OUTCOME BASED EDUCATION (OBE)

CURRICULUM BASED SYLLABUS IN M.Sc.

MARINE GENOMICS PROGRAMME

Department of Marine Biology, Microbiology and Biochemistry
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OUTCOME BASED EDUCATION (OBE), CURRICULUM BASED SYLLABUS FOR M.Sc. MARINE GENOMICS PROGRAMME

Background

UGC has made it mandatory to follow the system of Choice Based Course (CBC) and Outcome Based Education (OBE), as our UG courses with fairly well updated contents have been under choice based credit and semester system. Although their overall standard is quite good, their structure, composition, procedures and credit administration are to be further fine-tuned to incorporate the features of OBE. Courses are well designed instruction packages in specific knowledge fields, with preconceived results that go into the making of the outcome of the Academic Programme. They are scientifically structured with insights of continuity, sequence, and integration, appropriate for effective learning. Workshops are organized in different universities in the state in this direction for the Board of Studies for redesigning the courses at the UG/PG level.

A high priority task in the context of future education development agenda in India is fostering quality higher education. Further improvement of quality of higher education is considered critical for enabling effective participation of young people in knowledge production and participation in the knowledge economy, improving national competitiveness in a globalized world and for equipping young people withskills relevant for global and national standards and enhancing the opportunities or social mobility. Sustained initiatives are required for institutionalizing an outcome- oriented higher education system and enhancing employability of graduates through curriculum reform based on a learning outcomes-based curriculum framework, improving/upgrading academic resources and learning environment, raising the quality of teaching and research across all higher education institutions; technology use and integration to

improve teaching-learning processes and reach a larger body of students through alternative learning modes such as open and distance learning modes and use of MOOCs (massive open online courses). Other priority areas of action for fostering quality higher education include translation of academic research into innovations for practical use in society and economy, promotingefficient and transparent governance and management of higher education system, enhancing the capacity of the higher education system to govern itself through coordinated regulatory reform and increasing both public and private sector investment in higher education, with special emphasis on targeted and effective equity-related initiatives (https://www.ugc.ac.in/.)

India's National MOOC platform 'SWAYAM' (Study Webs of Active–Learning for Young Aspiring Minds) was launched in July 2017. The objective of the programmeis to make available the best teaching learning resources of an Institution to all, including the most disadvantaged. As per the UGC (Credit Framework for online learning courses through SWAYAM) Regulation 2016, Universities can identify courses where credits can be transferred on to the academic record of the studentsfor courses done on SWAYAM. Up to 20% of the total credit in each semester can be based on online courses offered through SWAYAM Platform (www.swayam.gov.in). Courses delivered through SWAYAM are available free of cost to the learners, and students are advised to register for the final proctored exams, some of which come at a fee and attend in person at designated centres on specific dates, so as to get SWAYAM certificate. Universities/colleges approving credit transfer for these courses can use the marks/certificate obtained in these courses for the same. With this prelude, the curriculum based syllabus MSc Marine Genomics Programme is designed based on the Outcome Based Education.

Program Outcomes (PO)

PO 1	Apply the principles of genomics and the practical expertise in pursuing various research questions in biology
PO 2	Develop skills in higher end genomics techniques which will enable them to find employment in genomics based industries
PO 3	Will be able to develop entrepreneurship in the emerging field of marine genomics

Program Specific Outcomes (PSO)

PSO 1	Create skills on analyzing marine genetic and genomic data, including practical lab skills in molecular biology and bioinformatics
PSO 2	Gain expertise in identifying and characterizing various marine organisms, from microbes to higher marine life forms, and to assess and monitor marine biodiversity and ecosystem health using genetic and genomic tools
PSO 3	Acquire the skills to apply genomic techniques for the improvement of aquaculture practices, for enhanced productivity and disease resistance
PSO 4	Develop the ability to use genomic data and techniques for conservation, genetic management, habitat restoration, and assessing genetic diversity to mitigate environmental impacts
PSO 5	Build competence in discovering and developing marine-derived drugs, nutraceuticals, and bioresources using genomic and bioanalytical techniques for bioprospecting
PSO 6	Develop proficiency in bioinformatics for robust analysis of marine genomic data, enabling insights into marine biodiversity, evolutionary processes, and genomic adaptations
PSO 7	Enhance interdisciplinary skills and to prepare students to undertake innovative research and entrepreneurial ventures in the field of marine genomics

Mapping of Programme Outcomes (POs) and Programme Specific Outcomes (PSOs)

Programme Outcomes (POs)	Programme Specific Outcomes (PSOs)						
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
PO1	2	3	3	3	3	3	3
PO2	3	2	2	2	2	1	3
PO3	3	1	2	1	2	3	3

Note: Correlations Levels: 1 = Low, 2 = Medium, 3 = High

DEPARTMENT OF MARINE BIOLOGY, MICROBIOLOGY AND BIOCHEMISTRY

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

M.Sc. Marine Genomics - Scheme and Syllabus

Duration of the Course – 4 Semesters

Total Credits = 82

Semester I (Total credits = 19)

Course Code	Course	C/ E	Credits	Internal Marks	External Marks	Total Marks
24-864-0101	Introduction to Marine Sciences	C	3	50	50	100
24-864-0102	Fundamentals of Genetics and Genomics	C	3	50	50	100
24-864-0103	Introduction to Marine Genomics	C	3	50	50	100
24-864-0104	Molecular Biology (Practical)	C	2	100	-	100
24-864-0105	Marine Biodiversity (Practical)	C	2	100	-	100
	Elective-1	E	2	50	50	100
	Elective-2	E	2	50	50	100
	Elective-3	E	2	50	50	100

C – Core, E – Elective

Semester 2 (Total credits = 20)

Course Code	Course	C/E	Credits	Internal Marks	External Marks	Total Marks
24-864-0201	Marine Microbiology and Microbial Genomics	C	3	50	50	100
24-864-0202	Biosafety, Bioethics, IPR and Entrepreneurship	C	3	50	50	100
24-864-0203	Discovery of Marine drugs and Nutraceuticals	C	3	50	50	100
24-864-0204	Aquaculture Genomics	C	3	50	50	100
24-864-0205	Marine Microbiology & Microbial Genomics – Practical	C	2	100	-	100
24-864-0206	Discovery of Marine drugs and Nutraceuticals (Practical)	C	2	100	-	100
	Elective-1	E	2	50	50	100
	Elective-2	E	2	50	50	100

C – Core, E - Elective

Semester 3 (Total credits = 22)

Course Code	Course	C/E	Credits	Internal Marks	External Marks	Total
24-864-0301	Biochemistry and Nutrigenomics	C	3	50	50	100
24-864-0302	Conservation Genomics	C	3	50	50	100
24-864-0303	Transcriptomics & Proteomics	C	3	50	50	100
24-864-0304	Bioinformatics	C	3	50	50	100
24-864-0305	Bioinformatics - Practical	C	2	100	-	100
24-864-0306	Bioanalytical Techniques and Instrumentation - Practical	C	2	100	-	100
24-864-0307	Transcriptomics & Proteomics - Practical	C	2	100	-	100
	Elective-1	E	2	50	50	100
	Elective-2	E	2	50	50	100

C – Core, E - Elective

Semester 4* (Total credits = 21)

Course Code	Course	C/ E	Credits	Internal Marks	External Marks	Total
24-864-0401	Project work and Dissertation	C	18	50	50	100
24-864-0402	**MOOC	E	3	-	100	100

Electives

Course Code	Course	C/ E	Credits	Internal Marks	External Marks	Total
24-864-0106	Marine Genetic Biodiversity & Conservation	E	2	50	50	100
24-864-0107	Biological Oceanography	E	2	50	50	100
24-864-0108	Developmental Genomics	E	2	50	50	100
24-864-0109	Marine Botany	E	2	50	50	100
24-864-0110	Applied Molecular Biology	E	2	50	50	100
24-864-0207	Immunogenomics & Pharmacogenomics	E	2	50	50	100
24-864-0208	Systems Biology	E	2	50	50	100
24-864-0209	Marine Microbiology	E	2	50	50	100
24-864-0308	Marine Ecology	E	2	50	50	100
24-864-0309	Ecological and Evolutionary Genomics	E	2	50	50	100

Credit Distribution of M.Sc. Marine Genomics

Sl. No.	Courses	CC/EC	No. of Courses	Credit Per Course	Total Credit
1	Core Courses (other than Project and Dissertation)	CC	11	3	33
2	Core Courses (Lab)	CC	7	2	14
3	Elective Courses (excluding MOOC course)	EC	7	2	14
4	Elective Courses (MOOC course)	EC	1	3	3
5	Project work and Dissertation	CC	1	18	18
	Total Courses	-	27	-	82

Note: CC – Core courses and EC – Elective Courses

There are 19 core subjects and 8 electives, which are interdisciplinary in nature. A student shall register for a minimum of 55 credits in the first three semesters before he/she registers for the fourth semester. Accumulated minimum credit required for successful completion of the programme is 72 credits.

The student has to devote the fourth semester to dissertation work related to a relevant area of specialization either in the Department or in an industry/research/academic institution outside the University. All the students have to submit a project dissertation at the end of the fourth semester. Besides the major project in the 4^{th} semester, each semester should have an internship/industry training of a minimum duration of one week to 10 days duration.

**In addition, it is mandatory for the students to register for a suitable MOOC (as recommended by the faculty members of the department from

time to time), available in the SWAYAM platform (www.swayam.gov.in).

The students can avail the courses at any time during the first three semesters, based on the availability of suitable courses at www.swayam.gov.in and should procure the required credits for MOOC before completion of the fourth semester. Grading of MOOC will be decided by the Department Council and University based on the results obtained from www.swayam.gov.in

The award of maximum 100 marks for the project dissertation to student is based on:

A) *Continuous assessment by his/her guide based on his/her performance and progress during the dissertation work will carry a maximum of 50 marks.*

B) *The Project dissertation submitted by the student at the end of the semester will be evaluated internally for a maximum of 50 marks.*

Equal weightage shall be given for the continuous assessment and the end-semester components.

Grading Scale

Range of Marks	Grade	Weightage
Below 50%	F (FAILED)	0
50 – 59	D (SATISFACTORY)	6
60 - 69	C (GOOD)	7
70 - 79	B (VERY GOOD)	8
80 – 89	A (EXCELLENT)	9
90 and above	S (OUTSTANDING)	10

CLASSIFICATION SCALE

Classification	**CGPA**
First Class with Distinction	8 & above
First Class	7 & above
Second Class	6 & above

$$GPA = \frac{G_1C_1 + G_2C_2 + \dots GnCn}{C_1 + C_2 + \dots Cn}$$

G = Grade Weightage C = Credit Value

$$GPA = \frac{A_1T_1 + A_2T_2 + \dots AnTn}{T_1 + T_2 + \dots Tn}$$

A = GPA

T = Total Credit Value for a Semester

Percentage of Marks = [55 + 10 (CGPA – 6)] Approximately

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SEMESTER-I

24-864-0101 - INTRODUCTION TO MARINE SCIENCE

Course Outcome (CO):

After completing this course, the students will be able to

CO1: *Identify and relate the interconnections between biological, physical and chemical processes in the marine environment*

CO2: *Understand the physical/climatic, chemical and geological components in marine ecosystem and discuss their role in the dissemination of life across the oceans*

CO3: *Define the zonation in marine environment with respect to abiotic and biotic components and compare its ecological variationsCO4- Discuss on the marine flora and fauna as well as its habits and habitat*

CO5: *Identify and illustrate marine pollutants, its ecological consequences and control measures*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	1	2	2	2	2	2	2
CO2	1	1	1	1	1	2	1
CO3	2	2	2	3	3	3	2
CO4	2	2	2	3	3	3	3
CO5	2	1	1	3	3	2	2

Unit I

Fundamentals of Oceanography: Earth as a marine planet; Major wind systems; Ocean circulation; Coriolis effect; El Nino; La Nina; Ekman motion; Waves and tides; Tsunami; Upwelling and downwelling processes; Ocean-atmosphere coupling; Marine weather and climate. Satellite-based Physical Oceanography. Oceanographic features of the Indian seas.

Unit II

Fundamentals of Marine Geology: The Ocean floor – bathymetry; Structure and origin of ocean basins; Sea floor spreading; Plate tectonics; Continental shelves; Slopes; Continental margins; Submarine canyons; Trenches; Sea mounts; Guyots; Ocean ridges; Geothermal vents; Classification of coasts and shorelines; Marine sediments – texture, types and distribution; mineral wealth of the ocean; Methods of exploring the ocean floor; Geological time scale. Tsunami and coastal hazards.

Unit III

Introduction to Marine Chemistry: Elemental composition of sea water; Physical and chemical properties of seawater - distribution of temperature, salinity, density, major and minor elements and nutrients. Constancy of seawater, residence time, geochemical balance of oceans. Dissolved gases and their solubility in sea water - Factors affecting the concentration of gases in seawater, pH, alkalinity, specific alkalinity, buffer capacity, carbon dioxide equilibria, precipitation and dissolution of carbonates. Micronutrients: nitrogen, phosphorus, Iron and silicon, - distribution of nutrients and their effect on phytoplankton growth, N/P ratio. Dissolved and particulate organic matter in the sea - nature, origin and distribution.

Unit IV

Fundamentals of Marine Biology: Biological divisions of the sea - estuaries and backwaters, lagoons, mangroves, coastal waters, 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 – distribution, geographic ranges and patterns of migration; Marine reptiles, birds and mammals; Benthos – intertidal and subtidal zones, Marine boring and fouling organisms; Concept of food chain and food web; ecological efficiency; Photosynthesis and primary production - methods of estimation of marine productivity. Climate change and marine biota.

Unit V

Marine Pollution: Major Pollutants - Sewage, heavy metals, radioactive compounds, petroleum hydrocarbons, industrial effluents; eutrophication; Ocean Acidification, Marine litter – plastic litter in the oceans and their effect on marine biota, microplastics; Fate of pollutants in the seas; Impact of pollutants on marine life-laws pertaining to the protection of the marine environment from impairments. One Ocean, One Health-Marine aerosols affecting human health, Pharmaceutical effluents.

References

1. *Lab Manual: Introduction to Marine Biology* (4thEdition) (2012), George, Karleskint., Richard, Turner.& James, Small Brooks Cole.
2. *The Oceans – Their Physical, Chemistry and General Biology* (1968), Sverdrup, H.U., Martin, W. Johnson., & Richard, H. Fleming. Prentice Hall.
3. *Marine Biology: An Ecological Approach* (6thEdition) (2004). James, W. Nybkken.,& Mark, D. Bertness, Benjamin Cummings.
4. *Marine Geology: Exploring the New Frontiers of Ocean* (Revised Edition) (2003). John, Erickson ,Checkmark Books.
5. Descriptive Physical Oceanography- An Introduction 5th Edition (1990), George L Pickard,W J Emery
6. Oceanography - An Introduction to the Planet Oceanus 1992 Edition by P. Pinet. Publisher - Jones and Bartlett
7. Oceanography - A Brief Introduction by K Siddhartha. Publisher - Kitab Mahal
8. Introduction to Physical Oceanography Robert H. Stewart, Texas A&M University. Copyright Year: 2008
9. Introduction to the biology of marine life by John Morrissey (10th Edition). Publisher Jones and Bartlett Learning.
10. Marine Pollution by Clarke, R.B. (5th Edition). Publisher - Biogreen Books

24-864-0102 - FUNDAMENTALS OF GENETICS AND GENOMICS

Outcome:

After completing this course, the students will be able to

- ***CO1:*** *Explain the central dogma of biology, illustrating the process of genetic information flow from DNA to RNA to protein.*
- ***CO2:*** *Apply principles of practical tools in gene manipulation, including cloning, PCR, and gene expression analysis.*
- ***CO3:*** *Implement advanced techniques in gene editing, such as CRISPR-Cas9, to modify genetic material effectively.*
- ***CO4:*** *Analyze next-generation gene sequencing platforms, evaluating their principles and applications in genomics research.*
- ***CO5:*** *Demonstrate proficiency in isolating and purifying genetic material from marine environmental samples and organisms, employing techniques like DNA extraction and purification.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	1	1	1	1	1	1	1
CO2	1	2	3	1	1	1	1
CO3	1	1	3	3	1	1	1
CO4	1	1	1	3	1	1	2
CO5	1	1	1	1	3	1	1

Unit I

History of genetics; Introduction to genetics, cell and cellular organization, chromosomes: structure of prokaryotic and eukaryotic chromosomes, chromatin, chromatin organization, special type of chromosomes. Concept of gene, Structure and types of DNA and RNA, DNA replication, Protein synthesis, Post-transcriptional and post-translational modifications.

Unit II

Techniques in Gene manipulation**:** - Restriction enzymes, ligases, cloning vectors, host cells, marker genes, screening and selection of transformation, cDNA synthesis, reverse transcription, insertions inactivated, nucleic acid hybridization, PCR screening, lmmunological screening. Methods of gene transfer, Strategies of Gene Cloning: Cloning interacting genes - Two-and three hybrid systems, Y2H, Y3H. cloning differentially expressed genes, cloning system for producing single-stranded and mutagenized DNA.

Unit III

Genetic Engineering and Biotechnology: Application of genetic engineering in industry, medicine and agriculture. Scope of Recombinant DNA Technology, Genetic engineering tools - Restriction enzymes, cloning vectors, ligases, marker genes. Screening and Selection of recombinants/ transformants. Recombinant vaccines, Gene therapy, drugs from the sea, Mechanism of drug resistance

Unit IV

Beyond Genomics—Epigenetics, Translation and Modification; Epigenetic Modifications of Genomes. Ethical implications of the genome modification, Multiple levels of non-coding variation in gene expression (epigenetics), Regulation of translation, and intervening in gene expression. Genome editing technologies - Zinc finger nuclease and history of genome editing technologies, TALEN, CRISPR/Cas, Comparison of TALEN and CRISPR/Cas 9.

Unit V

DNA Sequencing Techniques: Evolution of DNA Sequencing Technology. Isolation, purification, separation (Gel electrophoresis) and quantification of DNA and RNA from sediment, phytoplankton, zooplankton, microorganisms and animals. Sequencing strategies, Genome sequencing techniques and applications; DNA sequencing platforms - Sanger

sequencing, Next-Generation sequencers; Nanopore and 10X Sequencing, Massive parallel sequencing and its applications. 5th generation sequencing, Barcode of life, CoML, eDNA.

References

1. James Watson (2017). Molecular biology of the gene, 7th Edition. Pearson Press
2. Bruce Alberts, Dennis Bray, James Watson, and Julian Lewis. (2015). Molecular Biology of the Cell Garland Publishers
3. Geoffrey M Cooper and Robert Hausman (2013). The Cell: A molecular approach
4. Suraksha Agarwal, (2008). Techniques in Molecular Biology
5. Veerbala Rastogi (2006). Principles of Molecular Biology
6. Desmond S. T. Nicholl (2008). An introduction to Genetic Engineering
7. Bernard R Glick and Cherry Patten (2017). Molecular Biotechnology – Principles and Applications.
8. Monika Jain, (2011). Recombinant DNA techniques – A text book
9. Bernard R Glick and Jack J Pasternack (2011). Molecular Biotechnology – Principles and Applications of Recombinant DNA 2nd Edition.

24-864- 0103 - INTRODUCTION TO MARINE GENOMICS

Outcome:

After completing this course, the students will be able to

CO1: *Explain the significance of marine model organisms in biological research, detailing their role as representatives of broader biological processes.*

CO2: *Apply genomics tools to analyze and interpret data related to marine biodiversity, emphasizing the practical use of genomic*

techniques in ecological studies.

CO3: *Extend understanding of the genomics of marine algae, exploring their genetic makeup and adaptation strategies in diverse marine environments.*

CO4: *Analyze developmental genomics to investigate the origin and evolution of chordates, integrating genetic data to understand evolutionary processes.*

CO5: *Employ e-DNA techniques to detect and study invasive species, demonstrating proficiency in using environmental DNA for biodiversity monitoring and conservation efforts.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	1	1	1	1	1
CO2	3	3	1	1	1	1	1
CO3	1	1	3	1	2	1	1
CO4	1	1	1	3	1	1	2
CO5	1	1	1	1	3	1	1

Unit I

Genomic approaches to understand population structure and environmental adaptation of marine organisms. Marine model organisms (Sea urchins, Tunicates, Sponges etc.) Genome programmes in marine biology. Emerging and future genome models for marine biosystems. Marine biodiversity exploration employing genomics. Case studies of marine organism genomics, Whole Genome Sequence of Atlantic Cod, Puffer Fish Genome, Genomes of crustaceans.

Unit II

Genomics of marine algae - introduction to marine algae; marine algae in a global context. Shaping the nuclear genome by endosymbiotic gene transfer. Gene acquisition through lateral gene transfer; Advances in

genetic transformation of algae. Seaweed genome. Whole Genome Sequence of Diatom.

Unit III

Developmental and evolutionary genomics on the origin and evolution of chordates- The *Ciona intestinalis* genome, The *Branchiostoma floridae* genome, The *Saccoglossus kowalevskii* and *Ptychodera flava* genomes. Environmental genomics of coral reef biology- The *Acropora digitifera* genome, *Symbiodinium* genome, The Crown-of-Thorns starfish (COTS) genome. The pearl oyster genome, Genome decoding project of metazoans- The *Lingula anatina* genome.

Unit IV

Genomic techniques and their application to marine questions – Genomic methods relevant to assess marine ecosystem health- DNA barcoding and metabarcoding- The Moorea Biocode Project; The Earth microbiome project, The Ocean Sampling Day; Microarrays; Real-Time PCR- Short nucleotide polymorphisms- Fish Poptrace; Infrastructures for genomic monitoring. Genomics to secure the future of seafood. Sustainable blue economy.

Unit V

Genomics as a way to characterize marine biodiversity. Case studies - microevolution of marine organisms. Marine biodiversity exploration employing genomics. Major issues in marine ecological genomics. Global ocean sampling campaign. Current Challenges in Marine Genomics, e-DNA to study invasive species in the Marine Environment.

References

1. Kristin Tessmar Raible, J. Mark Cock and Catherine Boyen (2012).Introduction to marine genomics Springer

2. Marine Genomics – Methods and Protocols (2016) Editor Bourlat Sarah J – e-book
3. Metagenomics – Methods and Protocols. Editors – Streif Wolfgang and Daniel Rolf – e-book
4. Choudhury S S - Genomics - Fundamentals and Application (2010) Published by Taylor and Francis (First Edition)
5. Pevsner, J - Bioinformatics and Functional Genomics (2013) Published by John Wiley (2nd Edition)
6. Arthur Lesk - Introduction to Genomics (2015). Published by Oxford University Press
7. Primrose, S.B. - Principles of gene manipulation and genomics (2014). Publisher - John Wiley

24-864-0106-MARINE GENETIC BIODIVERSITY AND CONSERVATION

Outcome:

After completing this course, the students will be able to:

- ***CO1:*** *Analyze the importance of marine biodiversity for the well-being of the marine ecosystem.*
- ***CO2:*** *Apply biodiversity indices to assess changes in ocean biodiversity.*
- ***CO3:*** *Interpret international regulations and treaties related to biodiversity and conservation.*
- ***CO4:*** *Evaluate molecular phylogeny techniques.*
- ***CO5:*** *Assess the consequences of anthropogenic activities on the marine environment.*
- ***CO6:*** *Engage in conservation activities and collaborate with international organizations.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	3	1	2	1	1	1
CO2	2	3	1	2	1	1	1
CO3	1	2	1	3	1	1	2
CO4	2	3	1	2	1	2	1
CO5	1	2	1	3	1	1	2
CO6	1	2	1	3	1	1	3

Unit I

Basic concept of Biodiversity – Elements of Biodiversity - Ecosystem Diversity, Genetic Diversity, Species Abundance and Diversity, Patterns of Species Diversity. Global patterns of Biodiversity – measuring biodiversity, Cataloguing and Discovering Species, Geographical Patterns of Species Richness, Diversity indices – alpha and beta diversity, Shannon Weiner Index, Simpson's index, Pielous evenness index, etc. Biogeography, Importance of Distribution Patterns - Local Endemics, Sparsely Distributed Species, Migratory Species, Barcode of Life, Census of Marine Life.

Unit II

Biodiversity & Conservation – Overexploitation threatening living species, International Trade, Animals threatened by international trade, Problems in Controlling International Trade (Enforcement, Reservations, Illegal Trade), Free Trade and the Environment, Free Trade and Conservation, Common patterns of Overexploitation. Marine forensics. Exotic Species – Plants, Invertebrates, Fishes, Amphibians, Reptiles, Birds, Mammals, Detrimental Effects of Exotic Species. CBD, CITES. Marine protected areas and Marine biodiversity reserves.

Unit III

Impact of human activities, Maritime Zones, UNCLOS, Strategic Plan for Biodiversity. Marine and Coastal Biodiversity Programme. Ecologically or

biologically significant areas (EBSAs), International Convention for the Control and Management of Ships' Ballast Water and Sediments, International Convention for the Regulation of Whaling, FAO Code of Conduct for Responsible Fisheries, Duties of the flag State, Measures taken by a port State, - Regional Sea Agreements, Large Marine Ecosystem Mechanisms.

Unit IV

Phylogeny and tree of life - Taxonomy in relation to Chromosomal morphology and evolution – Chromosomal evolution, why location of genes matter, evolutionary oddities about chromosomes, evolutionary effect of rearrangements of chromosomes, karyotypic ortho selection, chromosomal evolution & speciation. Cladistics – biological identification through DNA barcodes.

Unit V Molecular phylogenies – Immunological techniques, Amino acid sequences, Quantitative DNA measurements, Repetitive DNA sequences, Nucleic acid phylogenies based on DNA-DNA hybridizations, Restriction enzyme sites and nucleotide sequence comparisons and homologies, Combined nucleic acid-amino acid phylogenies, Rates of Molecular change: Evolutionary Clocks, Regulatory genes & evolutionary consequences.

References

1. Hill, M.N. (1962).*The Sea* (Ed.). John Wiley and Sons.
2. Hydres, H.B.N. (1972) *The Biology of Polluted Waters*. University Torondo Press.
3. *Fjord Systems and Archives*: (2011). Howe, J.A., Austin, W.E.N., Forwick, M., &Paetze, M. Special Publication 344 (Geological Society Special Publication).
4. *Marine Chemical Ecology (Marine Science)* (2001), James, B. McClintock., & Bill, J. Baker. CRC Press.

5. *Marine Biology: Function, Biodiversity, Ecology* (2nd Edition) (2001). Jeffrey, S. Levinton. Oxford University Press, USA.
6. *Dynamics of Marine Ecosystem, Biological- Physical Interaction in the Ocean* (3rdEdition) (2005). Mann, K.M. and Lazier, J.R.N. Wiley-Blackwell.
7. Keith Hiscock - Marine Biodiversity Conservation - A Apractical Approach (2014) - Published by Routledge (Taylor and Francis Group)
8. Ramasamy Santhanan - Handbook of endangered marine life (2017) Published by Viva Books Private Limited.
9. Martin Solan, Rebeca Aspden and David Paterson - Marine Biodiversity and Ecosystem Functioning - Framework Methodologies and Integration (2012) - Published by Oxford University Press.
10. Kannaiyan, S and K. Venkataraman - Marine Biodiversity in India (2018) Published by Associated Publishing Company

24-864-0107 - BIOLOGICAL OCEANOGRAPHY

Outcome:

After completing this course, the students will be able to:

CO1: *Explain the history and recent developments of biological ceanography*

CO2: *Describe the salient ecological features of the marine ecosystems and the chemical and physical characteristics of sea water*

CO3: *Describe the current threats to marine biodiversity and the impact of climate change and human activities on the marine ecosystem*

CO4: *Discuss the environment laws and marine protected areas*

CO5: *Explain the international and national agencies and scientific organizations responsible for the conservation and management of marine life*

CO/PO	PS01	PS02	PS03	PS04	PS05	PS06	PS07
CO1	1	1	1	1	2	1	2
CO2	1	3	1	2	1	2	3
CO3	2	3	1	3	1	2	3
CO4	1	2	1	3	1	2	2
CO5	1	2	1	3	1	1	2

Unit I

Introduction to the Marine Environment. History of marine biological investigations in India and major expeditions. Challenger expedition, IIOE-1 & IIOE-2. Salient features of world oceans. Oceanographic features of the Arabian Sea, Bay of Bengal and Andaman Sea. Divisions of the sea - Zonation in marine environments. Physico-chemical features of Marine environment- tides, currents, waves, upwelling and monsoon cycles, Mud banks.

Unit II

Salient ecological features of coastal ecosystems-wetlands, estuaries, mangroves, sea grasses, coral reefs, rocky and sandy shores, and deep sea ecosystems. Deep ocean mission. Continental shelf and seabed, Extreme environments – polar regions and hydrothermal vents.

Unit III

Marine living and non-living resources. Planktonic deposits and oozes in marine environments. Classification of marine organisms by habit and habitat. Introduction to marine flora – microalgae, macroalgae, seagrass, salt marshes and mangroves and their distribution patterns in Indian EEZ. Systematic and general description of marine faunal groups. Indicator organisms, Plankton blooms, Toxic algae and its impact on fisheries. Remote sensing and molecular tools.

Unit IV

Marine biodiversity, Conservation status, Endangered marine mammals

and sea turtles, CITES, Red data list and its categories. Regulations concerned with conservation of the marine fauna and flora. Marine sanctuaries, Marine Protected Areas (MPAs), Large Marine Ecosystems (LMEs), etc. Regulations related to maritime boundaries, EEZ and territorial waters. Marine Biodiversity of India.

Unit V

Marine ecosystems and climate change - climate forcing on the marine ecosystem, human impact on marine ecosystem, socio-ecological aspects of global warming and sea-level rise. Marine ecosystem and marine resource management in the changing scenario. Extreme climatic events in the Indian coasts, Adaptation and mitigation measures, Ocean acidification and c oral bleaching.

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24-864- 0108 - DEVELOPMENTAL GENOMICS

Outcome:

After completing this course, the students will be able to

- ***CO1:*** *Explain the developmental biology of marine organisms, detailing stages of development and environmental influences.*
- ***CO2:*** *Investigate functional genomics using knockout models, demonstrating proficiency in experimental techniques.*
- ***CO3:*** *Analyze the significance of teratogens and deformities in the developing embryo, evaluating their impact on developmental processes.*
- ***CO4:*** *Utilize appropriate model organisms to study developmental genomics, applying genetic and molecular techniques.*
- ***CO5:*** *Evaluate environmental regulation on animal development, integrating ecological factors into developmental biology studies.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	1	1	1	1	1
CO2	3	3	1	1	1	1	1
CO3	1	1	1	1	1	1	1
CO4	1	1	3	1	2	1	1
CO5	1	1	1	1	3	1	1

Unit I

Principles of Developmental Biology of Marine Organisms. Approaches to developmental biology: Anatomical, genetic, evolutionary, teratology, mathematical modeling and experimental approaches.

Unit II

The Genetic core of development - The Embryological origins of Gene Theory, Early attempts at Developmental Genetics, Genomic equivalence, determining the function of genes during development, Gene targeting

(Knockout) experiments, determining the function of a message: Antisense RNA. Genetics of cell-cell communication in development. Teratogens and implications on marine organisms.

Unit III

Introduction to model organisms: *Dictyostelium, Caenorhabditis elegans, Drosophila*, Zebrafish, *Fundulus heteroclitus, Nothobranchius furzeri, Oryzias latipes*, Xenopus, Chick, Mouse,. Genetic analysis of developmental pathways in model organisms – Drosophila, *C. elegans*, Xenopus, Zebrafish, Chick & Mouse. Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in *Dictyostelium*, formation of vulva in *C. elegans*. Genetics of Metamorphosis, Regeneration & Aging. Medical implications of Developmental Biology –Genetic errors of development, inborn errors of metabolism, Teratogenesis – environmental assaults on development of organisms.

Unit IV

Fertilization and early development in marine organisms: Cleavage, gastrulation, cell specification; axis and pattern formation with examples from *C. elegans*, Drosophila, amphibians, chick and mammals. Differential gene expression from the same nuclear repertoire –differential gene transcription, selective nuclear RNA processing, Selective mRNA translation, differential protein modification, DNA methylation & gene activity, chromatin modification induced by DNA methylation, dosage compensation.

Unit V

Environmental regulation of Animal development –Phenotypic plasticity, Environment–as part of normal development, Polyphenisms & Plasticity, environmentally adaptive nervous system, Endocrine disruptors. Developmental mechanisms of Evolutionary change– 'Unity of Type & 'Conditions of Existence', preconditions for macroevolution through developmental change – Modularity & Molecular parsimony, mechanisms

of macroevolutionary change, Homologous pathways of development, Developmental constraints (Physical, Morphogenetic & Phyletic). Life cycles and evolution of developmental patterns. Environmental regulation of animal development.

References

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5. Sally A Moody - Principles of Developmental Genetics (2014) Published by Academic Press
6. Prabhakar Sharma and Meenakshi chakraborty - A textbook of developmental genetics (20026) - Published by Wisdom Press
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24-864-0109 - MARINE BOTANY

Outcome:

After completing this course, the students will be able to

CO1: *Describe the classification of micro and macroalgae, discuss their physiology, reproduction and identify cological importance.*

CO2: *Explain the spatio-temporal variations in marine primary production and relate to the potential environmental drivers*

CO3: *Discuss on wetlands and its ecosystem services with reference*

to saltmarshes, seagrass, mangroves etc.

CO4: *Explain harmful/ toxic algal blooms, its dynamics and impacts on marine environment as well as to develop mitigation measures.*

CO5: *Identify seaweed resources of India, its taxonomy and economic importance.*

CO6: *Apply various culture techniques for microalgae as live feed in quaculture and for developing biofuel production techniques.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	3	3	3
CO2	2	2	1	1	2	3	3
CO3	3	3	1	1	2	3	3
CO4	3	2	3	3	3	3	3
CO5	3	3	1	2	1	3	3
CO6	1	2	3	3	3	3	3

Unit-I

Introduction to marine flora: marine algae, fungi and angiosperms –general account, distribution, habit and habitat. Marine plant communities-– adaptations of planktonic algae, periphyton, microphytobenthos, epiphytes, seaweeds, seagrasses, salt marsh communities and mangroves. The role of various plant communities in the marine food chain. Systematics and characteristics of the ecosystem, scenario of seagrasses, salt marshes and mangroves. Mangrove ecosystems, types, stratification, importance, degradation and restoration. Kelp forest. Ecosystem services of seagrasses, salt marshes and mangroves. Blue carbon and its relevance.

Unit-II

Marine algae: General account, habits and habitats, cellular organization, reproduction. Microalgae: Collection, preservation, methods of estimation

of standing crop, qualitative analysis with special reference to Cyanophyceae, Bacillariophyceae, Cryptophyceae and Dinophyceae. Macroalgae (Seaweeds): Taxonomy and Morphology of economically important seaweeds, structure, reproduction and life cycle of seaweeds with special reference to Chlorophyceae, Phaeophyceae and Rhodophyceae. Seaweeds of coral reefs.

Unit-III

Marine fungi and Lichens: General account, classification, distribution and abundance. Fungal activities in the marine environment –fungal diseases of plants and animals. Marine Lichens –general account.

Unit-IV

Algal blooms -white and red water phenomena. Harmful and toxic algal blooms. Impact of algal blooms on the marine environment. Dynamics of algal blooms, major factors inducing the formation of algal blooms. HABs and Shellfish poisoning – DSP, ASP, MSP, NSP- Ciguatera poisoning. Analytical tools for toxin detection – HPLC, MS, animal bioassay (mouse bioassay). Major bloom-forming phytoplankton. Microbial aspects of algal blooms. Detection of algal blooms by remote sensing and molecular tools. Winter cooling and algal blooms in Arabian Sea. *Trichodesmium* bloom. Diazotrophs.

Unit-V

Algal culture: Microalgae -the importance of microalgal cultivation, culture enclosures, isolation, purification, culture media, sterilization, subculturing, coculturing, mass culturing, synchronous culture, continuous culture, tank culture, *in situ* culture and pond culture. Seaweed cultivation and environmental concerns.

Biofuel from Macroalgae: methods of cultivation, culture of green, brown and red algae. Seaweeds in food chain and safety in seaweed consumption. Economic importance of seaweeds. Seaweed resource of India. Utilization

of seaweeds – agar-agar, carrageenan, agarose etc. Value added products. Seaweed based industries for domestic and international markets.

References

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24-864- 0110 - APPLIED MOLECULAR BIOLOGY

Outcome:

After completing this course, the students will be able to:

CO1: *Evaluate a comprehensive understanding of molecular biology, encompassing historical development, molecular processes, and the significance of molecular biology in various fields.*

CO2: *Demonstrate proficiency in molecular biology techniques, including Recombinant DNA Technology, DNA isolation, PCR, gel electrophoresis, and spectrophotometry.*

CO3: *Apply molecular tools in marine biology and aquaculture, demonstrating the ability to identify microorganisms, perform DNA barcoding, and use molecular diagnostics in fish health.*

CO4: *Analyze advanced molecular biology techniques, including genomic approaches, Next-Generation Sequencing (NGS), mass spectrometry, CRISPR-Cas9, and systems biology.*

CO5: *Evaluate ethical considerations in molecular biology research, genetic engineering, and emerging technologies, emphasizing responsible scientific practices.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	2	2	2	2	1
CO2	3	3	2	1	1	1	1
CO3	2	2	3	2	2	1	1
CO4	3	3	3	3	2	2	1
CO5	2	2	2	1	3	1	1

Unit I: Introduction to Molecular Biology

Definition and historical development of molecular biology. Overview of molecular processes in living organisms- DNA replication, transcription, translation, and cellular signaling pathways. Significance and applications of molecular biology in various fields. Critical role of molecular biology in understanding marine ecosystems, biodiversity, and the adaptation of marine organisms to their environments. Key ethical considerations in molecular biology research.

Unit II: Recombinant DNA Technology

Principles of Recombinant DNA Technology. DNA cloning techniques: restriction enzymes, vectors, and ligases. Construction of recombinant DNA molecules. Gene expression systems: promoters, enhancers, and expression vectors. Functional applications - development of genetically modified organisms (GMOs), gene therapy, and the production of recombinant proteins. Ethical Considerations in Genetic Engineering. Functional Applications in Marine Biology - Genetically modified marine organisms, recombinant proteins derived from marine organisms.

Unit III: Instrumentation and Techniques

Principles of DNA isolation methods: phenol-chloroform extraction, silica-based methods. RNA extraction –methods, significance in studying gene expression and functional genomics. Expressed Sequence Tags (ESTs), Microarray Technology. Polymerase Chain Reaction (PCR): principles and applications. Advanced PCR techniques: quantitative PCR (qPCR), reverse

transcription PCR (RT-PCR), touchdown PCR, hot start PCR, colony PCR, and multiplex PCR. Gel electrophoresis:principles, techniques, and applications. Spectrophotometry: quantification of nucleic acids and proteins. Nucleic acid sequencing methods. Protein sequencing methods.

Unit IV: Applications of Molecular Tools in Marine Biology and Aquaculture

Molecular Identification Methods for Microorganisms- bacteria, fungi, viruses - 16S rRNA, and Internal Transcribed Spacer (ITS) regions. DNA barcoding for species identification. Molecular diagnostics in fish health - detection of pathogens, monitoring disease outbreaks. Principles and applications of eDNA- tracking the presence of aquatic organisms, monitoring biodiversity, and assessing environmental health. Molecular approaches in aquatic ecology. 16S rRNA typing methods - microbial community profiling.

Unit V: Emerging Trends and Applications

Principles and applications of advanced molecular biology techniques: Genomic approaches- Metagenomics, Proteomics, Metabolomics, Lipidomics. Multi-Omics Approaches. Next-Generation Sequencing (NGS) and its applications. Technological Platforms in Mass Spectrometry - MALDI-TOF, LCMS & NMR technological platforms. CRISPR-Cas9 and gene editing technologies. Systems biology: integrating molecular data for a holistic understanding. Ethical Considerations in Emerging Technologies.

References:

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2. Molecular Biology: Principles of Genome Function (2014) by Nancy Craig, Orna Cohen-Fix, Rachel Green, Carol Greider, Gisela Storz, Cynthia Wolberger (1st Edition, Oxford University Press,

Year of Publication).

3. Molecular Cloning: A Laboratory Manual (2012) by Michael R. Green, Joseph Sambrook (4th Edition, Cold Spring Harbor Laboratory Press).
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5. Molecular Biology Techniques: An Intensive Laboratory Course (2016) by Walt Ream, A. Malcolm Campbell (3rd Edition, Academic Press).
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10. CRISPR-Cas: A Laboratory Manual (2020) by Jennifer Doudna, Prashant Mali, 1st Edition, Cold Spring Harbor Laboratory Press.

SEMESTER-II

24-864-0201 - MARINE MICROBIOLOGY & MICROBIAL GENOMICS

Outcome:

After completing this course, the students will be able to

CO1: *Explain microbial structure, function, control and systematics*

CO2: *llustrate simulations of microbial growth and metabolism*

CO3: *Describe the roles of microbes in marine ecosystems, physiology ofthese microbes and their effect on the global biogeochemical cycle*

CO4: *Practice methods to isolate, identify and enumerate the bacterial growth with special reference to the marine environment*

CO5: *Use molecular tools in microbial community analysis*

CO6: *Apply metagenomic tools to explore culture-independent diversity and hidden functional capabilities*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	1	1	1	1	1
CO2	1	1	1	1	1	3	3
CO3	1	1	1	1	1	3	3
CO4	1	1	1	1	1	3	3
CO5	1	1	1	1	3	3	3
CO6	1	1	1	1	3	3	3

Unit-I

General characters of microorganisms. Influence of physical and chemical factors on the distribution of marine microorganisms Morphology and fine structure of bacteria, archaea and fungi. Staining of bacteria and fungi-simple and differential staining. Viruses -structure, replication, classification, isolation and identification. Sample collection methods. Robotics in sample collection from deep sea, barophilic reactors for the collection and cultivation of deep-sea microbes.

Unit II

Cultivation of bacteria - cultivation of autotrophs and heterotrophs. Enrichment culture technique, pure culture. Methods of isolation and preservation of cultures. Growth and nutrition of bacteria. Reproduction-bacterial growth curve. Nutritional types of bacteria -measurement of growth, effect of environmental parameters on growth. Control of microorganisms -control by physical agents, disinfectants and antibiotics. Classification of bacteria. Criteria for classification. Bacterial Systematics. Phenetic and phylogenetic classification systems. Numerical taxonomy. Polyphase taxonomy. Bergey's manual of determinative bacteriology. Introduction to SEQCODE.

Unit-III

Microbial ecology and biogeochemical cycles (Carbon, Nitrogen, Sulphur, Phosphorous and Methane cycle) - Host-microbe interactions in the marine environment (commensalism, parasitism, mutualism, proto co-operation, reductive evolution, etc.). Bacterial bioluminescence and quorum sensing. Microbial fouling and corrosion. Microbiology of specialized ecosystems –hydrothermal vents, Deep sea. Extremophiles. Microbial loop. Marine viruses and their role in the ecosystem. Organic matter decomposition. Degradation of hydrocarbons and pesticides.

Unit IV

Molecular techniques in microbial community structure analysis – Denaturing Gradient Gel Electrophoresis (DGGE), Amplicon sequencing, Terminal Restriction Fragment Length Polymorphism (T-RFLP). Fluorescence *insitu* hybridization (FISH). Box PCR. Molecular methods of microbial identification -16S rRNA, Internal Transcribed Spacer (ITS), Nanopore sequencing. Microbial databases and microbial culture collections -ARB, EZtaxon, NCBI, Greengenes, MTCC, ATCC.

Unit V

Introduction to microbial genomics. Microbial genomes - Archaea genome, Bacterial genome, Fungal genome, Viral metagenomics. Metagenomic analysis of environmental samples (Water and sediment), Metagenomics to map ocean microbial biodiversity. Microbial sequencing methods. Concept of the pan-genome and microbial diversity. Genomics to Biomes. Microbial transcriptome analysis, microbial metatranscriptomics. Microbial metabolomics and marine biogeochemistry. Microbial Plasmid Metagenomics. Metabolism and Element Cycling Discovered in Metagenomics Studies. Investigation of Microbial Communities Using Comparative Metagenomics. Relevance of marine bacterial models.

References

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20. Discovering Genomics, Proteomics and Bioinformatics (2003) by Malcolm Campell and Laurie J Heyer
21. Introduction to Genomics (2017) by Arthur Lesk
22. PCR Applications: Protocols for functional genomics (2013) by Michael A Innis, David G Gelfand and John J Sninsky. Academic Press

24-864- 0202 – BIOSAFETY, BIOETHICS, IPR AND ENTREPRENEURSHIP

Outcome:

After completing this course, the students will be able to

CO1: *Understand the relevant biosafety/ biohazard issues in a laboratory and able to adhere to them*

CO2: *Explain the importance of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms (GMO), national and international regulations.*

CO3: *Understand Legal, Ethical and Conservation issues related to uses of biodiversity*

CO4: *Recognize different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents*

CO5: *Identify different types of start-ups and forms of entrepreneurship including basic concepts of project management, including project identification, formulation, and appraisal*.

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	1	1	1	1	1	1
CO2	3	3	1	1	1	1	1
CO3	1	2	1	1	1	1	1
CO4	1	1	3	1	2	1	1
CO5	1	1	1	1	3	1	1

Unit 1

Biosafety in the laboratory institution: Laboratory-associated infections and 15L other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution. Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries, biosafety assessment procedures in India and abroad. Institutional Biosafety Committee (SC)

Unit II

Biotechnology and food safety: The GM-food debate and biosafety assessment procedures for biotech foods and related products, including transgenic fish and food crops, case studies of relevance. Ecological safety assessment of recombinant organisms and transgenic crops, Genetic Engineering Approval Committee case studies of relevance (Eg. Bt cotton).), GM food fish (growth hormone) and Genetic pollution of the wild. Biosafety assessment of biotech pharmaceutical products such as marine drugs and /vaccines etc. International dimensions in biosafety: Cartagena protocol on biosafety, bioterrorism and convention on biological weapons.

Ethical Issues: Introduction – causes of unethical acts, ignorance of laws, 15L codes, policies and procedures, recognition, friendship, personal gains. Professional ethics – professional conduct, Ethical decision-making, ethical dilemmas. Teaching ethical values to scientists, good laboratory practices, good manufacturing practices (GMPs), Animal Ethics, Ethical guidelines for the use of animals in research, Genetically Modified Organisms (GMO), GMO Regulations, Regulation of GMOs in India.

Bioethics & Society: Ethical issues on New Genetics – Human Genome Project – Gene therapy – Genetic screening – Experimentation with human subjects -National Practice of health care – Public & Private Medical Practice, Eugenic and bioethics. National resource allocations.

Unit III

Ethics of Conservation – Values of Biodiversity, Biopiracy, Hybridized plants, GM crops - benefits and criticism, Economic Value of Biodiversity. & ELSA - Legal, Ethical and Conservation issues related to uses of biodiversity, Global Conservation Issues. Endangered Species Conservation – The US Endangered Species Act, State Endangered Species Acts, Successes and Failures of the Endangered Species Act. Role of Endangered Species Act (ESA) in Habitat Protection, Critical Habitat, Problems with the Endangered Species Act, Habitat Conservation. Conservation of migratory species, Nagoya Protocol.

Unit IV

Intellectual property rights (IPR), sovereignty rights, Convention on Biodiversity (CBD), bioethics and patenting, General agreement on trade and tariffs (GATT) Indian sui-generis system for animal variety and farmer's rights protection act, PVFRA, WTO with reference to biotechnological affairs, TRIPs. Patent application procedure, Patent claims, the legal decision–making process, ownership of tangible and intellectual property, Patent litigation. Basic Requirements of Patentability: Patentable subject matter, novelty and the public domain, non - obviousness. Special issues in Biotechnology Patents: Disclosure requirements, Collaborative research, Competitive research. Recent Developments in Patent Systems and Patentability of biotechnological inventions. TRL and licensing. Biodiversity Act 2022. Patentability of marine biotechnological interventions and marine biological resources.

Unit V

Entrepreneurship 15L Concept, definition, structure and theories of

entrepreneurship. Types of start-ups. Types of entrepreneurship, environment, process of entrepreneurial development, Entrepreneurial culture, entrepreneurial leadership, Product planning and development. Project management Search for business ideas. Concept of projects. Project identification formulation. Design and network analysis. Project report and project appraisal. Patenting of life forms- including microbes, compulsory licensing.

References

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2. Sibi, G - Intellectual property rights, bioethics, biosafety and entrepreneurship in biotechnology (2021), Dreamtech Press
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6. Eastern Law House
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10. http://www.cbd.int/biosafety/background.shtml
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24-864- 0203: DISCOVERY OF MARINE DRUG AND NUTRACEUTICALS

Outcome:

After completing this course, the students will be able to

- ***CO 1:*** *Appreciate the potential of marine organisms in the development of novel drugs and nutraceuticals*
- ***CO 2:*** *Develop suitable methods for isolation and characterization of marine natural products*
- ***CO 3:*** *Develop suitable bioassays for screening bioactivities of marine natural products*
- *CO 4:* *Describe genomic approach used for discovering novel bioactive compounds*
- *CO 5:* *Become aware of the role of IPR in development of marine natural products and nutraceuticals*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	1	1	1	3	3	3
CO2	3	3	1	1	2	3	1
CO3	1	1	1	1	3	3	3
CO4	1	1	1	1	3	3	3
CO5	1	1	1	1	3	3	1

Unit I

Marine Natural products as Drug Leads: Natural products as Drug lead, Marine Environment as source of natural products, Marine chemical ecology; Bioprospecting deep-sea, polar ocean, twilight zone, symbiotic microorganisms. Challenges in natural product research. Dereplication tools in Natural Product research; GNPS and Modern Applications with Molecular Networking, Natural Product Atlas, AntiBase, MarinLit, BioMAP

Unit II

Isolation and Characterization of Marine Natural Products: Isolation and separation of marine natural products (MNP) from marine flora and fauna; extraction methods; bioassay guided fractionation; chromatographic separation, Types of chromatographic separations (TLC, paper, Flash Chromatography, HPLC), HPLC method development for Isolation, Column selection, Characterization of lead compounds, LC-MS, NMR. Mass Spectrometry, interpretation of LC-MS and NMR data.

Unit III

Drug Screening Platforms and Bioassays: Drug target identification and

validation, Assay development for bioactivity screening, High throughput and high content screening strategies: In vitro biochemical and cell based assays; Reporter Gene based Assays. Chromogenic assays; Fluorescence assays; Fluorescence polarization; Homogenous time resolved fluorescence assays; Fluorescence resonance energy transfer (FRET), BRET, Anticancer activity screening assays: DNA laddering assay; TUNEL Assay, SRB Assay, MTT assay; LDH assay; Caspase assay; NCI60 anticancer screening programme; Antibacterial assays; quorum sensing and biofilm inhibition assays, antifungal assays; antiviral assays; Anti-inflammatory assays; Assays for tropical diseases.

Unit IV

Source and nature of marine bioactive compounds: Diversity of marine

organisms, sources of bioactive compounds, Chemical diversity of marine compounds, Marine Toxins, Marine enzymes; pigments; nutracetuicals;, Marine biominerals; Biominerelized structures; Biocomposites; Biopolymers- polysaccharides, chitin, marine collagens. Marine derived drugs in use, and their use and mode of action.

Unit V

Marine Genomics and marine natural products : Biosynthetic pathways, Polyketide synthase (PKS I& II) non-ribosomal peptide synthetase, hybrid pathways, Mevalonate pathway, Biosynthetic gene cluster (BGC) identification, Secondary Metabolite. Unique Regions Finder (SMURF), antiSMASH, Cryptic Natural Products- its induction. Metagenome based MNP discovery, synthetic biology approach for MNP synthesis.

Marine genetic resources , IPR ,access and Benefit Sharing: National Biodiversity Act, National Biodiversity Strategy, resource utilization, Intellectual Property Right (IPR), access and Benefit sharing, Convention on Biological Diversity (CBD), United Nations Convention on the Law of the Sea (UNCLOS), conservation and sustainable use of marine biodiversity in Areas Beyond National Jurisdiction.

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24-864- 0204 - AQUACULTURE GENOMICS

Outcome:

After completing this course, the students will be able to

CO1: *Apply molecular markers in genetic improvement of aquacultured species, demonstrating proficiency in marker-assisted selection techniques.*

CO2: *Understand the epigenetic impacts in aquaculture, analyzing how epigenetic factors influence traits in cultured species.*

CO3: *Explore the application of functional genomics in enhancing*

disease resistance and growth in aquaculture species.

CO4: *Utilize methods of transgenesis in aquaculture, applying genetic engineering techniques to modify aquatic organisms.*

CO5: *Evaluate the impact of transgenic organisms on wild species and genetic ecosystems, assessing potential risks of genetic pollution.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	2	2	2	2	1
CO2	2	2	3	2	1	1	1
CO3	3	3	3	2	2	2	1
CO4	2	2	3	3	2	2	1
CO5	2	2	2	2	3	2	1

Unit- I

History and Scope of aquaculture, Aquaculture practices of different parts of the world, Present global and national scenario. General principles of Aquaculture. Classification of fish farms and farming techniques, Criteria for selection of species for aquaculture. Commercially important aquaculture species. Recent trends in aquaculture: Integrated multitrophic aquaculture systems (IMTA), Recirculatory aquaculture system, Aquaponics, Biofloc, Ecosystem approach to aquaculture. Overview on the breeding and seed production of commercially important fishes, Endocrine control on reproduction of fishes and shellfishes.

Unit II

Genomics in Aquaculture - History, Applications and benefits of genomics in aquaculture, Milestones in aquaculture genomics. Genomic Tools for Aquatic Organisms - Molecular markers, genetic mapping, and genome sequencing techniques, Case studies in Aquaculture Genomics, Transcriptomics and Gene Expression - Relevance of gene expression analysis in aquaculture; Differential gene expression analysis of immune

genes. Epigenetics impact in aquaculture - Influence of epigenetics on gene regulation and phenotype, Applications of functional genomics in disease resistance and growth improvement.

Unit III

Selective breeding programmes- Current status, Development of selective breeding plans, Individual or mass selection, Selection within cohorts and exchange of breeders, Within-family and between-family selection, Combined selection. Progeny testing, Factors affecting selective breeding, Broodstock management: inbreeding, hybridization and Crossbreeding, Pure breeding, genetic drift, domestication. Short-term and long-term genetic improvement strategies, Chromosome set manipulations and sex manipulations. DNA markers and mapping QTLs and marker-assisted selection, Constraints and opportunities Case studies in selective Breeding programs.

Unit IV

Introduction to transgenesis, Basics of genetic engineering and its applications in aquaculture. Development of Transgenic Fishes: Methods and techniques for introducing foreign genes. Genetically Modified Fishes: Examples of transgenic fishes and their modified traits. Applications of Transgenesis in Aquaculture - Growth Enhancement: Genetic modification for improved growth rates and size, Disease Resistance: Developing fishes with enhanced resistance to common pathogens, Protein Quality Improvement: Modifying fishes for improved nutritional content, Tailoring Fishes for Specific Environments: Adapting species for varying aquatic conditions, Ornamental Fishes: The case of glow fish and other genetically modified ornamental species. Benefits and Risks: Assessing the advantages and potential drawbacks of transgenic fishes in aquaculture

Unit V

Ethical Considerations in Aquaculture Genomics Research: Animal welfare and genetic modification. Regulatory Frameworks: International

and national regulations governing aquaculture genomics. Socioeconomic Implications: Balancing technological advancements with societal needs. Future Directions: Emerging trends and potential advancements in aquaculture genomics.

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24-864-0207 - IMMUNOGENOMICS & PHARMACOGENOMICS

Outcome:

After completing this course, the students will be able to

CO1: *Understand the concept of personalized medicine in aquaculture, analyzing its application to individualized treatment strategies.*

CO2: *Utilize genomic databases and resources in immunogenetics and pharmacogenomics, applying bioinformatics tools for data analysis.*

CO3: *Extend understanding of marine natural products used to enhance immunity and manage diseases, evaluating their potential applications in aquaculture.*

CO4: *Design vaccines in-silico using bioinformatics tools, demonstrating proficiency in computational vaccine design techniques.*

CO5: *Analyze genetically engineered vaccines, evaluating their development, efficacy, and potential impacts in aquaculture.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	1	1	1	1	1
CO2	3	3	2	1	1	1	1
CO3	2	2	3	1	2	1	1
CO4	3	3	3	2	2	2	1
CO5	2	2	2	1	3	1	1

Unit-I

Introduction to Immunogenomics and Pharmacogenomics in Marine Species - Overview of Immunogenomics and Pharmacogenomics - Introduction to pharmacogenomics and personalized medicine in aquaculture. Importance in the context of marine science and aquaculture.

Unit-II

Basic principles of the immune system in marine organisms. Host-pathogen interactions in marine organisms. Genomic databases and resources in immunogenomics and pharmacogenomics. Genetic diagnosis of disease: Methods and ethical issues. Genetic basis of immune response in aquaculture species.Genomic approaches to disease resistance in aquaculture.

Unit-III

Immunogenetics To Immunomics: Functional prospects of gene and transcripts, Identification of potential genes responsible for pathogenesis-case study of DNA microarray applications – Immunogenomics. Immunoinformatics: Bioinformatics strategies for better understanding of immune function, Future of computational modeling and prediction systems in clinical immunology, Role of Immunoinformatics in personalized medicine. From immunome to vaccine- epitope mapping, vaccine design tools. Insights from MHC bound peptides.

Unit-IV

Introduction to marine pharmacology Terms and definitions; Medicinal

compounds from marine flora and fauna -marine toxins, antiviral and antimicrobial agents. Pharmacogenetics. High throughput screening in the genome for drug discovery. Identification of gene targets, Pharmacogenetics and drug development. Transcriptomics and proteomics in marine immunology and pharmacology. Genetic factors influencing drug response in marine species. Genomic scale assessment of toxicology of drugs and environmental agents. Pharmacogenomics for optimizing drug therapies in aquaculture. Case studies on pharmacogenomics in aquaculture fisheries.

Unit-V

Computational Vaccinology- Vaccines- conventional vaccines- attenuated, killed and subunit vaccines; modern vaccines-recombinant vaccines, DNA vaccines and edible vaccines. Vaccine design - *In silico* vaccination. Immunogenomics and gene expression changes in adaptive response. Immunoinformatics databases, knowledge bases, ontologies. Modeling immune responses. Artificial immune system. Gene networks, Systems biology in immunity, Allergenicity prediction.

References

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24-864-0208 - SYSTEMS BIOLOGY

Outcome:

After completing this course, the students will be able to

CO1: *Develop an understanding on importance of systems biology in marine research*

CO2: *Construct and analyse biological networks*

CO3: *Understand inter-organism interactions and intra-organism interactions*

CO4: *Apply OMICS tools in understanding the functionalities in complex marine systems*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	1	1	3
CO2	3	1	1	2	1	1	1
CO3	2	2	3	1	2	1	1
CO4	3	3	3	2	2	2	1

Unit-I:

Introduction to Systems Biology and Its Application in Marine Sciences - Overview of Systems Biology: Concepts and Principles. Importance of Systems Biology in Marine Research. Emergence of Systems Biology Approaches. Case Studies: Applications in Marine Ecosystems.

Unit-II

Network Biology and Data Integration in Marine Systems - Principles of Network Biology. Construction and Analysis of Biological Networks. Integration of Omics Data in Marine Biology. Case Studies: Understanding Marine Biological Systems through Networks. Metabolic engineering. Synthetic Biology. Inter-organism interactions and interactions within the organism. Metabolic cell signaling networks.

Unit-III

Environmental Systems Biology - Systems Approaches to Understanding Marine Ecosystems. Impact of Climate Change on Marine Systems. Systems Biology of Marine Microbial Communities. Case Studies: Environmental Systems Biology in Action.

Unit-IV

Systems Pharmacology and Marine Biotechnology - Systems Pharmacology: Bridging Biology and Medicine. Applications of Systems Biology in Marine Biotechnology. Synthetic Biology in Marine Organisms. Future Directions and Emerging Technologies in Marine Systems Biology.

Unit V

Integrative Omics and Systems Biology-Multi-Omics Approaches in Marine Research. Network Biology and Pathway Analysis. Data Integration and Visualization. Systems Biology Approaches to Understand Marine Biological Processes. Future Directions and Emerging

Technologies in Marine Omics. Computational methods in System Biology.

References

1. Edda Clip, Wolfram Liebermeister, Christoph Vierling and Axel Kowald - Systems Biology - A textbook (2009) - Published by Wiley VCH
2. Karthik Raman - An introduction to computational systems biology - systems level modeling of cellular networks (2021) - Published by CRC Press
3. Masao Nagasaki, Ayumo Saito, Atsushi Doi, Hiroshi Matsuno and Satoro Miyano - Foundations of systems biology - Using cell illustrator and pathway databases (2017) - Published by Springer
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6. Marian Walhout, A.J., Marc Vidal and Job Dekker - Handbook of systems biology (2013) Published by Elsevier Press
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24-864-0209 - MARINE MICROBIOLOGY

Outcome:

After completing this course, the students will be able to

- ***CO1:*** *Explain the Origin, Scope, and Significance of Marine Microbiology*
- ***CO2:*** *Analyze Metabolic Diversity and Ecophysiology of Marine Microbes*
- ***CO3:*** *Describe Marine Microbial Diversity and Evolution*
- ***CO4:*** *Evaluate the Role and Significance of Extremophiles in Marine Environments*
- ***CO5:*** *Analyze Microbial Interactions and their Impact on Marine Ecosystems*
- ***CO6:*** *Assess the Contribution of Marine Microbes to Biotechnological Applications*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	1	2	1	1	1	1	3
CO2	1	2	1	1	1	3	3
CO3	1	2	1	1	1	3	3
CO4	1	2	1	3	1	3	3
CO5	1	2	1	1	3	3	3
CO6	1	1	1	1	3	3	3

Unit I

Introduction to marine microbiology, Origin and scope of marine microbiology,Significance of three domain classification, Metabolic diversity and ecophysiology of marine microbes:Sources of energy and carbon, phototrophy and chemotrophy, carbon and nitrogen fixation,

Heterotrophic metabolism. Overview of marine bacterial diversity- major families with examples, OTUs ASVs, Candidatus phyla radiation,

Unit II

Marine Archae, Methanogens and Anaerobic methane oxidisers, Sulfate reducers and iron oxidisers, hyperthermophiles and extreme halophiles. Significance of extremophiles, Parasitic archaea.

Marine Eukaryotic microbes: Marine protists and their role in marine ecosystem.Prymnesiophytes and diatoms, Thraustochytrids and labyrinthulids, Radiolarians and Foraminiferans, Marine fungi

Unit III

Marine viruses, Phages infecting archaea and bacteria, Co evolution of bacteria and their phage, Nucleocytoplasmic large marine viruses (NCLDVs) and other giant viruses Pathogenic viruses, viral shunt and nutrient recycling, Role of marine virus in microbial loop.

Unit IV

Microbial interactions: Photosynthetic, Chemosynthetic and heterotrophic symbiotic microbes, Zooxanthellae, chemosynthetic microbes in deep sea and hydrothermal vent organisms, Endosymbionts, Bacterial bioluminescence. Microbial diseases of marine organisms-diseases of seagrasses, sea weeds, corals, sponges, molluscs, echinoderms, fishes reptiles and marine mammals.Microbial human pathogens of marine origin

Unit V

Role of microbes in biofouling and biodeterioration, Microbial indicators of marine pollution, Marine microbes in bioremediation, Marine microbial biotechnology : Enzymes, biofuels, polymers from marine microbes, nutraceuticals and bioactive compounds produced by marine microbes.

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SEMESTER-III

24-864- 0301 BIOCHEMISTRY AND NUTRIGENOMICS

Outcome:

After completing this course, the students will be able to

CO1: *Describe the structure, physico-chemical properties and functions of the major biological macromolecules*

CO2: *Explain the role of biologically important molecules in cell structure and function*

CO3: *Analyze and formulate mechanisms of enzymatic reactions*

CO4: *Extend understanding on the role of gut microbiome in health and disease conditions*

CO5: *Use advanced analytical instruments in modern biochemical research*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	1	1	1	1	3	1	3
CO2	1	1	1	1	3	1	3
CO3	1	2	1	1	1	1	3
CO4	1	1	2	1	1	1	1
CO5	1	1	1	1	3	1	3

Unit I

Structure, composition and properties of nucleic acids: Chemical structure of purines, pyrimidines AMP, ADP and ATP.Primary and secondary structures of RNA and DNA.Nucleic acid metabolism.Outline study of replication and transcription of DNA. Structural features and biochemical functions of different types of RNA. The genetic code: Characteristics of the genetic code. Activation of amino acids and translation.Ribosomal events in translation.

Unit II

Basic concepts of Biochemistry: An overview, Types of chemical bonds, Bio-elements, Biomolecules and functions of biomolecules. Classification and physicochemical properties of carbohydrates.Structure, chemistry and biological roles of monosaccharides, disaccharides, homo and hetero-polysaccharides and other complex polysaccharides. Marine polysaccharides. Dietary carbohydrates. Digestion and absorption of carbohydrates. Outline of carbohydrate metabolism: glycogenesis, glycogenolysis, glycolysis,gluconeogenesis, HMP pathway, citric acid cycle, electron transport chain and oxidative phosphorylation.

Unit III

Classification of Lipids. Structure and physicochemical properties of fats, oils and waxes. Fatty acid nomenclature, Characterization of fats and oils. Structure and biological roles of triglycerides, polyunsaturated fatty acids (PUFA), lipoproteins, phospholipids and sphingolipids. Chemistry and properties of Prostaglandins, leukotrienes, thromboxanes, sterols and steroids, Fat-soluble vitamins. Digestion and absorption of triglycerides. Overview of lipid metabolism, Fatty acid biosynthesis and oxidation, ketone body metabolism, Reactions and ATP yield in β-oxidation of palmitic acid. Cholesterol metabolism.

Unit IV

Classification, structure and properties of standard amino acids. Essential and non-essential amino acids. Biological roles of non-protein aminoacids. Effect of pH on the ionic forms of alanine. Elementary study of the primary, secondary, tertiary and quaternary structures of proteins. Ramachandran Plot, Basic principles of the analysis of the aminoacid sequence of polypeptides. Overview of aminoacid metabolism: Aminoacid biosynthesis. Catabolism of amino acid nitrogen -transamination, deamination, ammonia formation and urea cycle. Catabolism of amino acid carbon skeleton. Classification and nomenclature of enzymes. Effect of enzyme concentration, substrate concentration, temperature and pH on

enzyme activity. Michaelis-Menten equation. The Double reciprocal plot. Determination of Km and Vmax values. Enzyme inhibitors, Competitive and Non-competitive inhibition, Allosteric modulation. Zymogens. Co-enzymes, cofactors & vitamins. Biochemical role of water and fat-soluble vitamins in metabolism.

Unit V

Nutrigenomics: Introduction to nutritional genetics and genomics, Scope and Importance to Human Health and Industry, Public health significance of nutrigenomics and nutrigenetics. Nutrients and Gene expression with its regulation, Nutrients and epigenetics: Molecular methods used in nutritional genomics. Transporter gene polymorphisms -interaction with effects of micronutrients in humans. Polymorphisms in genes affecting the uptake and transport of omega-6 and omega-3 polyunsaturated fatty acids: interactions with dietary lipids and chronic disease risk. Nutrigenomics and nutrigenetics in ageing and calorie restriction, obesity, Cardiovascular disease and cancer. The gut microbiome - role in nutrigenomics.

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24-864- 0302 CONSERVATION GENOMICS

Course Outcome (CO):

After completing the course, students will be able to

CO1: Develop strategies for in-situ and ex-situ conservation

CO2: Extend understanding on cryptic species and barriers to natural gene flow

CO3: Explain the need for marine protected areas and marine bio-reserves to safeguard marine biodiversity

CO4: Use population genetics tools to understand genetic variation among the species

CO5: Develop ecosystem restoration and management practices

CO6: Know activities of DBT, NBFGR, ZSI, CMLRE, FSI etc.

CO/PO	PS01	PS02	PS03	PS04	PS05	PS06	PS07
CO1	2	3	1	3	1	3	2
CO2	3	3	1	2	1	3	2
CO3	1	2	1	3	1	2	2
CO4	2	3	1	3	1	2	2
CO5	2	2	1	3	1	2	2
CO6	1	1	1	1	1	1	3

Unit 1

Conservation of Biodiversity- Strategies for conservation: In-situ and ex-situ conservation- environmental assessment, protected areas-biosphere reserves, national parks, sanctuaries, Status of marine biodiversity and conservation, Vulnerable, endangered and critically endangered marine species, De-extinction, Torpid species, Habitat degradation and fragmentation; inbreeding and inbreeding depression; Barriers to natural gene flow, Cryptic species.

Unit II

Taxonomic units for conservation; International agreements, Illegal and commercial trade in wildlife, CITES; Marine national parks and Marine protected areas, Large Marine Ecosystems (LMEs) etc. Integrated Coastal Zone Management. International regulations related to maritime boundaries (UNCLOS, ANMJ, BBNJ etc.), EEZ and territorial waters.

Unit III

Introduction to Population Genetics, elements of population genetics. - Genetic variation. - Characterization of DNA sequence variations - Algebra of Probabilities, Population genomics of critically endangered marine species, eDNA, eDNA for population genetics, Application of genomics in population and biodiversity assessments; Admixture and species delineation, Association mapping and adaptation; Genomic inbreeding and genetic rescue

Unit IV

Genetic Conservation-Phenotypic and chromosomal variations, Genetic variation in natural populations – Proteins to Genomics, Hardy-Weinberg principle, Genetic drift, Effective population size, Natural selection, Population subdivision, Linkage disequilibrium, - Neutral evolution - Molecular clock, tests of neutrality. Quantitative genetics, Genetic identification and monitoring, Demography and Extinction, Genetic rescue Inbreeding depression, Metapopulations and fragmentation, Units of conservation, Hybridization, Exploited populations, and Conservation breeding.

Unit V

Ecosystem Restoration and Management Practices- Global biodiversity and its importance, Different approaches of biodiversity conservation and management, registering biodiversity. Conservation Practices in India and World- Organizations involved in resource, conservation IUCN,

WWF, UNEP, UNESCO, Biodiversity International, IPGRI, FAO, BSI, ZSI. Phytogeography – Hotspots of India and world. General account on activities of DBT, BSI, NBPGR, ZSI, FSI, NBFGR and NBAGR NFPTCR, Sacred groves, Biodiversity register.

References

1. F. W. Allendorf , G. Luikart, and S. Aitken (2012).Conservation and the Genetics of Populations; 2nd Edition, Blackwell Publishing.
2. Gillespie, J. H. 2004 Population Genetics, a concise guide. 2nd Edition. The John Hopkins University Press. — pretty reasonably priced, pretty good book.
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4. Dudgeon, D. (2020). Freshwater Biodiversity. Cambridge University Press.
5. Iriondo, J. M., Maxited, N. and Dulloo, M.E (2008) Conserving plant genetic diversity in protected areas – population management of crop wild relatives. Biddles Ltd. Kings' Lynn.
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7. Reed, D. H. and R. Frankham. 2001. How closely correlated are molecular and quantitative measures of genetic variation? Evolution 55(6); 1095-1103.
8. Frankham, R., Ballou, J.D. and Briscoe, D.A. - Introduction to Conservation genetics (2012) - Published by Cambridge University Press
9. Loeschcke, V. and Subodh K Jain - Conservation genetics (2018) - Published by Birkhauser

24-864- 0303 TRANSCRIPTOMICS & PROTEOMICS

Outcome:

After completing this course, the students will be able to

- ***CO1:*** *Extend understanding of concepts and applications of functional genomics, analyzing its relevance in current research.*
- ***CO2:*** *Apply tools and techniques in functional genomics, demonstrating proficiency in experimental methodologies.*
- ***CO3:*** *Utilize applications of transcriptomics in research, applying transcriptomic techniques to study gene expression.*
- ***CO4:*** *Use high throughput technologies for proteome analysis, demonstrating proficiency in proteomic data generation and analysis.*
- ***CO5:*** *Analyze bioinformatic tools for transcriptomic and proteomic data analysis, evaluating data outputs and drawing conclusions.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	2	1	1	1	1
CO2	3	3	2	1	1	1	1
CO3	2	2	3	1	1	1	1
CO4	2	2	2	3	2	2	1
CO5	2	2	2	2	3	2	1

Unit-I

Introduction to Functional Genomics in Marine Biology - Overview of Functional Genomics: Concepts and Applications. Importance of Functional Genomics in Marine Research. Techniques and Tools for Functional Genomics. Case Studies: Successful Applications in Marine Biology.

Unit-II

Fundamentals of Transcriptomics - Overview of Transcriptomics and its importance in the context of marine sciences. Basics of RNA: Structure and Function. RNAi, MicroRNAs. Transcriptome, Single cell transcriptomics, applications of transcriptomics, transcriptome databases, Transcriptome assembly, annotation and analysis. Techniques in Transcriptome Analysis. Transcriptomic Data Generation and Quality Control. Differential Gene Expression Analysis. Basic principles of gene expression and protein synthesis. High-throughput technologies for transcriptomic and proteomic analysis. Marine Transcriptomics. Case Studies: Applications of Transcriptomics in Marine Biology.

Unit-III

Proteomics in Marine Systems-Introduction to Proteomics: Principles and Methods. Sample Preparation and Protein Extraction. High-throughput technologies for proteomic analysis. Mass Spectrometry in Proteomics. Quantitative Proteomics Techniques. Applications of Proteomics in Marine Biology.

Unit-IV

Experimental Techniques in Transcriptomics and Proteomics - RNA sequencing (RNA-seq) for marine organisms. Quantitative PCR (qPCR) and reverse transcription PCR (RT-PCR). Mass spectrometry and 2D gel electrophoresis for proteomic analysis. Sample preparation and data collection techniques. Long-Read Sequencing Technologies. Functional Genomics and CRISPR/Cas9 Applications. Integration of Transcriptomic Data with Other Omics Data. Data Analysis and Interpretation - Bioinformatics tools for transcriptomic and proteomic data analysis. Differential gene expression analysis. Functional annotation and pathway analysis. Visualization tools for omics data

Unit-V

Transcriptomic and proteomic studies in marine ecosystems. Molecular responses to environmental stress in marine organisms. Applications in marine conservation and biodiversity studies. Case studies on the use of omics in marine ecology**.** Advanced Topics and Future Directions - Single-cell transcriptomics and spatial transcriptomics. Proteogenomics: Integrating genomics and proteomics data. Emerging technologies and trends in marine omics research. Ethical considerations and challenges in marine omics.

References

1. Bioinformatics and Functional Genomics (2003) by Jonathan Pevsner. 3rd edition. Publisher Wiley Blackwell
2. Discovering Genomics, Proteomics and Bioinformatics (2003) by Malcolm Campell and Laurie J Heyer
3. Introduction to Genomics (2017) by Arthur Lesk
4. PCR Applications: Protocols for functional genomics (2013) by Michael A Innis, David G Gelfand and John J Sninsky. Academic Press
5. Functional Genomics – Methods and protocols (2017) Editors Kauffman Michael, Klinger Claudia and Savelsbergh Andreas – e book.
6. Geraldo A Passos - Transcriptomics in Health and Disease (2022) - Published by Springer
7. Rakeeb Ahmad Mir, Sheik Manzoor Shafi and Sajad Majeed Sargar - Principles of genomics and proteomics (2023) Published by elsevier Inc.
8. Azamel Husen and Altaf Ahamad - Genomics, transcriptomics, proteomics and metabolomics of crop plants (2023) - Published by Academic Press.

24-864-0304 – BIOINFORMATICS

Outcome:

After completing this course, the students will be able to

CO 1: *Analyse the genetic sequences for phylogeny*

CO 2: *Develop an idea about the utility of Nucleic acid sequence databases and protein sequence databases*

CO 3: *Apply bioinformatics resources in marine genomics research*

CO 4: *Apply sequence based database search and usage of BLAST and FASTA algorithms*

CO 5: *Understand current advancements in bioinformatics*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	1	3	2	1	3
CO2	3	3	2	1	1	1	3
CO3	2	2	3	2	1	3	3
CO4	2	2	2	3	2	2	1
CO5	2	2	2	2	3	2	3

Unit I

Introduction to bioinformatics, bioinformatic resources and its applications. Types of datas-Various databases and bioinformatic tools. Nucleic acid sequence databases: GenBank, EMBL, DDBJ. Protein sequence databases: SWISS-PROT, TrEMBL, PIR, PDB. Genome Databases at NCBI, EBI, TIGR, SANGER. Other Databases of Patterns/Motifs/System Biology (Gene and protein network database and resources). Biological Data Acquisition: The form of biological information. Retrieval methods for DNA sequence, protein sequence and protein structure information; R packages.

Unit II

Sequence analysis: Various file formats for bio-molecular sequences: genbank, fasta, gcg, msf, nbrf-pir etc. Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues. Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series. Sequence-based Database Searches: BLAST and FASTA algorithms, various versions of basic BLAST and FASTA.

Unit III

Introduction to sequences and alignments. Local alignment and Global alignment. Pairwise and Multiple sequence alignments: basic concepts of sequence alignment, Needleman &Wuncsh, Smith & Waterman algorithms for pairwise alignments, Progressive and hierarchical algorithms for MSA. Use of pairwise alignments and Multiple sequence alignment for analysis of Nucleic acid and protein sequences and interpretation of results.

Unit IV

Phylogeny: Phylogenetic analysis, Definition and description of phylogenetic trees and various types of trees, Method of construction of Phylogenetic trees [distance based method (UPGMA, NJ), Maximum Parsimony and Maximum Likelihood method]

Unit V

Methods for presenting large quantities of biological data: sequence viewers (Artemis, SeqVISTA), 3D structure viewers (Rasmol, SPDBv, Chime, Cn3D, PyMol), Anatomical visualization. Current Advancements in Bioinformatics: Introduction to Systems Biology, Structural Biology, Structural bioinformatics, Chemoinformatics, Immunoinformatics etc.

References

1. Bioinformatics Algorithms (2014) An Active Learning Approach by Pavel A Pevsner and Philip Compeau

2. Bioinformatics and Functional Genomics 3rd edition (2003) by Jonathan Pevsner, Publisher Wiley Blackwell
3. Essential Bioinformatics (2006) by Jin Xiong. Cambridge University Press
4. Introduction to Bioinformatics (1999) Teresa K Attwood and David J Parry-Smith. Longman Publishers
5. Bioinformatics: Tools and Applications (2009) David Edwards, Jason Eric Stajich, David Hansen, Springer.
6. Bioinformatics: Sequence and genome analysis 2nd edition (2004), David W Mount Cold spring harbor laboratory press.
7. Thomas Dandekar, Meik Kunz (2023). Bioinformatics, An introductory text book, Springer Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-65036-3

24-864-0308 - MARINE ECOLOGY

Course Outcome (CO):

After completing the course, students will be able to

CO1: *Describe the different ecological features of marine ecosystems inrelation to the biotic and abiotic characteristics*

CO2: *Explain the nutrient cycles and exchanges in the marine environment*

CO3: *Describe the population characteristics including biogeography andtheir interconnections*

CO4: *Examine the impact of climate change, globalization and human action on the marine environment*

CO5: *Explain and operate different sampling techniques inmarine ecology studies*

CO/PO	PS01	PS02	PS03	PS04	PS05	PS06	PS07
CO1	1	3	1	3	1	2	3
CO2	2	2	1	2	1	3	3
CO3	2	2	1	3	1	3	2
CO4	2	3	1	3	1	2	2
CO5	1	2	1	3	2	1	3

Unit-I

Introduction and history of Marine Ecology. Important national and International marine institutes and personalities related to marine ecology. Physical and chemical features of the marine environment, Ecology of coastal and deep sea ecosystem.

Unit-II

Population dynamics- growth characteristics -natality, mortality, emigration and immigration. Population density and measurements, natural regulation of population size. r-selection and k-selection. Limitations of the population approach. Concept of yield. Species interactions -competition, predation and grazing. Bioinvasions.

Unit-III

Concept of community -community as a unit of study and its characteristics, growth forms, succession, keystone species, dominant species. Stratification in marine communities. Concepts of the ecotone, organic production, standing crop, food web, trophic structure, energy flow, ecological pyramids and modelling.

Unit-IV

Marine ecosystems and climate change -climate forcing on marine ecosystem, Climate change-adaptations and mitigations, Human impact on marine ecosystem, socio -ecological aspects of global warming and sea level rise. Marine ecosystem and marine resource management in the changing scenario. Chemical ecology.

Unit-V

Sampling designs for marine ecological studies -Profiling a beach, underwater profiles and techniques. Sampling populations –sampling designs, physico-chemical parameters,timing of sampling, size of the sampling area, sample size.Quantitative sampling –Various types of random sampling, quadrat method, fixed quadrat, point contact, line and belt transect, sequential sampling, rapid sampling methods, visual observation, cluster sampling, Strong method, Weinberg method and Mark/tag recapture method. Quantitative analysis -Types, standardization and transformation of data. Diversity and related indices -species richness, diversity, evenness and dominance, niche breadth, niche overlap and concordance. Softwares used for quantitative analysis of ecological parameters – PRIMER, PERMANOVA. SPSS.

References

1. Anastasios, Eleftheriou.,& Alsdair, Mclntyre. (2013). *Methods for the Study of Marine Benthos* (4th Edition). Wiley-Blackwell.
2. Barbara,Charton. (2007). *The Facts on File Dictionary of Marine Science (Facts on File Science Dictionary).* Facts on File
3. Barnes R.S.K., R.N. Hughes (1999). *An Introduction to Marine Ecology* (3rd Edition). Blackwell Publishing.
4. Odum, E.P.(1971). *Fundamentals of Ecology* (3rd Edition).W.B Saunders Co.
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9. Jeffrey, S. Levinton. (2017). *Marine Biology: Function, Biodiversity, Ecology* (5th Edition). Oxford University Press, USA.
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16. Moore, H.B. (1958). *Marine Ecology*. London: Chapman and Hall.
17. Newwell, R.C. (1970). *Biology of Intertidal animals*. Pisces Conservation Ltd, Logos Books.
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19. Tait R.V., Dipper F.A (1998). *Elements of Marine Ecology* (4th Edition), Elsivier
20. Yonge,C.M. (1990). *The Collins New Naturalist Series -The Sea Shore* (3rd Edition). Collins Bloomsbury Books.
21. https://marinespecies.org

22. https://obis.org/

23. https://www.sealifebase.ca/

24. http://www.worldoceanobservatory.org/

24-864-0309- ECOLOGICAL & EVOLUTIONARY GENOMICS

Course Outcome (CO):

After completing the course, students will be able to

- ***CO1:*** *Extend understanding of the role of genomics in understanding marine ecosystems*
- ***CO2:*** *Analyze genomic response to environmental stress*
- ***CO3:*** *Understand the concept of molecular clock*

CO/PO	PS01	PS02	PS03	PS04	PS05	PS06	PS07
CO1	3	3	1	2	1	2	3
CO2	3	3	1	3	1	3	2
CO3	3	3	1	1	1	2	2

Unit I

Introduction to Ecological and Evolutionary Genomics - Overview of Ecological and Evolutionary Genomics; Importance of genomics in understanding marine ecosystems; Key concepts in molecular ecology

Unit II

Ecological Genomics in Marine Adaptations - Molecular basis of adaptation in marine organisms; Genomic responses to environmental stress; Case studies on marine species adaptation

Unit III

Evolutionary Genomics and Phylogenetics - Principles of evolutionary genomics; Fundamentals of Phylogenetics, Phylogenomics. Phylogenomic Analyses. Phylogenetic trees. Population genomics. Phenotypic plasticity. Molecular phylogenetics and its application in marine science.

Unit IV

Comparative and evolutionary genomics; Comparative genomics across marine taxa Gene duplication; Genome duplication; Paralogous and orthologous genes; Neo-functionalization; Nucleotide substitution; Evolutionary rate; Molecular clock; Synonymous and non-synonymous substitution

Unit V

Case studies- microevolution of marine organisms. Major issues in marine ecological genomics. Genomic models for evolutionary biology.

References

1. Christian R Landry and Nadia Aubin Horth - Ecological Genomics, Ecology and evolution of genes and genomes (2014) - Published by Springer Nature.
2. Nico M Vaanstralen and Dick Roelofs - An introduction to ecological genomics (2006) - Published by Oxford university Press
3. U.S. Raghavender - Ecological Genomics (2018) - Published by Delve Publishing
4. Naruya Saitou - Introduction to evolutionary genomics (2018) - Published by Springer
5. Pierre Pontarotti - Evolutionary Biology, genome evolution, speciation, co-evolution and origin of life (2014) - Published by Springer.

IV SEMESTER

24-864-0401

Project work and Dissertation – (Core) Credits: 18

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PRACTICALS

SEMESTER-I

24-864- 0104 MOLECULAR BIOLOGY

Outcome:

After completing this course, the students will be able to:

CO1: *Apply molecular biology techniques to perform accurate DNA and RNA isolations from marine animal tissues, employing spectrophotometry and gel electrophoresis for quality assessment.*

CO2: *Execute PCR amplification, TA cloning, and heterologous gene expression protocols proficiently, demonstrating mastery in genetic manipulation techniques.*

CO3: *Analyze recombinant proteins using SDS-PAGE, Western blotting, and Ni-NTA column purification to characterize protein structure and function.*

CO4: *Evaluate gene expression levels using real-time PCR and 2-dimensional gel electrophoresis, interpreting differential gene expression patterns and their implications.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	1	2	2	2	1
CO2	2	3	1	2	1	2	1
CO3	2	1	3	2	1	3	2
CO4	1	2	2	3	2	2	3
CO1	3	2	1	2	2	2	1

1. Preparation of buffers and reagents for molecular biology.
2. DNA isolation from marine animal tissues

a. Evaluation of DNA quality.

b. Spectrophotometry .

c. Gel electrophoresis

3. RNA isolation and determination of quantity and quality

a. Spectrophotometry absorbance.

b. Gel electrophoresis

4. cDNA synthesis

5. Primer designing for PCR

6. PCR amplification

7. TA Cloning

8. Heterologous expression of specific genes

a. Restriction digestion of vectors (gel analysis) and insert.

b. Vector and insert ligation, and transformation in *E.coli* DH5

c. Plasmid isolation and confirming recombinant by PCR and RE digestion.

d. Transformation of recombinant plasmid in E. coli BL 21 (DE3) strain

e. Induction with IPTG and extraction of proteins

9. Recombinant protein analysis

10. Purification of protein using Ni - NTA column

a. SDS PAGE

b. Western blotting

11. Protein quantification

12. 2-dimensional Gel electrophoresis

13. Differential gene expression

14. Semi-quantitative methods of gene expression

15. Quantification of genes/transcripts using real time PCR

16. Cell culture techniques

24-864-0105-MARINE BIODIVERSITY

Outcome:
After completing this course, the students will be able to:

- ***CO1:*** *Develop Identification skills for marine organisms belonging to major and minor phyla*
- ***CO2:*** *Understand the ecological importance of the marine organisms*
- ***CO3:*** *Use and apply various sampling devices and softwares for marine biological studies*
- ***CO4:*** *Collect, analyze, interpret and communicate marine scientific data.*

CO/PO	PS01	PS02	PS03	PS04	PS05	PS06	PS07
CO1	1	3	1	2	2	2	3
CO2	1	2	1	2	1	2	2
CO3	2	3	1	2	2	2	2
CO4	3	1	1	3	1	2	3

1. Taxonomy and identification of marine organisms belongs to major and minor phyla and their ecological significance
2. (Protozoa, Porifera, Coelenterata, Platyhelminthes, Nematodes, Phoronida, Brachiopoda, Entoprocta, Sipunculoidea, Echiuroidea, Tardigrada, Pentastomida, Pogonophora. Bryozoa, Annelida, Arthropoda, Mollusca, Echinodermata, Hemichordata, Cephalochordata, Urochordata Vertebrata-Cyclostomata, Pisces, Marine reptiles and Mammals)
3. Identification of economically important seaweeds - Identification of vegetative and reproductive structures
4. Analysis of interstitial fauna. Identification of boring and fouling communities.
5. Theory and operation of equipment used for sampling water, sediment,

plankton and benthos.

6. Water samplers - Nansen's reversing water bottle, Niskin water sampler.
7. Sediment samplers – Types of Grab samplers – Van Veen Grab, Peterson's Grab, Core samplers.
8. Plankton nets – Bongo nets – vertical and horizontal plankton sampling, phytoplankton nets
9. Methods of collection and analysis of phytoplankton, zooplankton and Benthos - Preservation and analysis - Reporting on zooplankton collections - Preparation of whole mounts
10. Identification of zooplankton.
11. Software applications in marine ecology-PRIMER and other software in analysis of benthic biodiversity studies
12. Visit to institutes connected with Marine Science

SEMESTER-II

24-864-0205 MARINE MICROBIOLOGY & MICROBIAL GENOMICS

Outcome:

After completing this course, the students will be able to

- ***CO1:*** *Apply Basic Microbiological Techniques*
- ***CO2:*** *Analyze Bacterial Population Estimation in Sea Water, Sediment, and Fish*
- ***CO3:*** *Perform Pure Culture Techniques Using Streak Plate, Pour Plate, and Spread Plate Methods*
- ***CO4:*** *Evaluate Bacterial Staining Methods Including Simple Stain, Gram Stain, and Endospore Stain*
- ***CO5:*** *Analyze Biochemical and Molecular Tests*

CO/ PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	1	2	1	1	2	1	1
CO2	1	2	1	1	1	1	1
CO3	1	2	3	1	1	1	1
CO4	1	2	1	1	1	1	1
CO5	1	1	1	1	3	1	1

1. Basic microbiological techniques (sterilization, preparation of media, handling techniques etc.)
2. Estimation of the bacterial population in sea water, sediment and fish
3. Pure culture techniques –streak plate, pour plate and spread plate techniques.
4. Staining of bacteria -Simple stain, Gram stain and Endospore stain.
5. Demonstration of bacterial motility -hanging drop method and mannitol motility test.
6. Biochemical tests –Kovac's oxidase test, catalase test, marine oxidation fermentation tests,Triple sugar Iron – reaction. IMViC
7. Water quality analysis –MPN analysis of total coliforms, faecal coliforms and faecal streptococci.
8. Membrane filter test to detect coliform bacteria in water.
9. Production of exoenzymes by bacteria –gelatinase, amylase and lipase.
10. Nitrate reduction test.
11. Antibiotic sensitivity test.
12. Preservation of bacteria using cryopreservation and lyophilization
13. Estimation of indicators and pathogens in water/fishery products.

14. Detection of coliforms and pathogens -*Escherichia coli, Salmonella, Vibrio parahaemolyticus, Vibrio cholerae, Staphylococcus aureus*, Faecal Streptococci.
15. Siderophore production
16. Characteristics for use as probiont
17. Collection of water / sediment sample for metagenomic analysis
18. Bacterial diversity studies- 16S rRNA
19. Fungal diversity studies: ITS
20. Viral diversity studies
21. Extraction of metagenomic DNA and RNA
22. Purification of metagenomic DNA/RNA
23. Quality checking
24. Preparation of metagenomic library
25. Next generation sequencing of metagenome
26. Whole Genome sequencing and analysis
27. Transcriptome sequencing and analysis
28. Community analysis using DGGE

24-864-0206 - DISCOVERY OF MARINE DRUGS AND NUTRACEUTICALS

Outcome:

After completing this course, the students will be able to

CO 1: *Test the bioactive potential (anticancer, antimicrobial, anti-inflammatory) in marine organisms*

CO 2: *Develop chromatographic methods for isolation of the bioactives*

CO 3: *Construct Global Natural Products Social Molecular Network (GNPS) for dereplication*

CO 4: *Interpret spectral data of natural products*

CO 5: *Examine the cytotoxic activity of a natural products*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	3	1	1	3	3	3
CO2	1	1	1	1	3	2	3
CO3	3	1	1	1	3	3	2
CO4	1	1	1	3	3	3	3
CO5	3	2	1	2	3	3	1

1. Isolation and purification of novel marine natural products with bioactivity
2. Collection and identification of marine organisms for testing bioactivity.
3. Extraction of bioactive compounds from marine organisms (microbes, Sponges, Ascidians etc.)
4. Screening of marine extracts for anti-bacterial activity and strain prioritisation
5. Screening of marine extracts for anticancer activity by SRB assay

6. Bioassay guided fractionation of active crude extract through flash chromatography
7. Separation and purification of natural product by, TLC, column chromatography and HPLC.
8. LC-MS analysis and Mass Spectrum Interpretation,
9. Dereplication by Construction of molecular networks using Global Natural Products Social Molecular Networking
10. Acquiring NMR data (H and C) of pure compound and structural elucidation (Demonstration).
11. In vitro anticancer activity of pure compound on NCI-H 460 cell line

a. IC 50 calculation

b. TUNEL Assay for detecting DNA damage during Apoptosis

c. Annexin V/FITC assay for scoring apoptosis

12. Assay for anti-inflammatory activity of marine compounds by Griess assay for quantification of NO on RAW

SEMESTER-III

24-864-0305- BIOINFORMATICS

Outcome:

After completing this course, the students will be able to

CO1: *Identify and utilize various bioinformatics databases.*

CO2: *Design PCR primers and perform sequence alignments.*

CO3: *Analyze and predict protein structures using bioinformatics tools.*

CO4: *Conduct phylogenetic analysis and gene prediction.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	1	1	2	3	1
CO2	2	1	2	1	2	3	2
CO3	3	2	1	2	2	3	2
CO4	2	3	2	2	1	2	3

1. Databases

a. Nucleic acid sequence database

b. Protein sequence database.

c. Protein structure database

d. Taxonomic database.

e. Genomic database.

2. Submission of DNA/protein sequence to GenBank
3. Designing PCR primers and probes.
4. Protein families, domains and functional sites
5. Tools for similarity searches and sequence alignments.

a. BLASTn,

b. BLASTp,

c. tBLASTxetc

6. Alignment of pair sequences
7. Alignment of multiple sequence alignment
8. Phylogenetic analysis and tree evaluation methods.
9. Gene identification and prediction
10. Protein structure prediction

a. ExPASy

b. primary and secondary structure analysis and prediction

c. motifs, profiles, patterns and fingerprint search

d. comparative protein model for protein prediction

e. methods of 2D structure prediction

f. protein function prediction from a DNA sequence

g. prediction of 3D structure

24-864-0306 BIOANALYTICAL TECHNIQUES AND INSTRUMENTATION

Course Outcome (CO): After completing the course, students will be able to

CO1: *Apply foundational principles of bioanalytical techniques and instrumentation to analyze biological samples effectively.*

CO2: *Demonstrate proficiency in operating and troubleshooting various bioanalytical instruments used for chemical and biological analysis.*

CO3: *Evaluate data obtained from bioanalytical experiments using statistical methods and critical analysis.*

CO4: *Design experimental protocols for bioanalytical assays, integrating theoretical knowledge with practical applications.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	1	1	1	1	1
CO2	3	3	2	1	1	1	1
CO3	2	2	3	2	2	1	1
CO4	2	2	2	3	2	2	1

1. Microscopy- Bright field, Dark Field, Fluorescence, Phase Contrast and Electron Microscopes
2. Chromatography-TLC, HPLC, FPLC, GC, LCMS-MS
3. Colorimeter, Spectrophotometer: UV-Visible, Fluorescence & Atomic absorption spectrophotometers.
4. pH meter, Salinometer, Multi parameter Water Quality Analyser.
5. PCR, RT-PCR and Gel Documentation system.
6. Kel-plus Protein digestion analyzer.
7. Particle size analyzer.
8. Electrophoresis: SDS-PAGE, Agarose gel electrophoresis.
9. Laminar Flow Chamber, Autoclave, Deep Freezers, Fermenter and Lyophiliser.
10. Centrifuges, Environmental Chamber and Shaker Incubators.
11. Cell viability and cytotoxicity assays-MTT, XTT, FISH, ELISA
12. Confocal Microscope
13. Flow cytometry

24-864-0307 TRANSCRIPTOMICS & PROTEOMICS

Course Outcome (CO) :

After completing the course, students will be able to

- ***CO1:*** *Apply protein extraction techniques from marine organisms for practical use.*
- ***CO2:*** *Perform protein separation using chromatographic methods and electrophoresis.*
- ***CO3:*** *Analyze protein samples using advanced electrophoretic and chromatographic techniques.*

CO4: *Evaluate protein characterization methods and their application in proteomic studies.*

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	1	1	1	1	1
CO2	3	3	2	1	1	1	1
CO3	2	3	2	1	1	1	1
CO4	2	2	3	2	1	1	1

1) Collection of marine organisms for extraction of protein
2) Extraction of crude protein from marine organisms
3) Separation of protein by various techniques

a) Chromatography

b) HPLC

c) FPLC

d) Ion-exchange

e) Size-exclusion

f) Affinity chromatography

4) Electrophoresis
5) Polyacrylamide gel electrophoresis
6) *Isoelectric focusing (IEF)*
7) Two dimensional PAGE for proteome analysis
8) Image analysis of 2D gels

a) Fluorescence 2-D Difference Gel Electrophoresis

b) Blue native PAGE (BN-PAGE)

9) Characterization of proteins by various techniques

a) Mass spectrometry

b) Protein sequencing

c) NMR, XRD

10) Tools in functional proteomics

a) Protein microarrays

b) Immunoprecipitation

11)Computational methods

12) Protein and proteome databases

13) Public protein databases and interfaces

14) Data mining in proteomics

15) Generation of models in proteomic studies

16) Structure prediction from sequence

17) Deriving function from sequence