteins and activation pathways, Major Histocompatibility Complex in mouse and HLA system in human MHC haplotypes - class I and class II molecules - cellular distribution - peptide binding - expression and diversity - disease susceptibility and MHC/HLA organization and expression of Ig genes - Models for Ig gene structure - multigene organization of Ig genes - DNA rearrangements and mechanisms - Generation of antibody diversity - Differential expression of Ig genes. .					
Module 3	T CELL ACTIVATION AND DIFFERENTIATION			12 hours	
- Isolation, molecular components and structure of T-cell receptor complex - T-cell maturation and thymus - TH- cell activation mechanism - T- cell differentiation - Cell death and T- cell population - B- cell generation, activation and differentiation - B-cell receptors - Selection of immature self-reactive B-cells - B-cell activation and proliferation - TH- B- Cell interactions .					
Module 4	CYTOKINES			12 hours	

Definition and salient functional features - Cytokine receptors - Cytokines and immune response - Cell-mediated effector functions - Cell adhesion molecules - Effectors cells and molecules - CTL and NK cells-mechanism of action - Immunological tolerance and Anti-immunity - Delayed type hypersensitivity - Hypersensitivity: Types and immunological reactions and immune response to infection agents especially intracellular parasites		
Module 5	**SHELL AND FIN FISH IMMUNOLOGY**	**12 hours**
Overview of Fish and Crustacean immune system; Types of Immunity: Innate, adaptive, cell mediated and humoral immunity; Cell and organ involved immune system. Immune regulation in fish: Major Histocompatibility Complex (MHC), Cytokines, Antigen-Antibody recognition by B and T Cells. Crustacean defense mechanism: Toll Like Receptors (TRL) and Pattern Recognition Receptors (PRRs), Prophenol Oxidase system, Phagocytosis, Coagulation and antimicrobial peptides, Lysozyme activity and superoxide anion.		
ReferenceBooks	1. Chakravarthy, A.K., 1996, Immunology, Tata Mc Graw Hill Publishing Co. Ltd.,New Delhi. 2. Roitt, I.M., 2000, Essential Immunology, Blackwell Scientific Publishers. 3. Kuby, J., 1999, Immunology, W.H. Freeman and Company, New York. 4. Paul, 1999, Fundamental Immunology, 4th Edition, Lippencott Raven 5 Abas, Lichtman and Pobler, 1997, Cellular and Molecular Immunology, W.B. Saunders Company.	

Course Outcomes (CO): After completion of the course, a student will be able to achieve these outcomes

Course outcome (CO)	Description	Cognitive
CO1	Students gain knowledge about immune system and ttypes of immunity.They study about the components of immune system and their functions	K1,K2,K3
CO2	Understanding And knowledge on complement system and organization and expression of Ig genes	K2,K3
CO3	Ggain knowledge about structure, classes and functions of different	K1.K3

	immunoglobulins.They learn about the organization of immunoglobulin genes and about the development and function of T and B lymphocytes.	
CO4	Students gain knowledge about the interdependence of cell mediated and humoral immunity.They understand about the importance of Major Histocompatability complex and its classes.Also gain knowledge about Hypersensitivity and Autoimmunity.	K1,K2,K3,K5
CO5	Understandig on shell and fin fish immunology .	K2,k3.

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	M	H	M	M	H	M	H	M	M	M	M	M	M	L
CO2	H	H	H	M	H	M	M	H	H	L	M	L	L	M	M
CO3	H	H	M	M	H	M	M	M	M	M	L	M	M	M	M
CO4	H	M	H	M	H	L	M	M	M	M	L	L	L	L	M
CO5	H	M	H	M	H	H	M	M	M	M	L	M	M	L	M

CORE PAPER 8. MARINE BIOMATERIALS

Semester	**III Semester**
Course Type	**Core Compulsory Paper – 8**
Title of the Course	**MARINE BIOMATERIALS**
Course Code	

<table>
<tr><td colspan="2">Teaching Hours</td><td colspan="5">60 Hours/ Semester : 4 Hours/ week</td></tr>
<tr><td></td><td colspan="2">MARINE BIOMATERIALS</td><td colspan="2">Credits: 4</td><td colspan="2">Max. Marks: 100 (Internal: 25, External 75)</td></tr>
<tr><td colspan="7">Course Prerequisites:
The student should have a basic knowledge on Microbiology ,marine biotechnology and nanotechnology</td></tr>
<tr><td rowspan="2">CODE:</td><td colspan="2" rowspan="2">MARINE BIOMATERIALS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>4</td><td>-</td><td>-</td><td>4</td></tr>
<tr><td>Course Objectives</td><td colspan="6">• The diversity of marine natural products, their properties and applications are discussed thoroughly
• Marine biomaterials discovery and development ranging from coralline bone graft to polysaccharide-based biomaterials,chitin and chitosan, marine-derived collagen, and composites of different organisms of marine origin.
• To get an idea about the important applications of marine biomaterials include medical applications, antimicrobial agents, drug delivery agents, anticoagulants, rehabilitation of diseases such as cardiovascular diseases, bone diseases and diabetes, as well as comestible, cosmetic and industrial applications.</td></tr>
<tr><td>Module 1</td><td colspan="5">Introduction</td><td>12 hours</td></tr>
<tr><td colspan="7">Classification, Chemistry and characterization of biomaterials. The state of the art of biomaterials and the challenges. Synthesis of bio-materials, Characterization of Nanoparticles for physical, mechanical properties, visco elasticity, end group analysis by using ultraviolet-visible spectroscopy, Fourier Transform Infrared spectroscopy, transmission electron microscopy, X-ray diffraction, scanning electron microscopy, and energy-dispersive X-ray spectroscopy</td></tr>
<tr><td>Module 2</td><td colspan="5">Biocompatability</td><td>12 hours</td></tr>
<tr><td colspan="7">Biocompatibility of bio-materials-Discovery and development of marine biomaterials - Marine nanopharmaceuticals for drug delivery and targeting- -Marine derived biomaterials for bone regeneration and tissue engineering-Biological Activity of Marine Biomaterials.</td></tr>
<tr><td>Module 3</td><td colspan="5">Modified Biomaterials</td><td>12 hours</td></tr>
</table>

Biosynthesis of nanoparticles Ag, Au, Ru, Fe_2O_3, Cobalt (III) Oxide (Co_2O_3), ZnO and AgCl by marine organisms. Biodegradative biomaterials, Bioactive polymers and biosynthetic polymers, inert biomaterials, genetically engineered biomaterials- Biomedical applications of nanocomposites; Applications of nanoparticles in drug delivery. .		
Module 4	**Application of Biomaterials**	**12 hours**
: Biomaterials from Sponges, Ascidians and Other Marine Organisms-Biological materials of marine origin invertebrates. Biosilica, silicate, marine sponge collagen, Chitin from Marine sponges and its applications. Biomaterials from Cnidarians such as sea anemones, corals, sea pens. Coral-derived hydroxyapatite, Mussel adhesive proteins and its applications, Mutable collagenous tissue from echinoderms, sea urchin spines as highly ordered nanoparticles for the design of elastic concrete materials. Cellulose nanocrystals from tunicates and its applications. Biomineralisation of Coccolithophores, dinoflagellates and diatoms and its role in bone repair.		
Module 5	**Marine Biomaterials-Characterization, Isolation and Applications**	**12 hours**
: Isolation and characterization of marine biomaterials—bioceramics, biopolymers, fatty acids, toxins and pigments, nanoparticles, and adhesive materials. Biological activities of marine biomaterials, including polysaccharides, biotoxins, and peptides. Health benefits of the biomaterials, such as antiviral activity, antidiabetic properties, anticoagulant and anti-allergic effects. Commercialization of marine-derived biomaterials—marine polysaccharides and marine enzymes—and examines industry perspectives and applications. marine biomaterials for biological and biomedical applications. Isolation of novel materials from marine sources..		
ReferenceBooks	1. Nanomaterials Chemistry by C.N. Rao, A. Muller, A.K. Cheetham, Wiley VCH, 2007. 2. Nanoscale Materials in Chemistry by Kenneth J. Klabunde, Wiley Interscience Publications, 2001. 3. Nanochemistry by G.B. Sergeev, Elseiver Publication, 2006. 4. Nanomaterials – Handbook by Yury Gogotsi, CRC Press, Taylor & Francis group, 2006.	

	5. Biomaterials: A Nano Approach, Seeram Ramakrishna, Murugan Ramalingam, T.S. Sampath Kumar, Winston O. Soboyejo, CRC Press, 2010. 6. Bionanotechnology: Lessons from Nature, David S. Goodsell, by John Wiley & Sons, Inc., 2004. 7. Nanobiotechnology: Concepts, Applications and Perspectives, Eds. Christof M. Niemeyer and Chand A. Mirkin, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004.

Course Outcomes (CO): After completion of the course, a student will be able to achieve these outcomes

Course outcome (CO)	Description	Cognitive
CO1	The basic knowledge about the diversity of marine natural products, their properties,chemistry,synthesis and applications	K1,K2,K3
CO2	Understanding the fact that Marine biomaterials as an alternative to mammal sources (*e.g.*, collagens) and benefiting from their biological properties, such as biocompatibility, low antigenicity, biodegradability, among others.	K2,K3
CO3	Knowledge on Biosynthesis of marine materials and its applications in various fields	K1.K3
CO4	Knowledge and skill in the isolation of bioactive marine materials from marine invertebrates; especially from the main phyla of marine invertebrates explored so far, including sponges, cnidarians, molluscs, echinoderms and ascidians,	K1,K2,K3,K5
CO5	Developing marine bio materials and commercializing novel adhesives	K2,k3.K5,k6

	and coatings for the medical and industrial markets .	

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	M	H	M	M	H	M	H	M	M	M	M	M	M	M
CO2	H	H	H	M	H	M	M	H	H	L	M	L	L	M	M
CO3	H	H	M	M	H	M	M	M	M	M	L	M	M	M	M
CO4	H	M	H	M	H	L	M	M	M	M	L	L	L	L	M
CO5	H	M	H	M	H	H	M	M	M	M	L	M	M	L	M

PRCTICAL COVERING CORE PAPER 7 AND 8

Semester	**III Semester**		
Course Type	**Practical VI**		
Title of the Course	**IMMUNOLOGY AND MARINE BIOMATERIALS**		
Course Code			
Teaching Hours			
	IMMUNOLOGY AND MARINE BIOMATERIALS	**Credits: 4**	**Max. Marks:**

Course Prerequisites: The students should have a basic understanding of Microbiology,Biochemistry,Molecular biology, nanotechnology.lab works in immunology and also understanding about isolation,processing and production of Marine biomaterials					
CODE:	**IMMUNOLOGY AND MARINE BIOMATERIALS**	**L**	**T**	**P**	**C**
			-	**-**	
Course Objectives	• To provide students with a foundation in immunological processes , be able to distinguish and characterize antibody isotypes, • Knowledge on ELISA assays with visual readouts makes students more quantitative.				
Course Outcomes	After completing this course, student is expected to learn the following: CO1: The students will be able to describe the roles of the immune system in both maintaining health and contributing to disease. - CO2: Identify blood groups and types, Competently perform serological diagnostic tests CO3: Understanding, in the production of Silver nanoparticles CO4: Knowledge on the isolation and production of Marine bioactive biomaterials and its applications as antimicrobial agents, drug delivery agents, anticoagulants, etc				
	LIST OF PRACTICALS 1. Identification of lymphoid organs and cells. 2. Preparation of serum, plasma and antigens. 3. Antigen – antibody reaction – precipitation – ODD / SRID/CID 4. Antigen – antibody reaction – Agglutination – blood grouping / active / passive agglutination 5. Cell viability / cytotoxicity assay 6. Enzyme linked immunosorbant assay – demonstration 7. Prophenol Oxidase activity				

	8. Immune gene expression 9. Lysozyme activity by Intra agar assay 10. Biosynthesis of silver nanoparticles from marine sediment-derived bacteria. 11. Characterization of silver nanoparticles by UV-Vis spectroscopyIsolation of collagen from marine sponges 12. Isolation of chitin from marine invertebrates 13. Bioadhesives: Isolation and purification of adhesive proteins from mussels 14. Adhesion properties of Mussel glue on glass surface adhesion. 15. Isolation of nanocrystalline cellulose from tunicates 16. Microscopic studies of the calcitic spines in sea urchin

ELECTIVE PAPER

Elective Paper – 2a Marine Natural Products

Semester	**II Semester**
Course Type	**Elective Paper – 2a**
Title of the Course	**MARINE NATURAL PRODUCTS**
Course Code	

Teaching Hours	**45 Hours/ Semester : 4 Hours/ week**				
	MARINE NATURAL PRODUCTS	**Credits: 3**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: The student should have a more skill and knowledge in biology and chemistry					
CODE:	**MARINE NATURALPRODUCTS**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	A broad knowledge of several classes of secondary metabolites (commonly known as Natural Products) produced by marine macro- and microorganisms as well as their potential applications in pharmaceutical, cosmeceutical and food industries. An opportunity to learn the methods of extraction, purification and structure elucidation as well as some bioassays to evaluate some biological activities of marine natural products..				
Module 1	**Introduction**				**9 hours**
Survey, resource assessment, sampling and identification of organisms containing bioactive compounds					
Module 2	**ISOLAATION OF BIOACTIVE COMPOUNDS**				**9 hours**
Important products isolated from marine organisms and their uses: marine colloids and hydrocolloids, agarose, agar, alginates, carrageenans, chitin, chitosons and glucosamines- their extraction process, methods purifications, uses and importance.					
Module 3	**MARINE METABOLITES**				**9 hours**
Marine enzymes and lipids, marine flavourants, lectins, heparin and carotene – their extraction process, methods of purification, structural elucidation, uses and importance.					
Module 4	**MARINE BY PRODUCTS**				**9hours**

Other by-products from marine organisms: Fish meal, Silage products, FPC, fish hydrolysate, fish flakes, fish glue, pearl essence, fish peptones- their production process and importance.		
Module 5	**PHARMACEUTICALLY IMPORTANT PRODUCTS**	**9 hours**
Pharmaceutically important products from marine organisms: pharmaceutical surfactants, antimicrobial compounds, hormone like materials, nutraceuticals, B-carotene PUFA products, vitamins, immunomodulators, anticancer and cytotoxic compounds..		
ReferenceBooks	1.Gulland, J.A., 1971, Fish Resources of the Ocean, Fishing News (Books) Ltd., England, 1971. 2.Mary Francis Thomson (ED.) Rachakohda, Marine Biodeterioration, Oxford & IBM Publishing Co. Pvt., New Delhi. 3.Jefford, Rinehart, Sheld, 1988, Pharmaceuitcals and the Sea,. Technomic Publishing Co., AG Pensylvana, USA. 4.Winton, A.L., Winton, B., 1997, Fish and Fish Products, Allied Scientific Publishers, Vyas Nagar, Bilkaner. . 5.Fishery by products, CIFT Manual, 2000, CIFT publications, Cochin, India. 6.Bhakuni, D.S., and Rawat, D.S., (Eds.), 2005, Bioactive Marine Natural Products, Springer, Anamya Publications, New Delhi.	

Course Outcomes (CO): After completion of the course, a student will be able to achieve these outcomes

Course outcome (CO)	Description	Cognitive
CO1	The basic knowledge about the diversity of marine natural products, their properties,chemistry,synthesis and applications	K1,K2,K3
CO2	Understanding on the isolation of Marine bioactive compunds	K2,K3
CO3	Knowledge on extraction,purification,structural elucidation of marine	K1.K3

	metabolites	
CO4	Knowledge and skill in the isolation of Fish meal, Silage products, FPC, fish hydrolysate, fish flakes, fish glue, pearl essence, fish peptones- their production process and importance.	K1,K2,K3,K5
CO5	Developing marine bioproducts and their potential applications in pharmaceutical, cosmeceutical and food industries. .	K2.K3K5K6

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

	PO1	**PO2**	**PPO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	H	H	H	M	H	H	H	M	M	M	L	H	M	M
CO2	H	H	H	H	L	H	H	H	M	L	M	L	H	L	M
CO3	H	H	H	H	M	H	M	M	M	M	L	M	M	L	L
CO4	H	H	H	H	M	H	M	M	M	M	M	M	M	L	M
CO5	H	M	H	H	M	H	H	M	ML	M	M	M	M	L	M

ELECTIVE PAPER 2b: BIOSAFEY, BIOETHICS & IPR

Semester	**II Semester**		
Course Type	**Core Elective Paper –2b**		
Title of the Course	**BIOSAFEY, BIOETHICS & IPR**		
Course Code			
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**		
	BIOSAFEY, BIOETHICS & IPR	**Credits: 3**	**Max. Marks: 100 (Internal: 25, External 75)**

Course Prerequisites: Students should have a knowledge on biological regulations					
CODE:	**BIOSAFEY, BIOETHICS & IPR**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives					
Module 1	**Introduction to Bio-safety and Regulations**				**9 hours**
Bio-safety regulations and definitions, national and international guidelines, rDNA guidelines. Experimental protocol approvals, levels of containment, environmental aspects of biotech applications, degradation of pollutants, Bacterial mining- vaccines- Biological pesticides, use of genetically modified organisms and their release in environment.					
Module 2	**Bioethics**				**9 hours**
Bioethics: Definition- ethics- norms in India- Licensing of animal house- norms for conducting studies on human and animal subjects- Ethical clearance, ELSI. Bioethics for cosmetics and nano materials development-environmental safety and impact of toxicity- social and ethical issues of nanoparticles- toxicity related to animal models					
Module 3	**IPR – Introduction & Registration**				**9 hours**
Introduction to IPRs, Basic concepts and need for Intellectual Property - Patents, Copyrights, Geographical Indications, IPR in India and Abroad – Genesis and Development – the way from WTO to WIPO –TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations – Important examples of IPR. Meaning and practical aspects of registration of Copy Rights, Trademarks, Patents, Geographical Indications, Trade Secrets and Industrial Design registration in India and Abroad.					
Module 4	**IPR – Agreements, Legislations, Digital Products and Law**				**9 hours**

International Treaties and Conventions on IPRs, TRIPS Agreement, PCT Agreement, Patent Act of India, Patent Amendment Act, Design Act, Trademark Act, Geographical Indication Act. Digital Innovations and Developments as Knowledge Assets – IP Laws, Cyber Law and Digital Content Protection – Unfair Competition – Meaning and Relationship between Unfair Competition and IP Laws – Case Studies. Infringement of IPRs, Enforcement Measures, Emerging issues – Case Studies.		
Module 5	**Enforcement of IPRs and Patents**	**9 hours**
Infringement of IPRs, Enforcement Measures, Emerging issues – Case Studies. Definition of patents- conditions for patent ability: Novelty testing- composition of patent - patenting of biotechnological discoveries - commercialization- Biotech companies - Natures implications- screening and selection of genetic materials for patenting- Public attitude - Genetic counselling.		
ReferenceBooks	1. Cartagena Protocol on Biosafety, 2006, Ministry of Environment and Forest, Government of India, New Delhi 2. Gopalakrishnan, N.S., and Agitha, T.G., 2014, Principles of Intellectual Property, 2nd Edition, Eastern Book Company, Lucknow. 3. Kshitij Kumar Singh, Springer, 2015, Biotechnology and Intellectual Property Mittal, D.P., 1999, Rights: Legal and Social Implications, Indian Patents Law, as amended by Patents (Amendment) Act 1999, Taxman Publication. 4. Laboratory Biosafety Manual, 2004, 3rd Edition, World Health Organization, Geneva. 5. Narayanan, P., 2021, Intellectual Property Law, 3rd Edition, Eastern Law Book House Ltd. 6. Sasson, A., 1988, Biotechnologies and Development, UNESCO Publications. 7. Sasson, A., 1993, Biotechnologies in Developing Countries: Present and Future, UNESCO Publications. 8. Singh, K., Intellectual Property Rights on Biotechnology, BCIL, New Delhi. 9. Wadera, B.L., 2010, Law relating to Patents Trade Marks Copyright Designs and Geographical Indications, Delhi University Law Publishing.	

After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
CO1: Remember the basic knowledge on biosafety, national and international guidelines and regulations for biosafety. Gain knowledge on organization rDNA guidelines, approval of protocols, Analyze the benefits of degradation of pollutants, bacterial mining, vaccines and biological pesticides. Evaluate the use of environmental aspects of biotech applications, and genetically modified organisms and their release in environment	K1, K2, K3
CO2: Remember the definition of ethics, Gain knowledge on ethical clearance, ELSI (Ethical, Legal and Social Implications, Comprehend the application of ethical principles in India, Analyze the norms of bioethics in India, Acquire knowledge on licensing of animal house and norms for conducting studies on human and animal subjects – regarding ethical clearance	K1, K2, K3
CO3: Understand and remember concepts of IPR, copyrights etc	K1, K2, K3
CO4: Remember the IPRs, Treaties, TRIPS agreement and laws	K1, K2, K3
CO5: Acquire knowledge on obtaining Indian patent and international patents	K1, K2, K3

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

	PO1	**PO2**	**PPO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**

CO1	M	H	L	L	L	M	L	L	L	L	L	L	M	L	L
CO2	L	M	L	L	L	1	L	L	L	L	M	L	M	L	L
CO3	M	M	L	L	L	H	M	M	M	L	L	L	M	L	L
CO4	L	L	M	M	M	H	L	M	L	L	L	L	M	L	L
CO5	L	L	L	L	L	L	L	L	L	L	M	M	M	M	M

CORE PAPER 9 GENETICS

Semester	**II Semester**		
Course Type	**Core Compulsory Paper - 9**		
Title of the Course	**GENETICS**		
Course Code			
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	GENETICS	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**

Course Prerequisites: The student should have a basic knowledge on molecular biology, immunology and genetics					
CODE:	**GENETICS**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	• To understand the principle concept of Genetics • To extend the knowledge on molecular basis of mutation at microbial level • To focus on gene regulation and expression mechanisms • To understand the principles role of plasmids and gene transfer methods				
Module 1	**BASIC CONCEPTS OF GENETICS**				**12 hours**
Mendelian principles: Dominance, segregation, independent assortment. Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests. Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters..					
Module 2	**GENE MAPPING**				**12 hours**
Gene Mapping Methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, DNA foot printing. Extra chromosomal inheritance: Inheritance of Mitochondrial genes, maternal inheritance. Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders - Human Genome Project. Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.					
Module 3	**MUTATION AND RECOMBINATION**				**12 hours**
Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications. Recombination: Homologous and non-homologous recombination including transposition					
Module 4	**MOLECULAR GENETICS**				**12 hours**

Molecular Genetics: Structure of gene – genetic code – gene regulation – genome analysis – functional genomics – RNA processing – Transcription: factors and regulation – Translation: control and regulation. Molecular population genetics: Patterns of change in nucleotide and amino acid sequences		
Module 5	**HUMAN GENETICS**	
Genes in pedigree – Human genetic diseases. Down's Syndromes, klinefelter's syndrome, turner's syndrome, patau's and Edward's syndrome – Human genome project – Euthernics – Eugenics – euphenics – Genetic Counselling, Significance of twin study – gene therapy and prenatal diagnosis (Amniocentesis)..		
ReferenceBooks	1. Old R.N and Primrose, S.B., 1994. Principles of Gene Manipulation, Blackwell Scientific Publications. 2. Brown, T.A., 1995. Gene Cloning – An introduction, chapman & Hall. 3. Rehn, H.J and Red, G., 2000. Biotechnology, Wiley VCH, 606. 4. Chirikjian, J.G., 1995. Genetic Engineering. Mutagenesis Separation Technology, vol. II, Jones and Bartlett. 5. Brooker: Genetics: Analysis and Principles 6. Gardner et al: Principles of Genetics 7. Griffith et al: Modern Genetic Analysis 8. Hartl & Jones: Essential Genetics: A Genomic Perspective 9. Lewin, Genes 10. Russell: Genetics 11. Snustad & Simmons: Principles of Genetics	

After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
CO1: Students will be taught Mendelian genetics, their principles and gene interaction. • They learn about chromosomal aberrations and structure of chromosomes • The student will gain a basic understanding on human genetics and hereditary.	K1, K2, K3
CO2: Understanding of gene mapping, extrachromosomal	K1, K2, K3

inheritance ,human genome project	
CO3: concepts and genetic code, gene expression, gene regulation and also learn about mutation Comprehensive and detailed understanding of genetic methodology and how quantification of heritable traits in families and populations provides insight into cellular and molecular mechanisms	K2, K3
CO4: Got an idea of genes at molecular level • They learn about DNA, RNA and their replication, mutations, DNA repair mechanism	K2, K3, K4, K5
CO5: understanding genetics and relate modern DNA technology for disease diagnostics and therapy	K2, K3, K4, K5

Mapping with PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PO14**	**PO15**
CO1	H	H	H	H	H	H	L	H	H	H	L	L	H	L	L
CO2	H	H	H	H	L	H	L	H	M	M	L	L	H	L	L
CO3	H	M	H	H	L	H	M	M	M	L	L	L	H	L	L
CO4	H	L	H	H	H	H	M	M	H	L	M	M	M	L	M
CO5	H	L	H	H	M	H	H	M	M	M	M	M	H	L	M

CORE PAPER 10 AQUACULTURE BIOTECHNOLOGY

Semester	**III Semester**
Course Type	**Core Compulsory Paper - 10**
Title of the Course	**AQUACULTURE BIOTECHNOLOGY**

Course Code			
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**		
	AQUACULTURE BIOTECHNOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**

Course Prerequisites:
The student should have a basic knowledge on aquaculture

CODE:	**AQUACULTURE BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**

Course Objectives	• To get an idea about the pond construction and management for aquaculture, different types of aquaculture system • To get an idea for finfish and shell fish culture • To acquire knowledge on moulting, hypophysation and spawning • To get an idea about the live feed culture

Module 1	**Introduction**	**12 hours**

Purpose and importance of aquaculture; basic qualification for candidate species; cultivable fresh water and marine fishes; Global and Indian scenario of aquaculture, Construction of ponds: Site selection – Soil and water types – types of ponds. Preparation and management. Aquatic plants and their control; control of predatory insects; Fish enemies and their control. Liming, fertilization of ponds.

Module 2	**Types of Aquaculture**	**12 hours**

Extensive, semi intensive, intensive, super intensive; monoculture, mono sexculture, polyculture, integrated fish farming; animal husbandry cum aquaculture, agriculture cum aquaculture, pen and cage culture of fish, prawns.

Module 3	**Finfish and Shellfish Culture**	**12 hours**

Finfish culture: Culture of Indian major carps, tilapia, murrel, mullets, milkfish, trout culture, seaweed culture, sewage fed fish culture, shell fish culture. Culture of freshwater and marine prawns, lobsters, crabs, edible and pearl oysters.

Module 4	**Molting**	**12 hours**

Growth stimulating hormone (GSH) from y-organ growth increase in crustaceans by moulting – Moulting inhibiting hormone (MIH) secreted X- organ – Sinus gland complex – Vitellogensis and reproduction : enhanced by Gonad stimulating hormone (GSH) controlled by thoracic ganglion, gonad / Vitellogenesis inhibiting hormone from X-organ – Eyestalk ablation for moulting and induced maturation in crustaceans – Hypophysation : Pituitary extracts injection – induced maturation and spawning in teleost – Hatchery, nursery and broodstock management.		
Module 5	**Live Feed Culture**	
Culture of microalgae – Laboratory culture, maintenance of pure culture, mass culture, Artemia culture – Collection of cysts, decapsulation and hatching of cysts, significance of naupliar size in feeding larvae of cultivable species.		
ReferenceBooks	1. Aquaculture –Principles and Practices, 1990 – TVR Pillay, Fishing Nets Boooks. 2. Aquaculture Biotechnology, First edition, 2012, Eds. Garth L. Fletcher and Mathew L Rise, Wiley-Blackwell publication 3. Aquaculture Biotechnology, V. Ramachandran, 2013, Black Prints 4. Marine Biology – An ecological approach, 1988 – James W. Nybken, Harper Collins publication. 5. The Marine and freshwater fishes of Ceylon, 1982 – lan, S.R. Munro, Soni Reprints Agency. 6. Fish and fisheries of India, 1991 – V.J. Jhingran, Hindustan Publishing Corporation.	

After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
CO1: Understand how to construct the aquaculture pond and its maintenance and the aquaculture fishes both fresh water and marine	K1, K2, K3
CO2: Acquire knowledge on the different kinds of culture for fin and shell fishes	K1, K2, K3
CO3: Get an idea about the fin fish and shell fish culture with examples	K2, K3
CO4: Got an idea and skill on the role of hormones in eyestalk ablation, hypophysation and molting	K2, K3, K4, K5

CO5: Got an idea and skill on the laboratory culture, maintenance and collection of live feed culture	K2, K3, K4, K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	M	H	H	H	H	M	L	H	M	M	M	M	L	H
CO2	H	M	H	H	H	H	L	L	M	L	M	M	L	L	H
CO3	H	M	H	H	H	H	M	M	M	M	H	M	L	L	H
CO4	H	M	H	H	H	H	M	M	H	M	H	M	M	L	M
CO5	H	M	H	H	M	H	H	M	H	M	M	M	M	L	M

PRACTICAL COVERING CORE PAPER 9 AND 10

Semester	**II Semester**				
Course Type	**Practical V**				
Title of the Course	**GENETICS AND AQUACULTURE BIOTECHNOLOGY**				
Course Code					
Teaching Hours					
	GENETICS AND AQUACULTURE BIOTECHNOLOGY	**Credits: 4**	**Max. Marks: 100**		
Course Prerequisites: Basic understanding on principles and concepts of genetics, knowledge on marine aquaculture and genetics					
CODE:	**GENETICS AND AQUACULTURE BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
			-	**-**	

Course Objectives	• Students gain knowledge about the fundamentals of population genetics.. • They learn how phenotypes are observed based on the genotypes of the organisms • Blood grouping • knowledge necessary for professional or academic work in the field of aquaculture and fisheries like biology, physiology, health, reproduction, nutrition, behavior, and genetics..
Course Outcomes	After completing this course, student is expected to learn the following: CO1: Students are able to understand the basic principles of inheritance biology. CO2: Demonstrate the basic technical skills necessary for work in aquaculture and fisheries like system design, scientific method, data collection and analysis). CO3: understanding on the culture and identification of microalgae and fish.
	1. Analysis of simple Mendelian inheritance in a small population. 2. Breeding experiments to be demonstrated with the help of colour beads – Monohybrid cross (using chi-square test). 3. Breeding experiments to be demonstrated with the help of colour beads – Dihybrid cross (using chi-square test). 4. Estimation of gene and genotype frequencies in the light of Hardy-Weinberg law based on facial traits. 5. Estimation of gene and genotype frequencies in the light of Hardy – Weinberg law based on ABO blood groups. 6. Random genetic drift – using colour beads. 7. Analysis of dermatoglyphic patterns. 8. Charts, models and flash cards pertaining to theory syllabus a) DNA replication b)Karyotyping c)Operon concept c)Transposable elements. D)Syndrome e)Inborn errors of metabolism. F) Sex-linked inheritance 1. Eyestalk ablation technique in crustanceans. 2. Moulting stages in crustaceans. 3. Culture of microalgae. 4. Collection and identification of shrimp / fish seed from estuary.

	5. Live feed – Artemia culture. 6. Cryopreservation of crustacean naulii and eggs.

CORE PAPER 11 ENVIRONMENTAL BIOTECHNOLOGY

Semester	**III Semester**				
Course Type	**Core Paper**				
Title of the Course	**ENVIRONMENTAL BIOTECHNOLOGY**				
Course Code					
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**				
	ENVIRONMENTAL BIOTECHNOLOGY	**Credits: 4**	**Max. Marks: 100 (Internal: 25, External 75)**		
Course Prerequisites: The student should have a basic knowledge on environment and its impact on marine organisms					
CODE:	**ENVIRONMENTAL BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	• This course will discuss principles and applications of classical and modern day systematic to classification of living organisms, develop understanding of historical and contemporary patterns of distributions of organisms, • the basic understanding of ecosystem and its structural and functional aspects. It will explore the interconnectedness among all the biotic and abiotic components of environment and the dynamic nature of the ecological processes in maintaining equilibrium in nature and design effective				

	conservation strategies using biogeographic theories in an era of global change and large scale human induced degradation..	
Module 1	**THE ENVIRONMENT**	**12 hours**
Physical environment; biotic environment; biotic and abiotic interactions. Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.		
Module 2	**COMMUNITY ECOLOGY**	**12 hours**
Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax. Ecology of Ecosystem: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition..		
Module 3	**ENVIRONMENTAL POLLUTION**	**12 hours**
Environmental pollution and Bioremediation; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Conservation Biology: Principles of conservation, major approaches to management. Conservation and management of endangered species in marine ecosystem using biotechnological tools – germplasm conservation, cryopreservation – wild life conservation and management		
Module 4	**WATER POLLUTION AND ITS CONTROL**	**12 hours**
Water as a scarce natural resource, needs for water management, measurement of water pollution, sources of water pollution, waste water collection, waste water treatment – physical, chemical and biological treatment processes. Microbiology of waste water treatments, aerobic process: Activate sludge, oxidation ditches, trickling filters, towers, rotating discs, rotating drums, oxidation ponds – Aerobic processes: Anaerobic digestion, anaerobic filters, upflow anaerobic sludge, blanket reactors.		
Module 5	**MICROBIAL DEGRADATION**	**12 hours**

Microbiology of Degradation: Xenobiotics in environment – Ecological consideration, decay behaviour and degradative plasmids; hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides – Bioremediation – factors affecting bioremediation. .	
ReferenceBooks	1. Asthana D.K. & Meera Asthana, 1998, Environment: Problems and Solutions, S. Chand & Co., New Delhi. 2. Davis, B.D., Dulbecco, R., Eisen, H.N and Ginsberg. H.S., 1992, Microbiology, Harper and Row Publishers, Singapore. 3. Maier, R.M. Pepper, I.L and Gerba, C.P., 2000, Environmental Microbiology, Academic Press. 4. Eugene Odum, Murray Barrick, Gary W. Barrett, 2005, Fundamentals of Ecology, Brooks / cole 5. Geroge Tchobanoglous, Franklin L. Burton (ed.) & H. David Stensel, 2002, Comprehensive Biotechnology, M.Moo-Young (Ed-inchief), Pergamon Press, Oxford. 6. Hans-Joachim Jordening Josef Winter, 2005, Environmental Biotechnology: Concepts and Applications, Wiley-VCH Verlag GmbH & Co.KGaA 7. Pradipta Kumar and Mohapatra, 2007, Textbook of Environmental Biotechnology, 1st Edition, I.K. International Publishing House. Sharma, P.D., 2005, Ecology and Environment, Rastogi Publications

Course Outcomes (CO): After completion of the course, a student will be able to achieve these outcomes

Course outcome (CO)	Description	Cognitive
CO1	The basic knowledge about the natural ecosystem and role of microorganisms in the eco system, To understand and recall the basic concepts of ecology, environment and bioremediation	K1,K2
CO2	To explain the structure of various components of the environment,To understand about Ecology of Ecosystem,Knowledge on Indian ecosystem conservation and management	K1 K2

CO3	To understand about pollution and Bioremediation and impact of pollution. To describe and interpret the importance of biodiversity and its conservation in protecting nature treasures for future generation	K1.K3
CO4	Knowledge about different types of microorganism in water causes of water pollution, and methods to analyze the quality of water and treatment for purification of drinking water, hygienic practices to control the water borne diseases. An understanding the role and application of microorganisms to degrade the environmental contaminants. and microbes involved in solid and liquid waste management	K1,K2,K5
CO5	Compile the various biological treatment methods and describe the biodegradation of organic wastes in the waste water, petroleum hydrocarbon and xenobiotics	K2.K5K4K5

K1 – Remember, K2 – Understand, K3 – Application, K4 – Analysis, K5 – Evaluate, K6 – Create

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	M	M	M	M	H	L	M	H	M	M	M	M	L	M
CO2	H	H	M	M	M	M	H	H	H	L	M	L	H	L	M
CO3	H	H	H	H	M	H	H	H	H	M	L	L	M	M	M
CO4	H	M	H	H	H	H	M	H	H	M	L	L	M	L	M
CO5	H	M	M	H	H	H	M	H	M	M	L	M	M	L	M

MAPPING WITH PSO

COs	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	H	M	L	L	M	M

CO2	H	L	L	L	L	L
CO3	H	L	H	L	M	L
CO4	H	M	M	L	M	L
CO5	H	L	L	L	L	L

CORE PAPER 12: BIOPROCESS TECHNOLOGY

Semester	**III Semester**
Course Type	**CORE PAPER**
Title of the Course	**BIOPROCESS TECHNOLOGY**
Course Code	**NMYC34**
Teaching Hours	**60 Hours/ Semester : 4 Hours/ week**

NMYC34	**BIOPROCESS TECHNOLOGY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:

The student should acquire knowledge Understanding,knowledge and skill on applications of microorganisms in solving environmental problems.

CODE: NMYC34	**BIOPROCESS TECHNOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To understand the basic concepts of fermentation like types of fermentation and its optimized conditions, types of bioreactors and their parts & functions ➢ To know about microbes responsible for production of metabolites, its isolation, preservation and maintenance. Their growth conditions and media				

	required including different nutrients necessary for their growth ➢ Enable to understand the methods of downstream processing of metabolites. Immobilization techniques involved in preservation of metabolites ➢ To understand the elementary idea on production and preservation of industrially important food products.	
Unit I	**GENERAL ACCOUNT ON FERMENTATION**	**12 hours**
Types of fermentation – surface, submerged solid state, adhesive, batch, continuous and fed batch – principle of chemostat and thermostat, Bioreactors – types, parts and their functions – optimization conditions, aeration, agitation, foam control process control equipment's.		
Unit II	**ISOLATION, PRESERVATION & MAINTANANCE OF INDUSTRIALLY IMPORTANT MICROBES**	**12 hours**
Isolation, preservation and maintenance of industrial important microorganisms-Microbial growth kinetics and microbial death kinetics- media for industrial fermentation: Source of nutrients, types of media: synthetic and crude media for industrial fermentation: Source of nutrients, types of media; synthetic and crude media; Advantage and disadvantages.		
Unit III	**DOWNSTREAM PROCESSING**	**12 hours**
Introduction, removal of microbial cells and solid matter, foam separation, precipitation, filtration, centrifugation, cell disruption, liquid extraction, chromatography, membrane process. Drying and crystallization, effluent treatment -BOD, COD and disposal of effluents.		
Unit IV	**IMMOBILIZATION TECQNIQUE**	**12 hours**
Whole cell immobilization and their industrial applications, production of chemicals: alcohol (ethanol); acids (citric, acetic and gluconic acids), solvents (glycerol, acetone and butanol), antibiotics (penicillin, streptomycin and tetracycline); amino acids (lysine and glutamic acid); Single Cell Protein.		
Unit V	**INTRODUCTION TO FOOD TECHNOLOGY**	**12 hours**

Elementary idea of canning and packing – sterilization and pasteurization of food products – technology of typical food and food products (bread, cheese & idli) – basic food preservation techniques.	
ReferenceBooks	37. Biochemical Engineering Alba, S., Humphrey, A.E and Millis N.F. Univ. of Tokyo press, Tokyo.1985 38. Introduction to Biochemical engineering, D.G Rao (2nd edn.) Tata McGraw Hill education ltd., New Delhi, 2010. 39. Biochemical Engineering Fundamentals, baily, J.E. and Ollis, DiF., Mc Graw Hill book Co., New York, 2008 40. Bioprocess Technology, Fundamentals and Applications, P. Svenska, KTH, Royal Institute of Technology, Stockholm, 2000. 41. Bioprocess Technology, Anton Moser, Springer-Verlag, Austria, 1988 42. Advances in Bioprocess Technology, Pogaku Ravindra, Springer-Verlag, 2015. 43. Advances in Bioprocess Technology, P.Kartan, Delve Pub. 2017 44. Essentials in Fermentation Technology, A. Berenjian, Springer, 2019.
Web Source:	1 Principles and applications of Fermentation Technology https://www.wiley.com 2. Design and Preparation of media for fermentation https://www.mlsu.ac.in › econtents › 2201_design 3. Fermentation Products http://www.eolss.net

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will beable to –	CognitiveLevel
CO1	Understand about the basic concepts of fermentation	K1, K2

	technology and its types, bioreactors and their types and conditions responsible for fermentation.	
CO2	Know about how to isolate industrially important microbes, their preservation, nutrition and media and their types required for the growth of microbes.	K2, K3
CO3	Find out the suitable downstream processing technique to process the metabolites obtained after fermentation for industrial usage.	K3, K4
CO4	Determine the industrial and pharmaceutical applications of produced products	K5, K6
CO5	Make elementary idea on preservation of produced products in large scale level	K4, K5, K6

K1- Remember; K2- Understand; K3- Apply; K4- Analyze; K5- Evaluate; K6- Create.

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	H	H	M	M	H	M	H	M	M	M	M	M	M	M
CO2	H	H	H	L	H	M	M	H	H	L	M	L	L	M	M
CO3	H	H	M	L	H	M	M	M	M	M	L	M	M	M	M
CO4	H	H	H	M	H	L	M	M	M	M	L	L	L	L	M
CO5	H	H	H	M	H	H	M	M	M	M	L	M	M	L	M

PRACTICAL COVERING CORE PAPER 11 AND 12

ENVIRONMENTAL BIOTECHNOLOGY AND BIO PROCESS TECHNOLOGY

Semester	**III Semester**		
Course Type	**Practical VI**		
Title of the Course	**ENVIRONMENTAL BIOTECHNOLOGY AND BIO PROCESS TECHNOLOGY**		
Course Code			
Teaching Hours			
	ENVIRONMENTAL	**Credits: 4**	**Max. Marks:**

	BIOTECHNOLOGY AND BIO PROCESS TECHNOLOGY		

Course Prerequisites:

The student should have basic Understanding, knowledge and skill on applications of techniques in solving environmental problems,should have an idea about fermentation technology.

CODE:	**ENVIRONMENTAL BIOTECHNOLOGY AND BIO PROCESS TECHNOLOGY**	**L**	**T**	**P**	**C**
			-	**-**	

Course Objectives	• Use of microorganisms to transfer biological material for production of fermented foods has been an essential part of many foods, chemical and pharmaceutical industries**.** • Development programme in the areas relevant to waste management & environmental improvement, development & demonstration of wastewater specific effective bioremediation .
Course Outcomes	After completing this course, student is expected to learn the following: CO1: Understand about the basic concepts of fermentation technology and its types, bioreactors and their types and conditions responsible for fermentation. CO2: Find out the suitable downstream processing technique toprocess the metabolites obtained after fermentation for industrial usage. Determine the industrial and pharmaceutical applications of produced products CO3: Understanding, knowledge ,skill to analyse different physiochemical parameters of environmental samples.
	LIST OF PRACTICALS 1. Estimation of DO, salinity, nitrites, phosphates, calcium and alkalinity in water samples 2. Analysis of industrial effluents – TDS, TSS, BOD, COD 3. Estimation of fish population (any two species) 4. Microbial assessment of air quality 5 Potability test of water Isolation of industrially important microoganisms for microbial processes.

	5. Determination of thermal death point (TDP) and thermal death time (TDP) of microogainsms for design of a sterilizer. 6. Comparative studies of ethanol production using different substrates. 7. Microbial production of citric acid using different substrates. 8. Microbial production of antibiotics (Penicillin) 9. Production and estimation of alkaline protease. 10. Use of alginate for cell immobilization

ELECTIVE PAPER/Ppr-3a: EXTREMOPHILES

Semester	**III Semester**
Course Type	**ELECTIVE PAPER**
Title of the Course	**EXTREMOPHILES**
Course Code	**……..**
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**

……..	**EXTREMOPHILES**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
The student should possess basic knowledge on basic microbiology and its domains. They may have the genomic structure and their organization, their various environments and the important life threatening factors, their uses.

CODE: **……..**	**CELL AND MOLECULAR BIOLOGY**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**

Course Objectives	➢ To give solid foundation about the microbes which require extreme environmental conditions for their optimum and successful life. ➢ To give knowledge on their genome and their application in various field. ➢ To impart skill on these biotechnologically important organisms which do much for human welfare. ➢ To make aware of the existence of useful eukaryotic extremophiles such as *Artemia*, which has multiple applications.	
Module I	**GENERAL INTRODUCTION - ECOLOGICAL CLASSIFICATION AND ADAPTATIONS.**	**9 hours**
Introduction to Extremophiles; General classification of Extremophiles – Acidophiles, Alkaliphiles, Barophiles, Psychrophiles, Endoliths, Halophiles, Thermophiles, Oligotrophs, Toxitolerants, Xerotolerants - Extremophiles and their environments - adaptations of Extremophiles.		
Module II	**MOLECULAR CLASSIFICATION – PHYLOGENY AND GEOME STUDY**	**9 hours**
16s rRNA classification of Extremophiles; phylogeny of Extremophiles; genomes of Extremophiles; comparative genome organization of Extremophiles and mesophiles.		
Module III	**POTENTIALS OF EXTREMOPHILES**	**9 hours**
Potentials of Extremophiles – Extremophiles in food industry; in bioprocess technology; in biotechnology - potentials of Halo bacteria.		
Module IV	**EXTREMOZYMES AND LIGHT HARVESTING PIGMENTS**	**9 hours**
Extremozymes and their applications – Enzymes from acidophiles, psychrophiles, halophiles, acidothermophiles, piezophiles, xerophiles, alkaliphiles, thermophiles. Cloning of Extremozymes – Taq DNA polymerase; extracellular alpha amylase; cytidine deaminase. Light harvesting pigments – Bacteriochlorophylls, Bacteriorhodopsin, Proteorhodopsin, Halorhodopsin.		

Module V	**EUKARYOTIC EXTREMOPHILES AND THEIR APPLICATIONS**	**9 hours**
A eukaryotic Extremophile – *Artemia*; systematic classification of *Artemia franciscana;* its biology. Potentials of *Artemia* - role of *Artemia* in salt purification; *Artemia* as live feed in fin fish and shell fish larviculture; live feed *Artemia* in Zebra fish culture.		
ReferenceBooks	1. Edwards, C. 1990. (Ed) Microbiology of Extreme Environments. McGraw Hill, NewYork. 2. Aharon Oren. 1998. Microbiology and Biogeochemistry of Hypersaline Environments, CRC Press, Boca Raton London, New York, Washington, D.C. 3. Best, J., Adatto, I., Cockington, J., James, A and Lawrence, C. 2010. A novel method for rearing First-Feeding larval Zebrafish: Polyculture with type L saltwater rotifers (*Brachionus plicatilis*) zebra fish. 4. Brock, T.D., Brock, K.M., Belly, R.T and Weiss, R.L. 1992. *Sulfolobus*, a new gene of sulfur oxidizing bacteria living at low pH and high temperature Arch. Microbiol. 84: 54-58. 5. Carvalho, A.P., Araujo, L and Santos, M.M. 2006. Rearing zebrafish (*Danio rerio*) larvae without live food: evaluation of a commercial, a practical and a purified starter diet on larval performance. Aquaculture Research. 6. Lim, L.C., Soh, A., Dhert, P and Sorgeloos, P. 2001. Production and application of on-grown Artemia in freshwater ornamental fish farm. Aqua. Econ. Manag. 5 (3/4), 211-228 7. Lim, L. C., Cho, Y. L., dhert, P., Wong, C. C., Nelis, N and Sorgeloos, P. 2002a. Use of decapsulated Artemia cysts in ornamental fish culture. Aquac. Res. 33: 575-589.	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Acquire knowledge on the existence of microbes at various extreme environments and how do they survive with their adaptations at molecular level.	K1, K2.
CO2	Know about 16s rRNA based classification of extremophiles, their genome and the phylogenetic relationship between extremophiles and mesophiles.	K1, K2
CO3	Know and develop skill on the use of extremophiles in food industry, biotechnology and the multitude applications of halo bacteria.	K3, K4.
CO4	Acquire knowledge on the many uses of extremozymes. Get research mind and skill in using extremozymes in biotechnological studies for human welfare. Understand about the different light harvesting pigments and their	K2, K3, K6

	applications.	
CO5	Know about the eukaryotic extremophiles like *Artemia* and its applications in salt purification and in aquaculture industries as live feed. Get skill in fish culture using *Artemia* as live feed.	K1, K2, K3, K6.

K1- Remember; K2- Understand; K3- Apply; K4- Analyze; K5- Evaluate; K6- Create.

MAPPING WITH PO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	H	M	M	M	L	L	L	M	M	M	L	L	H	L	L
CO2	H	M	L	M	M	M	L	L	L	L	M	L	M	L	M
CO3	H	L	L	L	M	L	M	M	L	L	L	L	L	M	L
CO4	H	M	L	L	M	L	L	L	L	L	L	L	L	L	M
CO5	H	H	M	M	H	H	M	M	M	M	L	M	L	L	M

ELECTIVE PAPER 3b: RESEARCH METHODOLOGY

Semester	**III Semester**		
Course Type	**Core Elective Paper – 3 b**		
Title of the Course	**RESEARCH METHODOLOGY**		
Course Code			
Teaching Hours	**45 Hours/ Semester : 3 Hours/ week**		
	RESEARCH METHODOLOGY	**Credits: 3**	**Max. Marks: 100 (Internal: 25, External 75)**
Course Prerequisites: The student should have a basic knowledge on research and instrumentation			

CODE:	**RESEARCH METHODOLOGY**	**L**	**T**	**P**	**C**

		3	**-**	**-**	**3**
Course Objectives	• To get an idea about the research and how to write the research articles • To get an knowledge about the various instruments like centrifuges, microscopes, spectroscopy, etc in life sciences				
Module 1	**Introduction to Research**				**9 hours**
What is research? – literature Collection – literature citation – research report-manuscript preparation – formatting and typing – experimental designs – laboratory safety – Intellectual property rights. Concept and importance in research – Features of a good research design – Exploratory research design – concept, types and uses, Descriptive research designs – concept, types and uses. Experimental design: Concept of independent and dependent variables. Qualitative and quantitative research: Qualitative research – Quantitative research – Concept of measurement, merging the two approaches.					
Module 2	**Paper Writing**				**9 hours**
Layout of a research paper, Journals in life science, Impact factor of journals, When and where to publish?, Ethical issues related to publishing, Plagiarism and self-plagiarism. Use of tools/techniques for research: Methods to search required information effectively. Reference management software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of plagiarism.					
Module 3	**Spectroscopy Techniques**				**9 hours**
Beer-Lamberts law, UV-Visible, Raman and IR Spectroscopy, theory and application of Circular Dichroism. Flourimetry and its types. Fluorescence, NMR, PMR, ESR and Plasma Emission spectroscopy. Mass spectrometry-matrix assisted laser desorption ionization and surface enhanced laser desorption ionization.					
Module 4	**Centrifugation and Electrophoresis**				**9 hours**
Basic principles- RCF, sedimentation coefficient, types of centrifuges, preparative & analytical centrifugation. Chromatography Techniques: Principle and applications of Paper, Thin layer, LPCC, HPLC, Affinity, Gel permeation and Ion exchange chromatography. Electrophoretic techniques: Principle and applications of poly acrylamide gel electrophoresis, capillary electrophoresis, isoelectric focusing, 2D electrophoresis, disc gel electrophoresis, gradient electrophoresis, pulsed field gel electrophoresis and agarose gel electrophoresis. Radiation					

biophysics: Basic concept and measurement of radioactivity. Radioisotope techniques – GM Counter, Liquid scintillation and Solid scintillation counter.		
Module 5	**Microscopy and Imaging Techniques**	**9 hours**
Principle of light transmission, types of light microscopes –bright field – dark field – phase contrast – fluorescence – polarization – confocal – scanning micrometry. Electron microscopes and types – scanning probe microscopes – scanning tunneling – atomic force and magnetic force microscope – photomicrography. Physical biomedical method of imaging techniques, Intact biological structures – X ray, CAT, SCAN, ECG, EEG. Autoradiography, X ray crystallography, Photography, ultrasound, MRI, Angiography.		
ReferenceBooks	1. Uve Flick, 2015, Introducing Research Methodology – A Beginners Guide to do Research Project, 2nd Edition, SAGE Publishing. 2. Quality Inquiry and Research Design: Choosing among five approaches – John W. Creswell, Cheryl N. Poth, 4th Edition, SAGE Publications Inc, 2017. 3. Research Methodology – Methods and Techniques, C.R. Kothari and Gaurav Garg, New Age International Publishers, 2019. 4. Biostatistics – P.N. Arora, P.K. Malhan, Himalayan Publishing House, 2010. 5. Statistical Methods – S.P. Gupta, S. Chand & Sons, New Delhi, 2017. 6. Biostatistical Analysis – Jerrold H. Zar, 5th Edition, Northern Illionois University, Pearson, 2010. 7. Voet, D., and Voet, J.G., 1995, Biochemistry, 2nd Edition, John Wiely & Sons. 8. John Webster, 2004, Bioinstrumentation, John Wiely & Sons. 9. Veerakumari, 2006, Bioinstrumentation, 1st Edition, MJP Publishers. 10. Zubay, G.L., 1993, Biochemistry, 4th Edition, Wm C. Brown Publishers. 11. Wilson, K., & Walker, J., 1995, Practical Biochemistry, 5th Edition, Cambridge University Press.	

Course Outcomes (COs):

Course	**After the Completion of the Course, the student will be**	**CognitiveLevel**

Outcome	able to –	
CO1	Acquire knowledge on the research and its types	K1, K2.
CO2	Get a knowledge on how to write a research article, plagiarism checking etc.	K1, K2, K3
CO3	Acquire the knowledge on principle, working and applications of various spectroscopy	K2, K3, K4, K5
CO4	Acquire the knowledge on principle, working and applications of various centrifuges and electrophoresis	K2, K3, K4, K5
CO5	Acquire the knowledge on principle, working and applications of various microscopes and imaging techniques	K2, K3, K4, K5.

K1- Remember; K2- Understand; K3- Apply; K4- Analyze; K5- Evaluate; K6- Create.

	PO1	PO2	PPO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	M	H	L	L	L	M	L	L	L	L	L	L	M	L	L
CO2	L	M	L	L	L	H	L	L	L	L	M	L	M	L	L
CO3	M	M	L	L	L	H	M	M	M	L	L	L	M	L	L
CO4	L	L	M	M	M	H	L	M	L	L	L	L	M	L	L
CO5	L	L	L	L	L	H	L	L	L	L	M	M	M	M	M

SEMESTER IV

COURSE : DISSERTATION

Dissertation would be carried out by the students during 4th semester of their studies. It would be conducted simultaneously with the concurrent field work. The dissertation would be based on primary data, however, dissertation based on secondary data could also be undertaken by the student with due consultation of the field work supervisor. The dissertation work would enable the student to develop a clear understanding of the research and different steps associated with it. The topic for dissertation would be chosen based on a student's own area of interest in consultation with the field work/research supervisor. The student would work with a field work supervisor who would also provide guidance and support throughout the course of the research

Course outcomes

- To develop ability to initiate and conduct research
- To develop research Skills of identifying and selecting a research area and preparing research proposal
- . To develop skills of doing literature review and steps of research methodology
- To be familiarized with the process of data analysis and report writing,
- . To understand ethical considerations of research

7.TEACHING LEARNING PROCESS

The teaching learning process in the learning outcomes based curriculum framework in the subject of Marine Biotechnology is designed to develop the cognitive skills of every learner. The course offers the requisite skills for research and industry jobs in the field of Biotechnology. All courses have practicals as an integral part which promotes the learner to acquire the requisite skills for employment by experiential learning. An interesting combination of teaching learning processes is adopted in which the teacher and learners are actively involved.

Some of the salient teaching learning processes are

- Class lectures
- Presentations

- Group Discussion,
- Workshop
- Laboratory demonstrations
- Peer teaching and learning
- Flipped classroom , project based learning,
  - quiz, seminars,
  - exhibitions,
  - posters.
- Practical experimental design planning, analysis, interpretation, Application.

8. ASSESSMENT AND EVALUATION

Performance in each course of study shall be evaluated based on the basis of

(i) Continuous Internal Assessment throughout the semester and the

(ii) University Examinations at the end of each semester of the programme. The University examinations shall be conducted in the month of November during odd semester and in the month of April during even semester.

(iii) A candidate who has already appeared for an examination in a subject of a semester and also passed in the same is not entitled to reappear in the same subject for improvement of marks/grades.

(iv) Each course, i.e. Theory or Laboratory / Practicals or Mini or Major Project work/Dissertation or Field work shall be evaluated for a maximum of 100 marks.

(v) For each course, Theory or Laboratory/ Practicals or Mini or Major Project work / Dissertation or Field work, the Continuous Internal Assessment component will carry a maximum of 25 marks and the End –Semester University examination will carry a maximum of 75 marks. Thus, there is a total of 100 marks for each course/subject. 6.6 The marks secured in CIA (in total only) may be rounded off to the nearest integer.