SIES College of Arts, Science and Commerce – Autonomous

Sion (West), Mumbai – 400 022

NAAC Reaccredited 'A' Grade (CGPA: 3.51/4.00)

Best College Award – University of Mumbai

Syllabus for

Faculty: Science

Program: M. Sc.

Course: ZOOLOGY

Biotechnology-Oceanography and Fishery Science

Semester III and Semester IV

(As per Credit Based Semester and Grading System with effect from academic year 2018-2019)

M. Sc. Zoology Syllabus (Autonomous)
Biotechnology-Oceanography and Fishery Science
Semester III and Semester IV
(Semester Based Credit and Grading System, with effect from academic year 2018-19)

Preamble

"You cannot inquire into reality if you are not courageous. Hence, courage comes first and everything else follows."

Academic Autonomy signifies a paradigm shift to academic freedom which is instrumental in promoting academic excellence. One of the ways to achieve this is through fine-tuning the curriculum. As students at the postgraduate level would have a foundation of the basics of the subject, this syllabus focuses on the need to furnish them with skills and understanding essential to make them self-sufficient and build a future.

This syllabus acknowledges the significance of the world under water and the resources it provides, which can be directed for human benefit if used with precision. It also considers the technological advancements in Biology through Biotechnology that have raised the standard of living.

This syllabus is a product of the valuable inputs and ideas from the professors of Zoology at SIES College, Sion (West) and other board members from outside the institution. It was approved by the Board of Studies (Ad hoc) in the subject of Zoology, in the meeting held on 16th June 2018 at the institution's department of Zoology.

By implementing this course we expect to fulfil the aspirations of students who want to pursue careers in fields relating to marine science, aquaculture, pharmaceuticals, etc. and those who want to venture into hard core research, eventually benefitting the society in whole.

Dr. Satish Sarfare
Chairman,
Board of Studies in the subject of Zoology

M. Sc. Zoology Syllabus (Autonomous)
Biotechnology-Oceanography and Fishery Science
Semester Based Credit and Grading System
(With effect from academic year 2018-19)
Semester III

Theory				
Paper Code	**Unit No.**	**Unit Name**	**Credits**	**Lectures /week**
SIPSZOBT31	1	The implications of recombinant DNA technology of commercial products and microbial synthesis	4	1
	2	Large scale culture and production from recombinant microorganisms and genetically engineered animal cells		1
	3	Medical Biotechnology		1
	4	Environmental Biotechnology - I		1
SIPSZOBT32	1	Genome Management and Analysis	4	1
	2	Manipulation of gene expression in prokaryotes		1
	3	Bioinformatics		1
	4	Animal biotechnology and Human therapies		1
SIPSZOOCN33	1	General Oceanography - I	4	1
	2	Physical Oceanography - I		1
	3	Chemical Oceanography - I		1
	4	Biological Oceanography - I		1
SIPSZOOCN34	1	Planktology - I	4	1
	2	Fish and Fishery Science - I		1
	3	Biotechnology in Fishery and Biometric Studies - I		1
	4	Aquaculture - I		1
Practical				
SIPSZOBTP31	Based on SIPSZOBT31 (Practical I)		2	4
SIPSZOBTP32	Based on SIPSZOBT32 (Practical II)		2	4
SIPSZOOCNP33	Based on SIPSZOOCN33 (Practical III)		2	4
SIPSZOOCNP34	Based on SIPSZOOCN34 (Practical IV)		2	4
		Total	**24**	**32**

M. Sc. Zoology Syllabus (Autonomous)
Biotechnology-Oceanography and Fishery Science
Semester Based Credit and Grading System
(With effect from academic year 2018-19)
Semester IV

Theory				
Paper Code	**Unit No.**	**Unit Name**	**Credits**	**Lectures/ week**
SIPSZOBT41	1	Microbial synthesis of commercial products	4	1
	2	Large scale culture and production for Industrial Biotechnology		1
	3	Agricultural Biotechnology		1
	4	Environmental Biotechnology - II		1
SIPSZOBT42	1	Genome Management	4	1
	2	Manipulation of gene expression in eukaryotes		1
	3	The Human Genome Project		1
	4	Regulations and Patents in Biotechnology		1
SIPSZOOCN43	1	General Oceanography - II	4	1
	2	Physical Oceanography - II		1
	3	Chemical Oceanography - II		1
	4	Biological Oceanography - II		1
SIPSZOOCN44	1	Planktology - II	4	1
	2	Fish and Fishery Science - II		1
	3	Biotechnology in Fishery and Biometric Studies - II		1
	4	Aquaculture - II		1
Practical				
SIPSZOBTP41	Based on SIPSZOBT41 (Practical I)		2	4
SIPSZOBTP42	Based on SIPSZOBT42 (Practical II)		2	4
SIPSZOOCNP43	Based on SIPSZOOCN43 (Practical III)		2	4
SIPSZOOCNP44	Based on SIPSZOOCN44 (Practical IV)		2	4
		Total	**24**	**32**

Semester III – Theory

Paper Code: SIPSZOBT31
Basics of Industrial and Environmental Biotechnology – I

Learning Objectives

- To keep abreast with the current trends in this fast moving field of Biotechnology, that is an intersection of technology and Biology.
- To gain an in depth knowledge of the application of recombinant DNA technology in food, microbial technology and for the production of genetically engineered animal cells to obtain commercial products for human use.
- To emphasize the significance Biotechnology in the field of medicine for production of therapeutic agents viz., vaccines and monoclonal antibodies that have revolutionized medical science.
- To procure knowledge of the biotechnological aspects dealing with degradation of xenobiotics that are foreign to our environment, and the effective utilization of biomass.

Unit 1: The implications of recombinant DNA technology of commercial products and microbial synthesis **15 Lectures**

1.1: The implications of recombinant DNA technology:
*****1.1.1: General account on applications of biotechnology
*****1.1.2: Commercialization of biotechnology and biotech companies
1.1.3: Prospects of novel food technology
1.1.4: Economics of microbial biotechnology
1.1.5: Areas of significant public concern: Antibiotic resistance marker gene, transfer of allergies, pollen transfer from GM plants, social, moral and ethical issues associated with GMOs

1.2: Amino acids and their commercial use:
Production strain, process of L-glutamate, L-aspartate, L-phenylalanine, L-tryptophan

Unit 2: Large scale culture and production from recombinant microorganisms and genetically engineered animal cells **15 Lectures**

2.1: Large scale culture and production from recombinant microorganisms:
2.1.1: Batch fermentation
2.1.2: Fed batch fermentation
2.1.3: Continuous fermentation
*****2.1.4: Maximizing the efficiency of fermentation process
2.1.5: Harvesting, disrupting and downstream processing

2.2: Large scale culture and production from genetically engineered animal cell cultures:
2.2.1: Design of bioreactors for large scale animal cell culture: Batch, Fed batch
2.2.2: Mammalian cell lines and their characteristics
2.2.3: Media for the cultivation of mammalian cells
*****2.2.4: Commercial products produced with mammalian cell culture

Unit 3: Medical Biotechnology **15 Lectures**

3.1: Subunit vaccines:
*****3.1.1: Subunit vaccine production against viruses: Herpes simplex, Bovine foot and mouth disease virus
3.1.2: Peptide vaccines: Synthetic drugs (engineered proteins)
3.1.3: Genetic immunization: DNA vaccines, Antisense DNA, Therapeutic ribozymes
3.1.4: Live recombinant vaccines
3.1.5: Attenuated vaccines against Cholera, *Salmonella sp*.
3.1.6: Vector vaccines: Vaccine directed against viruses – Rabies virus G-protein, Hepatitis B surface antigen
3.1.7: Anti-idiotypic vaccine for cancer treatment

3.2: Monoclonal antibodies (mAbs) and therapeutic applications:
3.2.1: mAbs for prevention of rejection of transplanted organs
3.2.2: Treatment of bacterial blood infection
3.2.3: Human monoclonal antibodies
3.2.4: Hybrid human-mouse monoclonal antibodies
3.2.5: HIV therapeutic agents
3.2.6: Anti-tumour antibodies

Unit 4: Environmental Biotechnology - I **15 Lectures**

4.1: Biomass utilization:
4.1.1: Microorganisms in lignocellulose degradation
4.1.2: Isolation of prokaryotic and eukaryotic cellulase gene
4.1.3: Manipulation of cellulase gene
4.1.4: Production of single cell proteins by using biomass as raw material
4.1.5: Commercial production of fructose and alcohol from biomass
4.1.6: Improvements of fructose and alcohol production
4.1.7: Fuel ethanol from biomass

4.2: Bioremediation of xenobiotic compounds:
4.2.1: Characteristics of xenobiotics in the environment
4.2.2: Characteristics of aerobic microorganisms for degradation of organic pollutants
4.2.3: Genetic engineering of biodegradative pathways: Manipulation by transfer of plasmid, manipulation by gene alteration
*****4.2.4: Degradation of xenobiotic compounds: Petroleum products, n-alkanes, alkenes, cycloaliphatic compounds, aromatic hydrocarbons, polyaromatic hydrocarbons, chlorinated organic compounds (aliphatic and aromatic)

***marked topics for Seminars**

Semester III – Theory

Paper Code: SIPSZOBT32
Genetic Engineering Techniques and its applications

Learning Objectives

- To familiarize with the basic tools of genetic engineering involved in tailoring genetic information to delve into the genomes of organisms; designing cloning vectors and using DNA fragments as research tools.
- To gain insight of the potential of Bioinformatics – a field applying computer knowledge to study genomes.
- To recognize the relevance of recombinant DNA technology in making animals with manipulated genes – transgenic animals, that can be potential biofactories for production of biopharmaceuticals.

Unit 1: Genome Management and Analysis **15 Lectures**

1.1: The basic tools of genetic engineering:
1.1.1: Chemical synthesis of DNA: Oligonucleotide synthesis by Phosphoramidite method; synthesis of genes
*1.1.2: DNA Sequencing: Maxam-Gilbert method, Sanger's dideoxynucleotide method; by using bacteriophage M13; by Primer walking
1.1.3: Polymerase chain reaction and its advantages

1.2: Cloning vectors:
*****1.2.1: General purpose plasmid vectors: pUC19, pBR322 (Bacterial vectors)
1.2.2: Bacteriophage and cosmid vectors
1.2.3: Yeast artificial chromosomes (YACs)

1.3: Analysis of Genome/ Proteome:
1.3.1: DNA fingerprinting/ physical mapping/ pulsed field gel electrophoresis
1.3.2: Analysis of the proteome
1.3.3: Analysis of mRNA transcripts

Unit 2: Manipulation of gene expression in prokaryotes **15 Lectures**

2.1: Promoters of gene expression in prokaryotes:
2.1.1: Prokaryotic gene expression
2.1.2: Isolation of functional promoters
2.1.3: Promoter selection with *E.coli* plasmid pBR316
*****2.1.4: Promoter selection with plasmid pKO1
2.1.5: Gene expression from strong and regulatable promoters

2.2: Expression of cloned genes in prokaryotes:
2.2.1: Increasing protein production and secretion
*****2.2.2: Inclusion bodies and fusion proteins
2.2.3: Unidirectional tandem gene arrays
2.2.4: Translation expression vectors
2.2.5: Increasing protein stability

Unit 3: Bioinformatics **15 Lectures**

3.1: Uses and applications of computers in biological sciences
***3.2:** DNA profiling: cDNA and ESTs (Expressed sequence tags)
3.3: Basic research with DNA microarrays and its application in healthcare
3.4: Biomedical genome research and pharmacogenomics
3.5: Random amplified polymorphic DNA (RAPD)
3.6: Human genomic variation: SNPs (Single nucleotide polymorphisms), SNPs and disease; QTL (Quantitative trait loci) and its relation to SNPs
3.7: Satellite DNA and its types

Unit 4: Animal Biotechnology and Human therapies **15 Lectures**

4.1: Animal Biotechnology:
*****4.1.1: Transgenic animals and their applications: Mice as model system for human diseases and as test case model; cows, pigs, sheep, goats as biopharmaceuticals; transgenic insects and birds
4.1.2: Recombinant DNA technology to prevent animal diseases
4.1.3: Conservation biology: Embryo transfer
4.1.4: Regulation of transgenic animals and patenting genetically engineered animals

4.2: Human therapies:
4.2.1: Tissue engineering: Skin, liver, pancreas
*****4.2.2: Xenotransplantation
4.2.3: Antibody engineering
4.2.4: Cell adhesion based therapies: Integrins, inflammation, cancer and metastasis
4.2.5: Targeted gene replacement for correcting a mutated gene
4.2.6: Site directed mutagenesis

***marked topics for Seminars**

Semester III – Theory

Paper Code: SIPSZOOCN33
General, Physical, Chemical and Biological Oceanography

Learning Objectives

- To give a brief introduction to acclimate students with the different aspects of Oceanography.
- To learn about the general features of the earth's surface under water with reference to the ocean waters of the Indian subcontinent.
- To gain knowledge of the tools used for oceanographic studies and research.
- To analyse the physical attributes of sea water and comprehend their influence on aquatic life; to throw light on ocean circulation – a key regulator of climatic changes.
- To study inorganic constituents – the chemicals that make up the ocean and their role in nurturing oceanic life.
- To appreciate the vast array of life forms found in the ocean from bacteria to large nektons and their adaptations to best suit the niche in which they thrive, and to study the influence of the fluctuations they encounter in their habitats.

Unit 1: General Oceanography - I **15 Lectures**

1.1: Terminology of submarine topography: Continental shelf, continental slope, submarine canyons, submarine mountain ranges, Guyots and trenches with special reference to the Indian Ocean and adjacent seas

***1.2:** A general knowledge of typical oceanographic research vessel and its equipments, oceanographic labs and stations of the world and India

Unit 2: Physical Oceanography - I **15 Lectures**

2.1: Physical properties of sea water: Salinity, chlorinity, temperature, light, density, pressure; Salinity-Temperature-Density relationship (STD)

2.2: Oceanographic circulation: Ekman spiral, geotropic current, westward intensification with dynamic topography

Unit 3: Chemical Oceanography - I **15 Lectures**

***3.1:** Composition of sea water: Constancy of its composition and factors affecting the composition, major and minor constituents, trace elements and their biological role

3.2: Dissolved gases in sea water and their role in the environment; carbon dioxide system; dissolved oxygen and oxygen profile, hydrogen sulphide

3.3: Nutrients in the ocean, their cycles and factors influencing their distribution: Nitrogen, Phosphorus, Silicon

Unit 4: Biological Oceanography - I **15 Lectures**

***4.1:** Sea as a biological environment
***4.2:** Division of marine environment

4.3: 4.3.1: Marine biotic diversity: An account of plankton, nekton and benthos; implications of species richness, measuring diversity, quadrants of species diversity, models explaining diversity gradient
*4.3.2: Intertidal organisms and their zonation
4.4: Effect of physical factors on marine life:
4.4.1: Light: Photosynthesis, colouration, structural adaptations and bioluminescence
4.4.2: Temperature: Tolerance, geographical distribution, size, calcium precipitation, metabolism, bipolarity, tropical submergence and periodicity
4.4.3: Salinity: Tolerance and distribution, size, buoyancy and osmoregulation
4.4.4: Currents: Role in nutrition, transportation and propagation
*4.4.5: Marine bacteria and their role

***marked topics for Seminars**

Semester III – Theory

Paper Code: SIPSZOOCN34
Planktology, Fish and Fishery Science, and Aquaculture

Learning Objectives

- To study planktons, tiny drifting life forms inhabiting water bodies, that nourish the higher trophic levels in the ocean ecosystem.
- To gain knowledge of Fishery Science that opens an avenue for bioeconomics.
- To consider the application of techniques of Biotechnology in improving fish stock for better yields.
- To introduce aquaculture to know its immense potential for generating employment; to acquire knowledge for wise management of aquatic resources to minimize production costs and gain profit. Also to consider aquaculture as a subsidiary in the income of someone having a taste for it but not a professional/ an aquaculturist.

Unit 1: Planktology - I **15 Lectures**

1.1:
1.1.1: Classification of plankton
1.1.2: Adaptation to planktonic life
1.1.3: Factors influencing the distribution and abundance; plankton bloom; patchiness; vertical distribution and red tide

1.2:
1.2.1: Diurnal migration of zooplankton
1.2.2: Inter-relationship between phytoplankton and zooplankton

Unit 2: Fish and Fishery Science - I **15 Lectures**

2.1: An overview of fish classification as per Francis Day and FAO

2.2: 2.2.1: Major commercial fisheries:
a. Elasmobranchs (shark and ray)
b. Teleosts: Sciaenoids, Indian salmon, Seer fish, Mackerel, Sardine, Carangids, Tuna, Sole fish, *Harpodon*, Ribbon fish fisheries
*****2.2.2: Crustacean fisheries:
Prawns (penaeid and non penaeid), Shrimps, Lobster and Crab
*****2.2.3: Molluscan fisheries

Unit 3: Biotechnology in Fishery and Biometric Studies - I **15 Lectures**

3.1: Fish stock improvement through selective hybridization

3.2: Gene transfer technology in fish: General steps for developing transgenic fish –
Gene transfer by microinjection, electroporation, transfer of transgenes by injection with pantropic retroviral viruses, fish antifreeze protein gene, promoter in the production of growth hormone; *****characterization of transgenic fish (Identification of transgenic fish and expression of transgenes); gene transfer in common carp and channel fish

Unit 4: Aquaculture - I **15 Lectures**

***4.1:**
4.1.1: History, scope and importance of aquaculture
4.1.2: Aquaculture practices in India
4.1.3: Cultivable organisms for aquaculture and criterion for their selection

4.2: Different systems of aquaculture such as Pond Culture, Cage Culture, Pen Culture, Running Water Aquaculture, Raft Culture, Aqua ranching

4.3: Impact of aquaculture on environment

***marked topics for Seminars**

Semester III – Practical
SIPSZOBTP31 and SIPSZOBTP32

Based on SIPSZOBT31 and SIPSZOBT32

1. Demonstration of aseptic technique: Work place for aseptic handling; packing glassware (flasks, test tubes, pipettes, petri dishes) for sterilization; aseptic transfer of liquids (pipetting from flask to test tube).

2. Preparation of LB agar plate, slant, butt and demonstration of streaking technique using bacterial culture to obtain isolated colonies.

3. Determination of viable cell count in the given culture of bacteria by dilution and spreading technique.

4. Using mini-prep method isolate plasmid DNA from the given strain of bacteria and show the purity of the isolate by performing agarose gel electrophoresis.

5. To estimate the number of bacteria in the given culture by nephelometry.

Semester III – Practical
SIPSZOOCNP33

Based on SIPSZOOCN33

1. Determination of physico-chemical parameters:
a. Salinity (Argentometric and conductivity method)
b. Dissolved oxygen
c. Carbon dioxide
d. Nitrates-nitrites
e. Silicates
f. Phosphate-phosphorus

2. Textural features: Sediment analysis – size fraction (sand, silt, clay)

3. Identification of foraminiferans and radiolarians from sand.

4. Estimation of primary productivity by light and dark bottle.

5. Identification of intertidal organisms:
a. Rocky shore: Patella, Chiton, *Fissurella*, *Mytilus* species, *Perna viridis*, *Cardium*, *Balanus*, Gorgonids, *Littorina* and corals
b. Sandy shore: Solen, Umbonium, *Oliva*, Pea crab, Fiddler crab, Molluscan shells, Star fish and *Balanoglossus*
c. Muddy shore: *Lingula*, *Chaetopterus*, *Arenicola*, Tubiculus worm and Mud skipper

Semester III – Practical
SIPSZOOCNP34

Based on SIPSZOOCN34

1. Laboratory procedure for quantitative estimation of plankton settling method, wet weight method, weight displacement method, counting method.

2. Identification of zooplankton permanent slides:
Noctiluca, *Obelia medusa*, Zoea, *Zoea porcelina*, Copepods, Mysids, Echinoderm larvae, Nauplius, *Sagitta*, *Doliolum*, *Salpa*, Fish eggs and larvae, Jelly fish, *Physalia*, *Porpita*

3. Study of fecundity-maturation studies.

4. Plotting frequency polygon by ova diameter measurement.

5. Identification and classification of Marine fish:

a. Elasmobranchs
1. **Family: Carcharidae**
Carcharias sps., *Zygaena malleus*
2. **Family: Rhinobatidae**
Rhynchobatus djeddensis
3. **Family: Trygonidae**
Trygon uarnak

b. Teleosts
1. **Family: Percidae**
Lutianus johnii, Therapon sps., *Pristipoma maculatum, Synagris japonicus, Gerres filamentosus*
2. **Family: Squamipinnes**
Scatophagus argus
3. **Family: Mullidae**
Upenoides vittatus
4. **Family: Polynemidae**
Polynemus tetradactylus
5. **Family: Sciaenidae**
Pseudosciaena diacanthus, Sciaena sps.
6. **Family: Trichiuridae**
Trichiurus savala/ haumela
7. **Family: Carangidae**
Caranx rottleri, Chorinemus toloo
8. **Family: Stromatidae**
Pampus chinensis, Pampus argenteus
9. **Family: Scombridae**
Rastrelliger kanagurta, Cybium guttatum
10. **Family: Trachinidae**
Sillago sihama
11. **Family: Cottidae**
Platycephalus punctatus
12. **Family: Gobidae**

Periophthalmus sps., *Boleophthalmus* sps.
13. **Family: Sphyraenidae**
Sphyraena acutippinis
14. **Family: Mugillidae**
Mugil sps.
15. **Family: Gadidae**
Bregmaceros sps.
16. **Family: Pleuronectidae**
Psettodes erumei, Cynoglossus elongatus
17. **Family: Siluridae**
Arius dussumieri
18. **Family: Scopelidae**
Saurida tumbil, Harpodon nehereus
19. **Family: Sombresocidae**
Belone stongylurus, Hemiramphus sps.
20. **Family: Clupeidae**
Pellona feligera, Clupea longiceps
21. **Family: Chirocentridae**
Chirocentrus dorab
22. **Family: Muraenesox**
Muraenesox sps.

Note: Minimum number of animals to be used for experiments

Semester IV – Theory

Paper Code: SIPSZOBT41
Basics of Industrial and Environmental Biotechnology - II

Learning Objectives

- To keep abreast with the current trends in this fast moving field of Biotechnology, that is an intersection of technology and Biology.
- To know about enzyme immobilization techniques for obtaining products of commercial use.
- To realize the role of Biotechnology in agriculture and environment management in benefitting mankind.

Unit 1: Microbial synthesis of commercial products 15 Lectures

1.1: Organic acids and their commercial applications: Citric acid, gluconic acid, lactic acid

1.2: Antibiotics: Cloning antibiotic biosynthetic gene by complementation and other methods; synthesis of novel antibiotics and improving antibiotic production; *****Aminoglycosides and their uses

1.3: Polysaccharides:
a. Bacterial polysaccharides: General properties and their commercial applications – Dextran, xanthan, alginate; genetic engineering for large scale production of xanthan gum and its modification
*****b. Marine polysaccharides: General properties and their commercial application – Agar and agarose, Chitosan

1.4: Polyesters: Polyhydroxyalkanoates (PHA) – Biosynthesis of PHA; Biopol, a commercial biodegradable plastic

Unit 2: Large scale culture and production for Industrial Biotechnology 15 Lectures

2.1: Biotransformations
2.1.1: Selection of biocatalyst: Screening and use of novel existing biocatalyst
2.1.2: Genetic modification of existing biocatalyst (Indigo biosynthesis)
2.1.3: Biocatalyst immobilization:
Methods of immobilization – Cross linking, supported immobilization, adsorption and ionic binding, covalent coupling, lattice entrapment
2.1.4: Immobilized soluble enzymes and suspended cells
2.1.5: Immobilization of multi-enzyme systems and cells
*2.1.6: Immobilized enzyme reactors: Batch reactors, continuous reactors
2.1.7: Analytical enzymes: Enzymes in diagnostic assays – Test strip systems and Biosensors (Electrochemical and optical type)

Unit 3: Agricultural Biotechnology 15 Lectures

***3.1:** Nitrogen fixation

3.2: Nitogenase: Components of nitrogenase; Genetic engineering of nitrogenase cluster

3.3: Hydrogenase: Hydrogen metabolism; genetic engineering of hydrogenase gene

3.4: Nodulation: Competition among nodulation organisms; genetic engineering of nodulation gene

3.5: Microbial insecticides: Toxins of *Bacillus thuringiensis*, mode of action and use of thuringiensis toxins, thuringiensis toxin gene isolation, genetic engineering of *Bacillus thuringiensis* strains and cloning of thuringiotoxin gene

3.6: Developing insect resistant, virus resistant and herbicide resistant plant

3.7: Algal products: Fuels from algae, marine natural products and their medical potential (anticancer, antiviral compounds; antibacterial agents)

Unit 4: Environmental Biotechnology - II **15 Lectures**

4.1: Bioabsorption of metals (Recovery from effluents)
*****4.1.1: Bioabsorption by fungi, algae, moss and bacteria
4.1.2: Mechanism of bacterial metal resistance and genetic engineering for specific proteins
4.1.3: Bioreactors for bioabsorption: Packed bed, fluidized bed, rotating disc, single blanket, sequential reactors
4.1.4: Phytoremediation and its use in biotechnology

4.2: Bioleaching of metals
4.2.1: Biochemical mechanism of bioleaching
4.2.2: Extraction from mixtures
4.2.3: Types of bioleaching
4.2.4: Methods for bioleaching: Tank and heap bioleaching
*****4.2.5: Microorganisms used for bioleaching

***marked topics for Seminars**

Semester IV – Theory

Paper Code: SIPSZOBT42
Genome Management, Manipulation, Regulations and Patents in Biotechnology

Learning Objectives

- To familiarize with the basic tools of genetic engineering involved in tailoring genetic information to delve into the genomes of organisms; designing cloning vectors and using DNA fragments as research tools.
- To know about the basics of Human Genome Project, and Regulations and Patents in Biotechnology.

Unit 1: Genome management **15 Lectures**

1.1: Basic tools of genetic engineering:
1.1.1: Gene transfer techniques: Protoplast fusion, calcium phosphate, precipitation, electroporation, liposome, ligand mediated, gene gun or biolistic approach, viral mediated
1.1.2: Selection and screening of recombinants
*****1.1.3: Nucleic acid probes and hybridization, Southern blotting and Northern blotting
1.1.4: Immunological assays for identification of gene product; Western blot

1.2: Cloning vectors:
1.2.1: Retrovirus and SV40 vectors
1.2.2: Special purpose vectors: Expression vectors, secretion vectors, shuttle or bi-functional vectors, single stranded phage and phagemids

Unit 2: Manipulation of gene expression in eukaryotes **15 Lectures**

2.1: Eukaryotic gene expression
***2.2:** Introduction of DNA into fungi: Yeast and filamentous fungi (fungal transformation)
2.3: Heterologous protein production in yeasts
2.4: Heterologous protein production in filamentous fungi
2.5: Cultured insect cell expression systems: Baculovirus transfer vector
***2.6:** Mammalian cell expression systems: Human Papova BK virus shuttle vector

Unit 3: The Human Genome Project **15 Lectures**

***3.1:** The human genome; scope and goals of the human genome project
3.2: Genetic linkage maps, chromosome walking, restriction mapping
3.3: Polymorphic DNA markers
3.4: Restriction fragment length polymorphism (RFLP) and its uses
3.5: Physical maps, Sequence tagged sites
3.6: Integrating genetic linkage and physical maps
***3.7:** Mapping human diseases
3.8: Positional cloning: Getting closer to a disease causing gene
3.9: Testing for exons
3.10: Limitations of positional cloning

Unit 4: Regulations and Patents in Biotechnology **15 Lectures**

4.1: Regulating recombinant DNA technology

***4.2:** Regulatory requirements: Safety of genetically engineered foods, chymosin, tryptophan, bovine somatotropin

4.3: Regulating environmental release of genetically engineered organisms (GEO); Ice minus *Pseudomonas syringae*

4.4: Regulatory agencies and laws for product regulation

4.5: Risk assessment: How much risk?

***4.6:** Open field tests of GEO

4.7: Development of policy for human gene therapy

4.8: Patenting biotechnology inventions:
4.8.1: What constitutes the patent?
4.8.2: Patent process
4.8.3: Conditions to be satisfied for an invention to be patentable: Novelty, inventiveness, usefulness
4.8.4: Patenting in different countries; types of inventions that are not patentable in India
4.8.5: What is Paris convention? Principal features of Paris convention
4.8.6: Patenting multicellular organisms
4.8.7: Patenting and fundamental research

***marked topics for Seminars**

Semester IV – Theory

Paper Code: SIPSZOOCN43
General, Physical, Chemical and Biological Oceanography

Learning Objectives

- To gain knowledge of the tools used for oceanographic studies and research.
- To analyse the physical attributes of sea water and comprehend their influence on aquatic life. To study such physical aspects of Oceanography as tides, waves and currents that not only influence aquatic life but also life on the terrestrial realm.
- To make students mindful of the anthropogenic activities in the ocean that pose a threat not only to the aquatic life, but the environment as a whole.
- To value the offshore resources of the ocean (oil and natural gas) formed from large deposits of the remains of marine algae and plants.

Unit 1: General Oceanography - II **15 Lectures**

1.1: Oceanographic instruments:
Grab (Peterson and Van Veen) for benthos collection, naturalist's dredge (Ekman Sanders deep sea anchor dredge), trawl, plankton nets and continuous plankton sampling system, reversing Nansen bottles, reversing thermometer, salinometer, Secchi disc, Stempel pipette and dilution jar; underwater photography, remote sensing and satellite imaging, SCUBA apparatus

1.2: Oceanographic expeditions: Challenger, Indian Ocean and Antarctic

1.3: Law of sea

Unit 2: Physical Oceanography - II **15 Lectures**

2.1: Vertical circulation: Wind induced circulation, thermohaline circulation and upwelling of water

2.2: Waves: Characteristics of waves, deep water and shallow water waves, transitional waves, wind generated waves, internal waves and Tsunami

*__2.3:__ Tides: Tides generating forces, equilibrium theory of tides, dynamic theory of tides, tides as a source of power

*__2.4:__ Currents: Types of currents, major currents of the world, Coriolis effect and El Nino effect

Unit 3: Chemical Oceanography - II **15 Lectures**

3.1: Impact of anthropogenic activities:
3.1.1: a. Pollution: Domestic sewage, industrial/ heavy metals; agricultural: fertilizers and pesticides
b. Oil pollution
c. Ocean dumping
d. Radioactive and thermal waste
3.1.2: Reclamation

Unit 4: Biological Oceanography - II **15 Lectures**

4.1: Resources from the sea:
4.1.1: Mineral resources: a. Continental margin
b. Deep sea mud oozes and manganese nodules
c. Oil, gas and sulphur deposits, and the role of ONGC
4.1.2: Bioactive compounds from the sea
4.1.3: Scientific and economical aspects of seabed exploration and mining

***marked topics for Seminars**

Semester IV – Theory

Paper Code: SIPSZOOCN44
Planktology, Fish, Fishery Science and Aquaculture

Learning Objectives

- To study planktons, tiny drifting life forms inhabiting water bodies, that nourish the higher trophic levels in the ocean ecosystem and act as indicator species.
- To gain knowledge of Fishery Science with regards to Population Dynamics .
- To consider the application of statistical tools to study fishery science.
- To learn about aquaculture of fin fish as well as crustaceans and molluscs. To attain a clear perception of the present status of sea farming in India.

Unit 1: Planktology - II **15 Lectures**

1.1: Marine algae and plankton in relation to fisheries; indicator species
1.2: Methods of collection, preservation and analysis of plankton
1.3: Marine biodeterioration: Fouling and Boring organisms

Unit 2: Fish and Fishery Science - II **15 Lectures**

2.1: Population Dynamics:
2.1.1: Abundance in population and fishery; fishery catches and fluctuation
2.1.2: M.S.Y., optimum yield, age composition, population growth, population models

2.2: Socio-economics of fishermen

Unit 3: Biotechnology in Fishery and Biometric Studies - II **15 Lectures**

3.1: Statistical methods:
Collection of data, sampling methods, presentation of data, measurement of central tendency and dispersion, frequency distribution, analysis of variance and co-variance, correlation regression, theory of probability, tests of significance, Chi-square test

3.2: Measurement of fish:
Measurement of length and weight, morphometric measurements, meristic counts, Biometric index

Unit 4: Aquaculture - II **15 Lectures**

4.1: Hatchery and grow out practices for cultivable species of fresh water fish (Indian major carps and exotic carps) and prawns (*Macrobrachium rosenbergii*); culture of air breathing fishes

4.2: Integrated aquaculture and sewage-fed fishery; hatchery and grow out practices for the culture of brackish water fishes (*Chanos chanos* and *Lates calcarifer*) and prawns (*Penaeus monodon* and *Penaeus indicus*)

4.3: Culture of molluscs (clams, oyster: edible and pearl, and mussels), echinoderms (sea cucumber), sea weeds

***4.4:** Present status of sea farming in India

***marked topics for Seminars**

Semester IV – Practical
SIPSZOBTP41 and SIPSZOBTP42

Based on SIPSZOBT41 and SIPSZOBT42

1. Immobilize yeast cells in calcium alginate and prepare a bioreactor column to demonstrate invertase activity in the bioreactor column.

2. Restriction-digest the given DNA sample and demonstrate the separation of fragments by performing agarose gel electrophoresis. Interpret the results by comparing with the standard digests provided.

3. Demonstrate the Western blotting technique for the given sample of protein.

4. To plot a growth curve for the microorganisms provided.

5. Demonstrate the effect of media on growth curves of given microorganism, using two different media (minimal and enriched).

Semester IV – Practical
SIPSZOOCNP43

Based on SIPSZOOCN43

1. Oceanographic instruments:
a. Nansen reversing bottle
b. Deep sea reversing thermometer
c. Bathythermometer
d. Drift bottle
e. Ekman's current meter
f. Secchi disc
g. Plankton nets: Standard net, Hensen net and Clarke Bumpus net
h. Stempel pipette and counting slide
i. Nekton sampling device: Trawls
j. Benthic sampling devices: Dredges, grabs and corers

2. Detection of heavy metals:
a. Zinc
b. Lead
c. Copper

3. Study of food and feeding habits in fish.

4. Identification of crafts and gears.

Semester IV – Practical
SIPSZOOCNP44

Based on SIPSZOOCN44

1. Preparation of zooplankton mountings.

2. Collection of marine algae and preparation of herbaria (at least five different forms).

3. Biometric studies of fish/ prawn:
a. Study of relationship between total length and standard length/ head length/ body depth length/ body weight.
b. Calculate correlation (standard length and total length, head length and total length, body depth and total length). Calculate the index values for various relationships.

4. Identification of fouling and boring organisms:
Limnoria sps., *Lepas, Balanus, Caprella, Teredo, Littorina, Crassostrea, Pellaria/ Sertularia*.

5. a. Identification and classification of fresh water fish:
Rohu, *Catla*, Mrigal, *Tilapia, Gourami*
b. Identification and classification of fresh water prawn:
Giant fresh water prawn, *Macrobrachium rosenbergii*

6. Crustacean fishery:
Penaeus monodon, P. indicus, M. monoceros, P. stylifera, Solenocera indica, Nematopaleomon, Acetes indicus

7. Molluscan fishery:
Meretrix, Perna viridis, Katelysia sps., Crassostrea sps., Xancus pyrum, Solen kempi, Cuttle fish and gastropods

8. Visit to aquaculture centres, boat building yards, processing plants and marine biological institutions (Excursions or study tours); Student Activity:
a. Collection of molluscan shells
b. Preparing herbaria from marine algae (at least 5)
c. Preparation of shrimp pickle

Note: Minimum number of animals to be used for experiment

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Semester III and Semester IV

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Semester III and Semester IV

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Practical Examination Question Paper Pattern
Semester III – Practical (SIPSZOBTP31)

Based on SIPSZOBT31

Time: 5 hours **Marks: 50**

Q.1 Determination of viable cell count in the given culture of bacteria by dilution and spreading technique. **(Day 1)** **25**

OR

Q.1 Using mini-prep method isolate plasmid DNA from the given strain of bacteria and show the purity of the isolate by performing Agarose gel electrophoresis. **(Day 1)** **25**

Q.2 To demonstrate aseptic techniques: **15**
a. Work place for aseptic handling
b. Packing glassware (flask, test tube, pipette, petri dish) for sterilization
c. Aseptic transfer of liquids (pipetting from flask to test tube) **(Day 2)**

Q.3 Viva **05**

Q.4 Journal **05**

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Semester III – Practical (SIPSZOBTP32)

Based on SIPSZOBT32

Time: 5 hours **Marks: 50**

Q.1 Preparation of LB agar plate, slant, butt and demonstration of streaking technique using bacterial culture to obtain isolated colonies. **(Day 1)** **25**

Q.2 Estimate number of bacteria in the given culture by Nephelometry. **(Day 2)** **15**

Q.3 Viva **05**

Q.4 Journal **05**

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Practical Examination Question Paper Pattern
Semester III – Practical (SIPSZOOCNP33)

Based on SIPSZOOCN33

Time: 5 hours **Marks: 50**

Major Question:

Q.1 (A) Determination of physicochemical parameters: **10**
Salinity/ Dissolved oxygen/ CO_2/ Nitrates-Nitrites/ Silicates/ Phosphate-Phosphorus.

OR

Q.1 (A) Estimation of primary productivity by light and dark bottle.

Q.1 (B) Identification of foraminiferan and radiolarian shells. (ANY FOUR) **05**

Minor Question:

Q.2 Sediment analysis from the given sample. **07**

Q.3 Identify and describe (Any 6 intertidal organisms) **18**

Q.4 Viva **05**

Q.5 Journal **05**

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Semester III – Practical (SIPSZOOCNP34)

Based on SIPSZOOCN34

Time: 5 hours **Marks: 50**

Major Question:

Q.1 (A) Fish identification (1 Elasmobranch, 4 Teleosts) **15**

(B) Fish identification as per Francis day volume **05**

Minor Question:

Q.2 Study of maturity, plankton settling method/ weight method/ weight displacement method/ counting method and study of fecundity and maturation studies. **08**

OR

Q.2 Plotting frequency polygon by ova diameter measurement. **08**

Q.3 Identification (4 spots) **12**

Q.4 Viva **05**

Q.5 Journal **05**

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Practical Examination Question Paper Pattern
Semester IV – Practical (SIPSZOBTP41)

Based on SIPSZOBT41

Time: 5 hours **Marks: 50**

Q.1 Demonstrate the effect of medium on growth curves of given microorganism using enriched media. **(Day 1)** **25**

OR

Q.1 Demonstrate the effect of medium on growth curves of given microorganism using minimal media. **(Day 1)** **25**

Q.2 Immobilize yeast cells in calcium alginate, prepare beads and keep them overnight in activation medium. (**Day 1)** **15**

Q.3 Viva **05**

Q.4 Journal **05**

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Semester IV – Practical (SIPSZOBTP42)

Based on SIPSZOBT42

Time: 5 hours **Marks: 50**

Q.1 Prepare a bioreactor column to demonstrate invertase activity in the bioreactor column. **(Day 2)** **25**

Q.2 Restriction-digest the given DNA sample and demonstrate the separation of fragments by performing Agarose gel electrophoresis. Interpret the results by comparing with the standard digests provided. **(Day 2)** **15**

OR

Q.2 Demonstrate Western blotting technique for the given sample of protein. **(Day 2)** **15**

Q.3 Viva **05**

Q.4 Journal **05**

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Practical Examination Question Paper Pattern
Semester IV – Practical (SIPSZOOCNP43)

Based on SIPSZOOCN43

Time: 5 hours	**Marks: 50**
Major Question:	**12**
Q.1 Identification of oceanographic instruments. (3 spots)	
Minor Question:	
Q.2 (A) Detection of heavy metals: Zinc/ Lead/ Copper.	**10**
(B) Food and feeding habits in fish.	**06**
Q.3 Identification (2 crafts and 2 gears)	**12**
Q.4 Viva	**05**
Q.5 Journal	**05**

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Semester IV – Practical (SIPSZOOCNP44)

Based on SIPSZOOCN44

Time: 5 hours **Marks: 50**

Major Question:

Q.1 Biometric study of fish:

(A) Study of relationship between total length and standard length/ head length/ body depth length/ body weight. **04**

(B) Calculate correlation (standard length and total length/ head length and total length) **03**

Minor Question:

Q.2 Preparation of zooplankton mountings. (5 mountings of zooplankton) **10**

Q.3 Identification: **08**

a. Fouling and boring organism
b. Fresh water fish/ fresh water prawn
c. Crustacean fishery
d. Molluscan fishery

Q.4 (A) Herbarium **05**

(B) Field report (visit to aquaculture centre, boat building yards, processing plants, marine biological institutions – Excursion or Study tours) **04**

(C) Collection of molluscan shells (5 shells) **04**

(D) Report on shrimp/ prawn pickle **02**

Q.5 Viva **05**

Q.6 Journal **05**

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Scheme of Examination

The performance of learners will be evaluated in two parts for the Theory component of the Course:
1. Internal Assessment with 40% marks
2. Semester End Examination (written) with 60% marks
The Practical component of the Course will be evaluated by conducting Semester End Practical Examination of 50 marks.

Internal Assessment Theory (40%)
It is the assessment of learners on the basis of continuous evaluation as envisaged in the Credit Based System by way of participation of learners in various academic and correlated activities in the given semester of the program.

Marks: 40
Evaluation will be conducted on the basis of Seminar/ Presentation given by the student on a topic chosen from the syllabus for each paper. The marking scheme shall be:

- Content of Presentation: **10 marks**
- Quality of Presentation: **10 marks**
- Presentation skills: **10 marks**
- Question-Answer discussion: **10 marks**

Semester End Assessment Theory (60%)

Marks: 60
Duration: 2 hours
Theory question paper pattern:

- There shall be five questions of 12 marks each. On each unit there will be one question and the 5^{th} question will be based on the entire syllabus.
  OR
  There shall be four questions of 15 marks each, each question based on one unit.
- All questions are compulsory with internal choice within the questions.
- Questions may be subdivided and the allocation of marks depends on the weightage of the topic.

Semester End Assessment Practical

Marks: 50
Duration: 5 hours

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