

REVISED CURRICULUM

M. Sc.

MARINE  
BIOTECHNOLOGY



सत्यमेव जयते

Department of Biotechnology

Ministry of Science & Technology,  
Government of India

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<b>LIST OF ELECTIVES</b>			
1.	Computational Biology		
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**^Any two 1.5 credit courses can be taken up to make one 3 credit course.  
Contents for electives are given separately.**

# SEMESTER - I

## Biochemistry - 3 Credits

### Unit I

Chemical basis of life; Composition of living matter; Water – properties, pH, ionization and hydrophobicity; Emergent properties of biomolecules in water; Biomolecular hierarchy; Macromolecules; Molecular assemblies; Structure-function relationships

Amino acids – structure and functional group properties; Peptides and covalent structure of proteins; Elucidation of primary and higher order structures; Evolution of protein structure; Structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; Tools to characterize expressed proteins.

### Unit II

Enzyme catalysis – general principles of catalysis; Quantitation of enzyme activity and efficiency; Enzyme characterization and Michaelis-Menten kinetics; Relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; Single substrate enzymes

### Unit III

Sugars - mono, di, and polysaccharides; Suitability in the context of their different functions- cellular structure, energy storage, signaling; Glycosylation of other biomolecules - glycoproteins and glycolipids

Lipids - structure and properties of important members of storage and membrane lipids; lipoproteins

### Unit IV

Biomembrane organization - sidedness and function; Membrane bound proteins - structure, properties and function; Transport phenomena;

Nucleosides, nucleotides, nucleic acids - structure, diversity and function; sequencing; Brief overview of central dogma

### Unit V

Bioenergetics-basic principles; Equilibria and concept of free energy; Coupled processes; Glycolytic pathway; Krebs's cycle; Oxidative phosphorylation; Photosynthesis; Elucidation of metabolic pathways; Logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; Principles of metabolic regulation; Regulatory steps; Signals and second messengers.

### Texts/References

1. V.Voet and J.G.Voet, Biochemistry, 3<sup>rd</sup> edition, John Wiley, New York, 2004.
2. A.L. Lehninger, Principles of Biochemistry, 4<sup>th</sup> edition, W.H Freeman and Company, 2004.
3. L. Stryer, Biochemistry, 5<sup>th</sup> edition, W.H. Freeman and Company, 2002.

# Analytical Techniques and GLP - 3 Credits

## Unit I

### *Microscopy and Centrifugation*

Light Microscope; Phase contrast and electron microscope; Photomicrography; Centrifugation- Centrifugal force and principal of sedimentation; Sedimentation coefficient; Types of centrifugation; Molecular weight determination

## Unit II

### *Spectroscopic techniques*

Absorption and Emission principles – principle and application of colorimeters; UV-visible; Spectrophotometer; Spectrofluorometer; Flame photometer; Atomic absorption spectrophotometer; Inductively Coupled plasma Spectrophotometer (ICP) – Brief account of NMR, ESR and Mass spectrophotometry in Biology.

## Unit III

### *Immunochemical and Chromatography techniques*

Electrophoresis: General principles; Factors affecting mobility of charged molecules – principles and uses of paper electrophoresis; Agarose gel electrophoresis; Pulsed Field Gel Electrophoresis; Iso electric focusing; Polyacrylamide gel electrophoresis; SDS-PAGE; Chromatography – General principle, Types: Paper, Thin layer, Gas chromatography, HPLC, Ion-exchange chromatography – Principles and uses of each type.

## Unit IV

### *Radioisotope techniques*

Nature and units of radioactivity; Detection and measurement of radioactivity- Geiger and scintillation counters; Autoradiography; Applications of radioisotopes in biology; Radiation hazardous.

## Unit V

### *GLP (Good laboratory practice)*

Principles; Commodities; Apparatus; Reagents and materials; Pest control; Cryogenic safety - General Precautions; Storage; Test Systems; Standard protocols; Quality assurance; Laboratory signage- Biosafety level; Treatment and disposal –sharps, cultures, stock & labware; Biotxin and pathological waste – fixed tissues & bedding; Storage and retention of records.

## Texts/References

1. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
2. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, 2000.
3. D. Holme & H. Peck, Analytical Biochemistry, 3<sup>rd</sup> Edition, Longman, 1998.
4. R. Scopes, Protein Purification - Principles & Practices, 3<sup>rd</sup> Edition, Springer Verlag, 1994.
5. Sambrook, J. and D.W. Russell, Molecular cloning: A laboratory manual, 3<sup>rd</sup> Edition, (app. 900pp), 2001.
6. Selected readings from Methods in Enzymology, Academic Press.

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# Cell and Developmental Biology - 3 Credits

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## Unit I

### *Cell Theory & Methods of Study*

Microscope and its modifications – Light, phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunneling and Atomic Force Microscopy, etc.

### *Membrane Structure and Function*

Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo- and Exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata.

## Unit II

### *Organelles*

Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging; Cell cycle and control mechanisms; Mitochondria – structure, organization of respiratory chain complexes, ATP synthase, Structure-function relationship; Mitochondrial DNA and male sterility; Origin and evolution; Chloroplast– Structure-function relationship; Chloroplast DNA and its significance; Chloroplast biogenesis; Origin and evolution.

## Unit III

### *Endo-membrane System and Cellular Motility*

Structure and function of microbodies, Golgi apparatus, Lysosomes and Endoplasmic Reticulum; Organization and role of microtubules and microfilaments; Cell shape and motility; Actin-binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments; Extracellular matrix in plants and animals.

## Unit IV

### *Cellular Movements and Pattern Formation*

Laying of body axis planes; Differentiation of germ layers; Cellular polarity; Model plants like Fucus and Volvox; Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants; Cell lineages and developmental control genes in Caenorhabditis.

## Unit V

### *Differentiation of Specialized Cells*

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

### *Plant Meristem Organization and Differentiation*

Organization of Shoot Apical Meristem(SAM); Organization of Root Apical Meristem (RAM); Pollen germination and pollen tube guidance; Phloem differentiation; Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixis.

## Texts/References

1. Lodish *et al.*, Molecular cell Biology, 4<sup>th</sup> Edition, W.H. Freeman & Company, 2000.
2. Smith & Wood, Cell Biology, 2<sup>nd</sup> Edition, Chapman & Hall, London, 1996.
3. Watson *et al.*, Molecular Biology of the gene, 5<sup>th</sup> Edition, Pearson Prentice Hall. USA, 2003.
4. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley-Blackwell, 2002.
5. Benjamin Lewin, Gene IX, 9<sup>th</sup> Edition, Jones and Barlett Publishers, 2007.

# Molecular Biology - 3 Credits

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## Unit I

### *Genome organization*

Organization of bacterial genome; Structure of eukaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation & Imprinting

## Unit II

### *DNA Structure; Replication; Repair & Recombination*

Structure of DNA - A-,B-, Z- and triplex DNA; Measurement of properties-Spectrophotometric, CD, AFM and Electron microscope analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair- enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination.

## Unit III

### *Prokaryotic & Eukaryotic Transcription*

Prokaryotic Transcription; Transcription unit; Promoters- Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination; Transcriptional regulation-Positive and negative; Operon concept-lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA

Eucaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing

## Unit IV

### *Post Transcriptional Modifications*

Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

### *Translation & Transport*

Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons;



Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co- and post-translational modifications; Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation

## Unit V

### *Mutations; Oncogenes and Tumor suppressor genes*

Nonsense, missense and point mutations; Intragenic and Intergenic suppression; Frameshift mutations; Physical, chemical and biological mutagens; Transposition - Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins; Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators.

## Text/References

1. Benjamin Lewin, Gene IX, 9<sup>th</sup> Edition, Jones and Barlett Publishers, 2007.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6<sup>th</sup> Edition, Benjamin Cummings Publishing Company Inc, 2007.
3. Alberts et al; Molecular Biology of the Cell, 4<sup>th</sup> edition, Garland, 2002

# Marine Bioresources, Biodiversity & Oceanography - 3 Credits

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## Unit I

### *Introduction to Marine Biology*

Introduction to marine environment; Marine Flora-Phytoplankton, seaweeds, sea grasses and mangroves - their characteristics and identification.

## Unit II

### *Important marine Organisms and their behaviour*

Marine fauna–Zooplankton; Major marine invertebrates (crustaceans & molluscs); Vertebrates(Pisces) and marine mammals (dolphin and whales) - characteristics and identification; Biology - food & feeding - age & growth - reproduction - life history of crustaceans, molluscs and fishes.

## Unit III

### *Marine resources assessment*

Methods of surveying the living resources (Acoustic, Aerial and Remote sensing); Principal methods of exploitation (Indigenous and modern crafts & gears)

## Unit IV

### *Population study and Marine environment protection*

Population dynamics - Principles of population dynamics; Unit stocks; Age & size composition of the population; Abundance and density; Recruitment; Growth; Mortality(fishing & natural); Conservation and management-*in situ* and *ex situ*; IUCN categorization; Marine biosphere reserves; Marine parks - heritage sites.

## Unit V

### *Oceanography*

Physical: waves, tides and currents

Chemical-nutrient cycle, metals, minerals and trace elements Biological-primary and secondary productivity, finfish and shellfish resources.

### Texts/References

1. Carl E. Bond, *Biology of Fishes*, 2<sup>nd</sup> Edition, W.B. Saunders Company, Philadelphia, 1996.
2. Miller RI, *Mapping the Diversity of Nature*, Chapman & Hall. pp. 218. 1994.
3. Heywood V.H., *Global Biodiversity Assessment*. UNEP, Cambridge University Press PP. 1140, 1995.
4. King, M., *Fisheries Biology: Assessment and Management*, Fishing News Books. 1995.
5. Agarwal et. al., *Biodiversity and Environment*. APH., pp 351. 1996.
6. Naskar K. and Mandal R., *Ecology and Biodiversity of Indian Mangroves*. Daya. pp 361, 1999.
7. Jeffrey S. Levinton, *CD Marine Biology: Function, biodiversity, ecology (515pp) with cd-rom*". 2001.
8. Artikeya, K., *Biodiversity: Extinction and Conservation*, (202pp) 2005.

## Lab on Biochemistry & Analytical Techniques - 4 Credits

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1. To prepare an Acetic-NaAcetate Buffer system and validate the Henderson-Hasselbach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
3. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by TLC.
4. AN ENZYME PURIFICATION THEME (such as *E.coli* Alkaline phosphatase or any enzyme of the institutions choice).
  - (a) Preparation of cell-free lysates
  - (b) Ammonium Sulfate precipitation
  - (c) Ion-exchange Chromatography
  - (d) Gel Filtration
  - (e) Affinity Chromatography
  - (f) Generating a Purification Table
  - (g) Assessing purity by SDS-PAGE Gel Electrophoresis
  - (h) Assessing purity by 2-D gel Electrophoresis
  - (i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
5. Biophysical methods (Circular dichroism spectroscopy, fluorescence spectroscopy).
6. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

## Lab on Molecular Biology & Oceanography - 4 Credits

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### Molecular Biology

1. Plasmid DNA isolation and DNA quantitation: Plasmid minipreps
2. Restriction digestion
3. Preparation of competent cells.
4. Agarose gel electrophoresis
5. Restriction Enzyme digestion of DNA
6. Purification of DNA from an agarose gel
7. DNA Ligation
8. Transformation of E.coli with standard plasmids, Calculation of transformation efficiency.
9. Cloning of genomic DNA in standard plasmid vectors
10. Confirmation of the insert, Miniprep of recombinant plasmid DNA
11. Restriction mapping
12. Polymerase Chain reaction, using standard 16srRNA eubacterial primers
13. RFLP analysis of the PCR product
14. Transformation of yeast *Saccharomyces cerevisiae*

### Bioresources, Biodiversity & Oceanography

1. Identification of phytoplankton (diatoms and dinoflagellates)
2. Zooplankton, Seaweeds, Sea grasses and mangroves
3. Identification of commercially important crustaceans (prawns, Shrimps, lobsters and crabs), molluscs (pelecypods, gastropods and Cephalopods) and fishes (Cartilaginous & teleost) apart from dolphins & Whales.
4. Identification of larval stages of crustaceans (prawns, shrimps, lobsters and crabs), molluscan and fish eggs and larvae.
5. Food and feeding habits – Gut content analysis (crustaceans and fishes)
6. Assessment of age and growth - tags, morphometry, otolith, scales, vertebrae)
7. Reproduction – Gonadal maturity stages, GS index.
8. Working principles of Echo sounder
9. Crafts and gears – principles & operation. (Catamarans, dug out canoe & trawlers; cast net, push net, gill net, scoop net, purse seines, trawl net).

## Introductory Mathematics

### Notation, error analysis, and probability

Scientific notation: significant digits, rounding off, scientific notation; Error analysis; Counting and Probability; Addition rules; Permutations; Combinations; Inclusion-exclusion rule; Sampling with and without replacement; Conditional probability: Bayes' theorem; Independence

### Descriptive statistics and Random variables

Measures of central tendency: mean, median, mode; Expectation; Measures of spread: range, percentile, standard deviation; Higher moments: kurtosis, skew; Displaying data: Histograms, stem-and-leaf plots, box plots, frequency distributions; Discrete random variables: Bernoulli, Binomial, Poisson, Geometric distributions, Continuous random variables: Normal, Exponential distributions, Standard normal distribution

### Inferential statistics and one sample hypothesis testing

Samples and populations: Random, stratified and cluster sampling. Single- and Double-blind experiments. Point and interval estimates, Sampling distributions:  $t$ , chi-square, F distributions, Hypothesis testing: null and alternative hypotheses, decision criteria, critical values, type I and type II errors, the meaning of statistical significance, power of a test, One sample hypothesis testing: Normally distributed data:  $z$ ,  $t$  and chi-square tests. Binomial proportion testing.

### Multi-sample and nonparametric hypothesis testing

Two sample hypothesis testing; Nonparametric methods: signed rank test, rank sum test, Kruskal-Wallis test, Analysis of variance: One-way ANOVA. Curve fitting, Regression and correlation: simple linear regression, the least squares method, Analysis of enzyme kinetic data. Michaelis-Menten, Lineweaver-Burk and the direct linear plot, Polynomial curve fitting.

### Texts/References

1. G. B. Thomas and R. L. Finney, *Calculus and Analytic Geometry*, 9th Edition, ISE Reprint, Addison-Wesley, 1998.
2. E. Kreyszig, *Advanced engineering mathematics*, 8th Edition, John Wiley, 1999.
3. W. E. Boyce and R. DiPrima, *Elementary Differential Equations*, 8th Edition, John Wiley, 2005.

## Communication Skills

### Process of communication

Concept of effective communication- Setting clear goals for communication; Determining outcomes and results; Initiating communication; Avoiding breakdowns while communicating; Creating value in conversation; Barriers to effective communication; Non verbal communication- Interpreting non verbal cues; Importance of body language, Power of effective listening; recognizing cultural differences

### **Presentation skills**

Formal presentation skills; Preparing and presenting using Over Head Projector, Power Point; Defending Interrogation; Scientific poster preparation & presentation; Participating in group discussions

### **Technical Writing Skills**

Types of reports; Layout of a formal report; Scientific writing skills: Importance of communicating Science; Problems while writing a scientific document; Plagiarism; Scientific Publication Writing: Elements of a Scientific paper including Abstract, Introduction, Materials & Methods, Results, Discussion, References; Drafting titles and framing abstracts

### **Computing Skills for Scientific Research**

Web browsing for information search; search engines and their mechanism of searching; Hidden Web and its importance in Scientific research; Internet as a medium of interaction between scientists; Effective email strategy using the right tone and conciseness

### **Texts/References**

1. Mohan Krishna and N.P. Singh, Speaking English effectively, Macmillan, 2003.

## Immunology - 3 Credits

### Unit I

#### *Immunology- fundamental concepts and anatomy of the immune system*

Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoiesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue (MALT & CALT); Mucosal Immunity; Antigens - immunogens, haptens; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing

### Unit II

#### *Immune responses generated by B and T lymphocytes*

Immunoglobulins-basic structure, classes and subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Immunological basis of self –non-self discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten-carrier system

### Unit III

#### *Antigen-antibody interactions*

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosensor assays for assessing ligand –receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, Microarrays, Transgenic mice, Gene knock outs

### Unit IV

#### *Vaccinology*

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines; Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

### Unit V

#### *Clinical Immunology*

Immunity to Infection : Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T

cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation – Immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; Tumor immunology – Tumor antigens; Immune response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency-Primary immunodeficiencies, Acquired or secondary immunodeficiencies.

### Texts/References

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6<sup>th</sup> Edition, Freeman, 2002.
2. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.
3. Janeway et al., Immunobiology, 4<sup>th</sup> Edition, Current Biology publications., 1999.
4. Paul, Fundamental of Immunology, 4<sup>th</sup> edition, Lippencott Raven, 1999.
5. Goding, Monoclonal antibodies, Academic Press. 1985.

## Marine Microbiology - 3 Credits

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### Unit I

#### *Types of marine microbes and their biology*

Structure: Bacteria, fungi, algae, protozoa and viruses; Classification of microbes (Genetic level) -conventional and modern methods.

Biology of micro-organisms used in genetic engineering (*Escherichia coil*, *Rhizobium sp.*, *Agrobacterium tumefaciens*, *Saccharomyces cerevisiae*, *phage lambda*, *Nostoc*, *Spirulina*, *Aspergillus*, *Pencillium* and *Streptomyces*).

### Unit II

#### *Microbial Assessment*

Methods of studying the marine micro-organisms-Methods of collection, enumeration (total and viable counts), Isolation, culture & identification based on morphological, physiological and biochemical characteristics; Preservation of marine microbes; Culture collection Centres (ATCC, IMTECH, etc.).

Microbial nutrition - influence of environment factors on microbial growth, activity and distribution

### Unit III

#### *Role of microbes in marine environment*

Microbial nitrogen fixation; Carbon, nitrogen and phosphorus cycle; Decomposition of organic matter; Bioleaching and biodeterioration of natural and synthetic materials.

### Unit IV

#### *Microbial metabolites Microbial interaction*

Microbes of Biotechnological importance; Primary and secondary metabolites (enzymes, antibiotics, organic acid, toxins etc.)

### Unit V

#### *Microbial interaction*

Seafood microbiology - normal genera associated with fish, food spoilage, fish & human pathogens; Indicator of Pollution - faecal coliforms; Prevention & control.



## Texts/References

1. Pelczar MJ Jr., Chan ECS and Kreig NR., Microbiology, 5<sup>th</sup> Edition, Tata McGraw Hill, 1993.
2. G Reed, Prescott and Dunn's, Industrial Microbiology, 4<sup>th</sup> Edition, CBS Publishers, 1987.
3. M.T. Madigan and J.M. Martinko, Biology of Microorganisms, 11<sup>th</sup> Edition, Pearson Prentice Hall, USA, 2006
4. Rheinheimer, G., 1980. Aquatic Microbiology, Johnwiley & Sons, pp. 235.
5. Elay, A.R.1992. Microbial food poisoning. Chapman and Hall, London, 191 pp.
6. Ford, T.E., 1993. Aquatic microbiology. An ecological approach. Blackwell scientific publications, London, 518 pp.
7. Krichman, D.L., 2000. Microbial ecology of the oceans. Wiley – liss, New york, 542 pp.

## Genetic Engineering - 3 Credits

### Unit I

#### *Basics Concepts*

DNA Structure and properties; Restriction Enzymes; DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase; Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNaseI footprinting; Methyl interference assay

### Unit II

#### *Cloning Vectors*

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/bacculo & retroviral vectors; Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Baculovirus and pichia vectors system, Plant based vectors, Ti and Ri as vectors, Yeast vectors, Shuttle vectors

### Unit III

#### *Cloning Methodologies*

Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning; Jumping and hopping libraries; Southwestern and Far-western cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression

### Unit IV

#### *PCR and Its Applications*

Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; Proof reading enzymes; PCR in gene recombination; Deletion; addition; Overlap extension; and SOEing; Site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)



## Unit V

Sequencing methods; Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing;

Chemical Synthesis of oligonucleotides; Introduction of DNA into mammalian cells; Transfection techniques; Gene silencing techniques; Introduction to siRNA; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing; Gene knockouts and Gene Therapy; Creation of knock out mice; Disease model; Somatic and germ-line therapy- in vivo and ex-vivo; Suicide gene therapy; Gene replacement; Gene targeting; Transgenics; cDNA and intragenic arrays; Differential gene expression and protein array.

## Text/References

1. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6<sup>th</sup> Edition, S.B.University Press, 2001.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
3. Brown TA, Genomes, 3rd ed. Garland Science 2006
4. Selected papers from scientific journals.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

# Genetics, Genomics & Proteomics - 3 Credits

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## Unit I

### *Cell mutation*

Bacterial mutants and mutations- Isolation; Useful phenotypes (autotrophic; conditional, lethal; resistant); Mutation rate; Types of mutations (base pair changes; frame shift; insertions; deletions; tandem duplication); Reversion vs. suppression; Mutagenic agents; Mechanisms of mutagenesis; Assay of mutagenic agents(Ames test).

## Unit II

### *Gene Analysis*

Introduction of Genomics; Recognition of coding and non-coding regions and annotation of genes; Tools for genome analysis –RFLP, DNA fingerprinting, RAPD, PCR and Automated DNA sequencing; Linkage and pedigree analysis- physical and genetic mapping.

## Unit III

### **Genome Sequencing**

Genome sequencing – Microbes, plants and animals; Comparative genomics of relevant organisms such as pathogens and non-pathogens; Taxonomic classification of organisms using molecular markers – 16S rRNA typing/sequencing; Computational analysis; Sequences analysis; Similarity searches and pair wise alignment; Multiple sequences alignment; Phylogenetics; Toxicogenomics; Pharmacogenomics and metagenomics.

## Unit IV

### *Gene Expression studies*

Functional Genomics; Global gene expression analysis; Micro-array; Comparative Transcriptomics; Differential gene expression.

## Unit V

### *Proteomics*

Proteomics-definition; Identification and analysis of protein of proteins by 2D analysis; Mass spectrophotometry; MALDI-TOF; LC-MS; SAGE and Differential display proteomics; Protein-protein interactions; Yeast two hybrid system and phage display; Pharmacogenetics- high throughput screening for drug discovery- identification of drug targets; Drug development.

### Texts/References

1. Pennington. S. R and M.J. Dunn, Proteomics from Protein Sequences to Function, Vova Books private limited, India, 2002.
2. Peter Armitage and Theodore Colton, Biostatistics genetics and Genetic Epidemiology, John Wiley & Sons Ltd. England, 2002.
3. Gina Smith, The genomics Age, American Management Association, New York. 2005.
4. Campbell AM & Heyer LJ, Discovering Genomics, Proteomics and Bioinformatics, 2<sup>nd</sup> Edition, Benjamin Cummings 2007
5. Primrose S & Twyman R, Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell, 2006.
6. Glick BR & Pasternak JJ, Molecular Biotechnology, 3rd Edition, ASM Press,1998.

## Aquaculture Technology & Marine Pharmacology - 3 Credits

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### Unit I

#### *Culture systems and Hatchery techniques*

Importance of coastal aquaculture; Aqua farms; Design and construction; Criteria for selecting cultivable species; Culture systems and management practices – extensive, semi intensive and intensive culture practices

Seed production in controlled condition; Types; Design and management of hatchery –induced spawning; Mass production of seeds; Live feed culture technique and feed formulation; Artificial insemination - *in vitro* fertilization.

### Unit II

#### *Introduction to marine pharmacology*

Terms and definitions; Medicinal compounds from marine flora and fauna - marine toxins, antiviral and antimicrobial agents.

### Unit III

#### *Manipulation Techniques*

Chromosome manipulation in aquaculture – hybridization; Ploidy induction; Gynogenesis, Androgenesis and sex reversal in commercially important fishes.

### Unit IV

#### *Microbial techniques*

Application of microbial biotechnology in culture ponds; Bioaugmentation; Bioremediation for soil and water quality improvement - nutrient cycling; bio-fertilization; Probiotics – Immunostimulants; Regulation of bacterial growth.

## Unit V

### *Diseases diagnosis*

Tools for disease diagnosis in cultivable organisms; Enzyme immuno assays; Dot immunobinding assay; Western blotting; Latex agglutination test; Monoclonal antibodies; DNA based diagnosis; Cryopreservation.

### Texts/References

1. Mime, PH., Fish and shellfish farming in coastal waters, Fishing News Ltd., London, 1972.
2. Bradach, J.E., H.H. Ryther and W.D. MC Larney, Aquaculture, farming and husbandry and fresh and marine organisms, Wiley Interscience, New York. 1972.
3. Iverson, E.S., Farming the edge of the sea, Fishing News Ltd., London. 1976.
4. Fingerman M., Recent advances in Marine Biotechnology, Science Publishers, 2000.
5. Aquaculture, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
6. Kenneth, B.D., 2000. Environmental impacts of Aquaculture. CRC. pp. 214.
7. Stickney, R.R., 2000. Encyclopedia of Aquaculture. John Wiley Sons Inc. pp. 1063.
8. Rautenstraub, B. and T. Liehr, 2002. Fish technology, 494pp.

## Lab on Immunology - 3 Credits

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1. Selection of animals, Preparation of antigens, Immunization and methods of bleeding, Serum separation, Storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.
6. SDS-PAGE, Immunoblotting, Dot blot assays
7. Blood smear identification of leucocytes by Giemsa stain
8. Separation of leucocytes by dextran method
9. Demonstration of Phagocytosis of latex beads
10. Separation of mononuclear cells by Ficoll-Hypaque
11. Flowcytometry, identification of T cells and their subsets
12. Lymphoproliferation by mitogen / antigen induced
13. Lymphnode Immunohistochemistry (direct and indirect peroxidase assay)
14. Hybridoma technology and monoclonal antibody production.
15. Immunodiagnosics using commercial kits

## Lab on Marine Microbiology & Aquaculture Technology - 3 Credits

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### Marine Microbiology

1. Sterilization, Preparation of culture media, agar slants, isolation & identification of microbes, and maintenance of cultures. Gram's Staining, morphological, physiological, biochemical characterization of microbes, measuring growth rate, checking markers, penicillin selection for auxotrophy.

- a) Estimation of coliforms from water samples
  - b) Sea food quality –
    - i) Estimation of coagulase + ve *Staphylococci*
    - ii) Estimation of *Vibrio* spp
    - iii) Estimation of *Salmonella* spp.
  - c) Isolation and identification of important marine fungi.
  - d) Isolation and identification of marine cyanobacteria
2. Aseptic techniques - Staining - Preparation of competent *E. coli* cells for transformation.

### **Aquaculture Technology**

1. Dissect and display the lymphoid organs from fishes and mammals.
2. Observation of lymphoid organs in fishes (C.S. of Thymus, spleen, anterior kidney, Gut)
3. Observation of lymphoid organs in birds (C.S. of Bursa of fabricus, spleen)
4. Observation of lymphoid organs of mammals (C.S. of lymph node, C.S. of Spleen, C.S. of tonsil, C.S. of Peyer patches, C.S. of thymus, C.S. of bone marrow).
5. Smear preparation of lymphoid organ in fishes (anterior kidney and spleen)

## **Lab on Genetic Engineering - 2 Credits**

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1. Isolation of genomic DNA from *Bacillus subtilis*\* genome.
2. PCR amplification of *scoC* gene and analysis by agarose gel electrophoresis
3. Preparation of plasmid, pET-28a from *E.coli* DH5 $\alpha$  and gel analysis.
4. Restriction digestion of vector (gel analysis) and insert with NcoI and XhoI
5. a. Vector and Insert ligation  
b. Transformation in *E.coli* DH5 $\alpha$
6. Plasmid isolation and confirming recombinant by PCR and RE digestion.
7. Transformation of recombinant plasmid in *E.coli* BL21 (DE3) strain
8. Induction of ScoC protein with IPTG and analysis on SDS-PAGE
9. Purification of protein on Ni-NTA column and analysis of purification by SDS-PAGE
10. a. Random Primer labeling of *scoC* with Dig-11-dUTP  
b. Southern hybridization of *B. subtilis* genome with probe and non-radioactive detection.

\*Any other bacterial strain can be used.

## **Bioprocess Technology - 3 Credits**

### **Unit I**

#### *Basic principle of Biochemical engineering*

Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); Strain improvement for increased yield and other desirable characteristics.

### **Unit II**

#### *Concepts of fermentation processes*

Bioreactor designs; Types of fermentation and fermenters; Upstream processing: Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

### **Unit III**

#### *Downstream processing*

Bioseparation; Filtration; Centrifugation; Sedimentation; Flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of Effluent and its disposal.

### **Unit IV**

#### *Industrial production of chemicals*

Alcohol, acids, solvent, antibiotics, amino acids and single cell protein; Fermentation economics of large-scale production.

### **Unit V**

#### *Enzyme production*

Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications.

### **Texts/References**

1. Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs, 1991.
2. Shuler ML and Kargi F., Bioprocess Engineering: Basic concepts, Prentice Hall, Engelwood Cliffs, 2002.
3. Stanbury, RF and Whitaker A., Principles of Fermentation Technology, Pergamon press, Oxford, 1997.
4. Baily JE and Ollis DF., Biochemical Engineering fundamentals, McGraw-Hill Book Co., Newyork, 1986.
5. Aiba S, Humphrey AE and Millis NF, Biochemical Engineering, Univ of Tokyo press, Tokyo, 1973.

## Marine Environmental Biotechnology - 3 Credits

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### Unit I

#### *Marine organisms and environment interaction*

Types of marine environment - Physical, Chemical and Biological aspects and their interaction with marine life; Air – Sea interaction; Green house gases (CO<sub>2</sub> and Methane)

### Unit II

#### *Pollution*

Marine pollution-major pollutants (heavy metal, pesticide, oil, thermal, radioactive, plastics, litter and microbial); Biological indicators (Marine microbes, algae and crustaceans) and accumulators: Application of Protein biomarkers; Biosensors and biochips.

### Unit III

#### *Biomaterial interaction*

Biodegradation and Bioremediation; Biodegradation of natural and synthetic waste materials; Bioremediation; Separation, purification and bio removal of pollutants.

### Unit IV

#### *Fouling and corrosion*

Biofouling; Biofilm formation; Marine fouling and boring organisms - their biology, adaptation; Factors influencing the settlement of macrofoulers; Antifouling and Anti boring treatments; Corrosion Process and control of marine structures.

### Unit V

#### *Wastewater bio treatment*

BOD, COD; Biosensors; Biomolecules; membrane and transducer; Bioaugmentation-estimation of microbial load; Methods of Inorganic and Organic waste removal.

### Texts/References

1. 1 Recent Advances in Marine Biotechnology Volume 3 – Milton fingerman et al., 1999.
2. Cynobacterial and Algal Metabolisms and Environment Biotechnology – Tasneem Fatma, 1999.
3. Environmental Biotechnology and cleaner Bioprocess – Olguni, E.J. et al., 2000
4. Environmental Biotechnology Theory and applications – Evans et al., 2000.
5. Environmental Biotechnology – Gareth M.Evams et al., 2003
6. Biotechnology, Recombinant DNA Technology, Environmental Biotechnology – S.Mahesh et al., 2003.

## Endocrinology & Reproduction of Marine Animals - 3 Credits

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### Unit I

#### *Invertebrate endocrinology*

Endocrine system in marine invertebrates; Vitellogenesis; Oogenesis & Spermatogenesis; Basic concepts of neuroendocrine structures and functions in annelid, molluscan and echinoderm; Molluscan neuroendocrine control of growth; Reproduction.

## Unit II

### *Shell fishes reproductive biology*

Reproductive Biology in crustaceans; Factors influencing; Role of GIH; Role of 'x' and 'y' organs; Chemical nature of reproductive hormones; Neuro regulators – control mechanisms; Induced maturation & spawning; Moulting- moulting cycle and hormonal regulation in moulting.

## Unit III

### *Finfish reproductive biology*

Reproductive biology in finfishes; Migratory pattern; Maturity stages; Pigmentation; Structure and functions of pineal gland; Ovary and testis; Spawning and Fecundity; Gonado somatic Index.

## Unit IV

### *Regulatory mechanisms*

Role of endocrine glands in reproduction; Hormonal regulation in the ovarian pigmentation; Gonadotropins – structure, synthesis – sex hormones; Hermaphroditism – protandrous and protogynous, sex reversal.

## Unit V

### *Stem cell*

Scope of stem cells, properties; Stem cells –Factors influencing differentiation, hormone role in differentiation. Preservation protocols.

Potential uses - Cellular Therapies, Vaccines, Gene Therapy, Immunotherapy, Tissue Engineering, Blood and Bone Marrow, T cells.

## Texts/References

1. Kenneth, C. Highnam and Leonard Hill, 1969, The comparative endocrinology of the invertebrates, Edward Arnold Ltd.
2. Tombes, A.S., 1970, An Introduction to invertebrate endocrinology. Academic press, INC
3. Barrington, E.J.W., 1975, An introduction to general and comparative endocrinology, Oxford University press.
4. Bentley, R.J. 1976, Comparative Vertebrate Endocrinology, Cambridge University press
5. Hoar, W.S., D.J.Randall and E.M.Donaldson., 1983. Fish Physiology; Reproduction tissues and Hormones. Academic press INC
6. Wolf engels., 1984. Advances in invertebrates reproduction, 665pp, Elsevier Science publishers.

## IPR & Biosafety - 3 Credits

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### Unit I

#### *Introduction to Intellectual Property*

Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP

IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS



## Unit II

### *Concept of 'prior art'*

Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation

## Unit III

### *Basics of Patents*

Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application

## Unit IV

### *Patent filing and Infringement*

Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US

Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives

Patent infringement- meaning, scope, litigation, case studies and examples

## Unit V

### *Biosafety*

Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

## Important Links

<http://www.w3.org/IPR/>

<http://www.wipo.int/portal/index.html.en>

[http://www.ipr.co.uk/IP\\_conventions/patent\\_cooperation\\_treaty.html](http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html)

[www.patentoffice.nic.in](http://www.patentoffice.nic.in)

[www.iprlawindia.org/](http://www.iprlawindia.org/) - 31k - Cached - Similar page

<http://www.cbd.int/biosafety/background.shtml>

<http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm>

<http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html>



## Lab on Bioprocess Technology & Marine Environmental Biotechnology - 3 Credits

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### Bioprocess Technology

1. Isolation and screening of industrially important microorganisms.
2. Determination of thermal death point and thermal death time of microorganisms.
3. Studying the kinetics of enzymatic reaction by microorganisms.
4. Production and purification of various enzymes from microbes.
5. Comparative studies of Ethanol production using different substrates.
6. Microbial production of Citric acid using *A. niger*.
8. Microbial production of antibiotics (eg., Penicillin)
9. Various immobilization techniques of cells/enzymes, use of alginate for cell immobilization.
10. Studying various types of fermenters, bioprocess simulation and control and production of microbial products in bioreactors.
11. Various techniques of downstream processing.

### Marine Environmental Technology

1. Estimation of dissolved oxygen, salinity, H<sub>2</sub>S, BOD and COD
2. Estimation of heavy metals (Cu, Cd, Pb, Hg).
3. Demonstration – estimation of pesticide residues, petroleum hydrocarbons using GC
4. Experiment on heavy metal removal using biosorbent.
5. Microscopic studies of biofilm using test panels.
6. Identification of organisms involved in fouling and boring.
7. Experiment of prevention of fouling and boring using test panels.

## Lab on Endocrinology and Reproduction of Marine Organisms - 3 Credits

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1. Spotters (slides)
  - Pituitary gland (cross section)
  - Interreginal gland
  - Adrenal gland
  - Pancreatic tissue

Thymus

Ultimobranchial gland

Corpus of stannicus

Testis & Ovary

2. Dissection

Nervous system in shrimp and crab

Reproductive system in fishes

3. Hypophysation technique in fish

4. Dissection and location of 'x' and 'y' organs in shrimps

5. Dissection and location of testis and ovary in fishes

6. Maturity stages of ovary in crustaceans and finfish