Semester I

Course I: 18PS1ZO1

Phylogeny and Osteology

Module 1: Phylogeny & Systematics of non-chordates –

Phylogeny, salient features, classification up to class level (wherever applicable) of the following phyla

1.1 Protista (Protozoa)

1.2 Porifera

1.3 Coelenterata

1.4 Ctenophora

1.5 Mollusca

1.6 Bryozoa

1.7 Brachiopoda

1.8 Echinodermata

1.9 Chaetognatha

1.10 Platyhelminthes and Nemethelminthes

1.11 Acanthocephala

1.12 Annelida

1.13 Sipunculoidea

1.14 Arthropoda

1.15 Onychophora – Peripatus: A connecting link between Annelida and Arthropoda

1.16Hemichordata

Module 2: Type study – Sepia and Protochordate phylogeny

2.1 Type Study Sepia

2.1.1 Habit, habitat and morphology of Sepia

2.1.2 Systems: Digestive, Circulatory, Nervous and Reproductive (male and female)

2.1.3 Economic Significance of Sepia

2.2 Protochordates

2.2.1 Urochordata and its affinities.

2.2.2 Cephalochordata and its affinities

2.2.3 Vertebrate ancestry and origin of Vertebrates.

2.2.4 Changes leading to first vertebrates.

2.2.5 Salient features and phylogeny of Ostracoderms.

2.2.6 Affinities of Cyclostomes

a) resemblance with Cephalochordates b) differences from fishes. c) vertebrate characters. d) specialized characters.

Module 3: Chordate phylogeny

3.1 Discovery of Coelacanth

3.2 Overview of fish phylogeny

3.3 Primitive tetrapods- Labrynthodonts

3.4 Crossopterigians- A blue print.

3.5 Dipnoi- a group that has failed to evolve as amphibian

3.6 Lissamphibia

3.7 Sphenodon- a living fossil

3.8 Extinct reptiles.

3.9 Adaptive radiation in Reptilia

3.10 Warm blooded reptile Archaeopteryx- a connecting link between Reptiles and Aves

3.11 Affinities of Aves and classification upto subclass

3.12 Origin of flight (theory of cursorial & arboreal origin)

3.13 Birds as glorified reptiles

3.14 Egg laying mammals- connecting link between reptiles and mammals

3.15 Classification of mammals up to orders

3.16 Dentition in mammals

3.17 Walking gait (Plantigrade, Digitigrade, and Unguligrade)

Module 4: Comparative osteology (Axial and Appendicular skeleton of shark, bony fish, frog, varanus, pigeon and rabbit)

4.1 Skull

4.2 Jaw suspension

4.3 Vertebral column of tetrapods Atlas, Axis, Typical Vertebra, Thoracic vertebra, Trunk vertebra, Caudal vertebra

4.4 Pectoral girdle

4.5 Pelvic girdle

4.6 Limbs of tetrapods

Course II: 18PS1ZO2

Biomolecules and Cell Signalling

Module 1: Biomolecules – Carbohydrates, lipids

1.1 Carbohydrates

1.1.1Classification: mono-, oligo- and poly-saccharides.

1.1.2 Monosaccharides

1.1.3 Oligosaccharides

1.1.4 Polysaccharides- homo- and hetero-polysaccharides.

1.1.5 Biological functions of carbohydrates.

*1.2 Lipids

1.2.1 Classification: simple and complex lipids

1.2.2 Fatty acids

1.2.3 Acylglycerols

1.2.4 Complex lipids

1.2.5 Biological functions of lipids.

1.3 Carbohydrate Metabolism

1.3.1 Glycolysis Reaction sequence, flow of carbon, Conversion of pyruvate to lactate and Acetyl coenzyme-A, significance of pyruvatelactate interconversion, aerobic and anaerobic glycolysis and energetic of glycolysis. Regulation of glycolysis

1.3.2 Gluconeogenesis: Reaction sequence from pyruvate, gluconeogenesis from amino acids, glycerol, propionate, lactate. Regulation of gluconeogenesis

*1.3.3 Glycogen metabolism: Glycogenesis, Glycogenolysis. Regulation of the two pathways.

1.3.4 Significance of following pathways: Hexose monophosphate shunt as a multifunctional pathway* Uronic Acid Pathway, Glyoxalate cycle.

1.4 Lipid Metabolism

1.4.1 Dynamics of body lipids, mobilization of fats, regulation of hormone sensitive TG lipase, fate of glycerol and free fatty acids.

1.4.2 Fatty acid metabolism: Oxidation of even-carbon and odd-carbon atom fatty acid, oxidation of unsaturated fatty acids, biosynthesis of fatty acids including desaturation, metabolism of phospholipids, cholesterol and alcohol.

Module 2: Biomolecules –Nucleic acids and Proteins

2.1 Nucleic acids

2.2.1 Types, Components, Structure of DNA

2.2.2 Structure, types and functions of RNA

*2.2 Proteins 2.2.1 Amino acids: structure and classification

2.2.2 Organization of protein structure: Primary structure and peptide bond, secondary, tertiary and quaternary structure; conjugate proteins haemoglobin, cytochromes, myoglobin, bonds involved in protein organization.

2.2.3 Properties of proteins: classification, denaturation and protein folding.

2.2.4 Biological functions of proteins. Biologically important peptides: glutathione, octa-, nona and deca-peptides.

2.3 Complex biomolecules

2.3.1 Glycoproteins

2.3.2 Glycolipids

2.3.3 Lipoproteins

2.4 Protein Metabolism

2.4.1 Metabolism of amino acids: Amino acid pool, transamination; oxidative and nonoxidative deamination; metabolism of branched chain amino acids; fate of carbon skeleton of amino acids.

2.4.2 Metabolism of ammonia: Urea cycle

2.5 Metabolism of nucleic acids

2.5.1 Synthesis of ribonucleotides- a brief idea of de novo pathway and salvation pathway

2.5.2 Conversion of ribonucleotides to deoxyribonucleotides

2.5.3 Degradation of nucleotides

2.5.4 Integration of Metabolism, Energy demand and supply: Integration of major metabolic pathways of energy metabolism, intermediary metabolism; organ specialization and metabolic integration. Metabolism in starvation

Module 3: Biochemical Thermodynamics and Enzyme Kinetics

3.1 Biochemical Thermodynamics

3.1.1 Laws of thermodynamics, free energy, entropy, enthalpy, exergonic and endergonic reactions.

3.1.2 *High energy compounds: ATP, ADP, ATP-ADP cycle, ATP-AMP ratio

3.1.3 Biological oxidation, Electron transport chain and mitochondria, Oxidative phosphorylation mechanism, uncoupling of oxidative phosphorylation and its significance.

3.1.4 Free radicals, antioxidants and antioxidant system.

3.2 Enzymes and enzyme kinetics

*3.2.1 Enzymes Nomenclature and classification with numerical code; chemical nature of enzymes

*3.2.2 Mechanism of enzyme action: Fischer's Lock and Key Theory, Koshland's Induced fit model, Mechanism of enzyme catalysis.

3.2.3 Enzyme kinetics: Michaelis Menten equation; Lineweaver-Burk plot; significance of Vmax and Km; factors affecting enzyme activity; enzyme activation and inhibition.

3.2.4 Regulatory enzymes: a) Covalently modulated b) allosteric regulation c) Isoenzymes (LDH, CK, ALP, ADH)

*3.2.5 Non-protein enzymes- Ribozymes

*3.2.6 Advanced enzymes in human healthcare (e.g. fungal lactase, Hemicellulase, Trypsin chymotrypsin mix)

Module 4: Bio signalling

4.1.1 General features of signal transduction

4.1.2 G- protein coupled receptors

4.1.3 Receptor tyrosine kinases

4.1.4 Gated ion channels

4.1.5 Regulation of transcription by steroid hormones

Course III: 18PS1ZO3

Evolution, Genetics and Developmental Biology

Module 1: Evolution and molecular phylogeny

1.1 Evolutionary theories:

1. Darwinism

2. Lamarckism

3. Hugo de Vries theory

4. neo-Darwinism

1.2 Evolution of Horse

1.3 Evolution of Elephant

1.4 Human Evolution

1.5 Human Migration

1.6 Molecular Evolution

1.6.1 Patterns and modes of nucleotide substitutions

1.6.2 Nucleotide substitutions in DNA

1.6.3 Rate of substitution

1.6.4 Variation in evolutionary rate between genes

1.6.5 Molecular clock 1.6.6 Molecular Phylogeny

1.6.7 Phylogenetic tree and reconstruction methods

1.6.8 Horizontal gene transfer

1.6.9 Acquisition and origin of new functions

1.6.10 Multigene families

1.6.11 Gene duplication and conversion

Module 2: Genetics –Linkage, crossing over, gene mapping

2.1 Morgan's Experiment with Drosophila

*2.2 Gene recombination and role of chromosomal exchange

2.3 Constructing genetic linkage maps of Human Genome

2.3.1 The lod score method for analysing linkage of human genes

2.3.2 Human genetic maps

a) physical chromosome mapping: deletion mapping, cell hybridization mapping, mapping by in situ hybridization; correspondence of andphysical maps.

*b) Practical application of chromosome mapping tracking the inheritance of an allele with coupled DNA markers

Module 3: Inborn Errors of Metabolism and Teratology

3.1 Inborn errors of metabolism

- Carbohydrate metabolism: G-6PD deficiency
- Lipid metabolism: Metabolic Disorders of cerebrosides.
- Protein metabolism: PKU, Albinism
- Purine metabolism: Primary Gout
- Mineral metabolism and diseases:
- Hypocalcaemia, Hypercalcaemia and osteoporosis

3.2 Teratology

- Teratogens and their effects
- Sensitive period of teratogen
- Specificity of teratogen
- Thalidomide syndrome
- Teratocarcinoma and Teratoma
- Environmental teratogens

Module 4: Developmental Biology-

*4.1 Basic concepts of Developmental Biology – cell fate, competence, commitment, trans differentiation and differentiation, dedifferentiation, Cell specification

4.2 Cell aggregation and differentiation in Dictyostelium

4.3 Morphogenesis and cell adhesion- Differential cell affinity, cadherins and cell adhesion.

4.4 Axis formation and pattern formation: Drosophila and Xenopus.

4.5 Organogenesis

4.5.1 Vulva formation in Caenorhabditis elegans

4.5.2 Limb development

4.6 Metamorphosis

(a) Amphibian metamorphosis

(b) Metamorphosis in insects- (i) Eversion and differentiation of imaginal discs *(ii) Hormonal control of insect metamorphosis

(c) Programmed cell death

*4.7 Regeneration (a) Regeneration in Hydra (b) Regeneration of Salamander limbs

4.8 Aging: Senescence, life span and causes of aging *4.9 Stem cell and their role in development

Course IV: 18PS1ZO4

Instrumentation and Research Methodology

Module 1: Instrumentation and Research methodology Principles and applications of Microtomy, microscopy, Radioisotopes and Spectroscopy

1.1Microtomy

1.2 Principles and applications of microscopy

*a) Light microscopy

*b) Phase contrast microscopy

c) Fluorescence microscopy

d) Polarized microscopy

e) Confocal scanning microscopy

f) Transmission electron microscopy: *specimen preparation for electron microscopy, scanning electron microscopy

1.3 Principles and applications of radioisotopes:

* a) Use of isotopes in biological sciences

b) units of radioactivity

c) detection and measurement of radioactivity by scintillation counting

d) autoradiography

*1.4 Principles and application of filtration, distillation and extraction:

a) Ordinary filtration under suction pressure

b) fractional distillation

c)steam distillation

d) technique of extraction with solvents

1.5 Spectroscopy:

a) Ultraviolet and visible absorption spectroscopy

b) Fluorescence spectroscopy

c) Nuclear magnetic resonance spectroscopy

d) Mass spectroscopy

e) Atomic absorption spectrophotometer.

Module 2: Principles and application of chromatography and Electrophoresis

2.1.1*Planar chromatography (Course and Thin layer): Preparation of stationary support, solvent, detection and measurement of components, applications.

2.1.2 2D chromatography

2.1.3 HPTLC

2.1.4 Column chromatography

2.1.5 Ion exchange chromatography

2.1.6 Gel chromatography

2.1.7 Affinity chromatography

2.1.8 Gas chromatography

2.1.9 HPLC

2.2 Electrophoresis

*2.2.1 Theory of electrophoresis

2.2.2 Horizontal agarose gel electrophoresis

2.2.3 Vertical polyacrylamide gel electrophoresis

2.2.4 Pulse field electrophoresis

2.2.5 Capillary electrophoresis

2.2.6 Isoelectric focusing of proteins

2.2.7 Two dimensional electrophoresis

Module 3: Research methodology & Scientific writing

3.1 Definition of research, objectives, motivation, types of researches

*3.2 Significance of research

3.3 Methods of research – how research is done, various processes, criteria

3.4 Selection of a research problem, defining a problem, research design

3.5 Scientific writing

3.5.1 Definition and scope – peer reviewed journal, scientific Course for commercial use, scientific book, abstract

3.5.2 Interpretation and report writing: Meaning of interpretation; technique of interpretation; precautions in interpretation; significance of report writing; layout of research report, types of reports; *Presentation of research work oral, poster and writing research Course; Precautions for writing research report.

3.5.3 Review of related literature: Understanding the role of review; how to begin a search for related literature Library reference, recording and indexing, classification of references, internet sites for biological references; downloading the information through internet; requests for reprints through email and post; classification and filing of reprints.

3.5.4 Writing research proposal: Characteristics of a proposal; content and organization of a proposal; weakness in proposal seeking funding.

3.3.5 Writing a scientific Course – IMRAD format

3.5.6 Research Ethics: Ethical decision making, sharing scientific knowledge, Sharing authorship, Plagiarism etc.

Module 4: Biostatistics and case studies in research

4.1 Biostatistics

1. Framing of hypothesis
2. *Standard deviation
3. *Standard Error
4. *Variance
5. ANOVA
6. Fischer's F-test
7. Use of Microsoft Excel - graphs, basic statistical analysis, 3D modelling
8. SPSS
9. R Software

4.2 Case studies

1. Human Animal Conflict: SGNP Leopard
2. North East India: Elephants
3. Olive Ridley Turtles: an effort to protect.
4. Vulture Deaths due to Diclofenac
5. Extinction of Indian Cheetah, great Indian Bustard, Himalayan Quail
6. Organisations dealing with Conservation: WWF, BNHS

Semester I Practicals

Course I 18PS1ZO1P

1. Study of animal type – Sepia

a. Morphology

b. Digestive System

c. Nervous System

d. Reproductive Systems (Male and Female)

e. Mounting of Jaws, radula, statocyst, spermatophore

2. Study of systematic and major features of:

a) Protozoa (Amoeba, Noctiluca, Paramoecium, Plasmodium)

b) Porifera (Leucosolenia,Grantia, Euplectella, Euspongia)

c) Coelenterata (Obelia colony, Physalia, Sea anemone, Madrepora)

d) Mollusca (Chiton, Dentalium, Patella, Mytilus, Loligo, Nautilus)

e) Echinodermata (Starfish, Sea urchin, Sea cucumber, Feather star)

f) Minor Phyla (Comb jelly, Lingula, Sagitta)

g) Hemichordata (Balanoglossus)

3. Study of systematics and major features of:

a) Helminthes (Liverfluke, Tapeworm, Ascaris) Annelida (Nereis, Earthworm, Leech)

b) Sipunculoidea: (Sipunculus), Arthropoda (Crab, Spider, Centipede, Beetle)

4. Study of Protochordates and Chordates

a. Urochordata (Herdmania)

b. Cephalochordata (Amphioxus)

c. Agnatha (Petromyzon, Myxine)

d. Pisces (Shark, Sting ray, Electric ray, Hippocampus, Eel, and any lung fish)

e. Amphibia (Caecilian, Salamander, Frog, Toad)

f. Reptilia (Turtle/Terrapin, Tortoise, Calotes/ Chameleon, Draco, Phrynosoma, Viper, Rattle snake, Hydrophis, Crocodile/Alligator/Gharial)

5. Comparative Osteology: Axial and Appendicular skeleton with reference to:

a. Skull of Shark, Bony fish, Frog, Varanus, Pigeon and Rabbit

b. Vertebrae of tetrapods

c. Pectoral and Pelvic Girdles of tetrapods

d. Limb bones of tetrapods

6. Study of ear ossicles, hyoid apparatus from chicken

7. Study of systematics and major features of

a. Aves (Ostrich, Kiwi, Kite, Owl, and Duck)

b. Mammals (Duckbilled platypus, Echidna, Kangaroo, Shrew, Bat, Loris, Seal/ Walrus, Dolphin, Sea Cow, Tiger, Giant panda, Tapir, Camel, Striped squirrel, Guinea pig, Porcupine, Rabbit)

Course II 18PS1ZO2P

1. Extraction of oil from fish liver – Comparative Study

2. Estimation of reducing sugars by DNSA method

3. Extraction of glycogen from given tissue

4. Isolation of polysaccharides from potato or egg shell
5. Problems based on Thermodynamics
6. Protein from Egg white by Peterson Lowry Method
7. Estimation of Amino acids from protease treated tissue by Ninhydrin method
8. Hormone Assay- Kit for hCG

Course III 18PS1ZO3P

1. Construction of Phylogenetic tree from NCBI
2. Identification of evolutionary evidence: i) Horse ii) Human iii) Elephant
3. Observation of morphogenetic movements in chick embryo
4. Limb induction in chick embryo
5. Testing for metabolic disorder from serum sample – G6PD kit
6. Effect of insulin on Chick embryo

Course IV 18PS1ZO4P

1. Identification of pictograms, symbols and signs of safety in laboratory practice
2. Preparation of standard solutions Mode of expressing concentration of solutions- Molarity (M), Molality(m), normality (N), Mass concentration, mass fraction, mass percentage or % (w/w), % by volume (v/v), parts per million (ppm) with practical exercises. Types of solutions- Stock solutions practical exercises
3. Microtomy: i) Fixation of tissue ii) Dehydration iii) Embedding, block preparation and trimming iv) Sectioning and slide preparation v) Staining and mounting
4. Case study on environment and wildlife- Project report submission
5. Extraction of desired data from a given research Course
6. Separation of pigments from leaves or flowers by adsorption column chromatography
7. Separation of amino acids by ion exchange chromatography using cation exchanger
8. identification of amino acids by 2D Course chromatography

Semester II

Course I: 18PS2ZOOCN1

General Biotechnology I

Module I: Genome management 15L

1.1 The 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 II

Module II: Medical Biotechnology

3.1. Sub-Module vaccines

3.1.1 *Sub-Module Vaccine production against viruses-Herpes simplex, Bovine foot & mouth disease virus 3.1.2 Peptide vaccines-synthetic drugs (engineered proteins)

3.1.3 Genetic immunization-DNA vaccines 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) & 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 III

Module III: Environmental Biotechnology 15 L

4.1. Biomass utilization

4.1.1 Microorganisms in lignocellulose degradation

4.1.2 Isolation of prokaryotic & 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. Characteristics of xenobiotics in the environment

4.2.1 Bioremediation of aerobic compounds

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 & aromatic)

Module IV: Animal biotechnology 15L

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 mutant gene

4.2.6 Site directed mutagenesis

Course II 18PS2ZOOCN2

Oceanography - General, Physical, Chemical and Biological

Module I: General Oceanography 15 L

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 various platforms for oceanographic data collection (RVs, FORV, Remote operation vehicles etc.), Major oceanographic labs and stations of the world and India.

1.3 General properties of sea water: Salinity, Chlorinity, Temperature, Light, Density, Pressure, Salinity-Temperature- Density relationship (STD).

Module II: Physical Oceanography 15 L

2.1Oceanographic circulation: Ekman spiral, geotropic current, westward intensification with dynamic topography.

2.2Vertical circulation: wind induced circulation, Thermohaline circulation and upwelling of water.

2.3Waves: Characteristics of waves, deep water and shallow water waves, transitional waves, wind generated waves, internal waves and Tsunami

*2.4 Tides: Tides generating forces, equilibrium theory of tides, dynamic theory of tides, tides as a source of power

* 2.5Currents: Types of currents, major currents of the world, Coriolis effect and El Nino effect, Eddy currents

Module III: Chemical Oceanography 15 L

* 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 the sea water and their role in the environment, CO2 system, dissolved O2 and oxygen profile, hydrogen sulphide.

3.3 Nutrients in the ocean, their cycles and factors influencing their distribution a) Nitrogen b) Phosphorus c) Silicon.

Module IV: Biological Oceanography 15 L

*4.1 Division of marine environment.

4.2 a) Marine biotic diversity: Plankton, Nekton, Benthos- brief account Implications of species richness, measuring diversity, quadrants of species diversity, models explaining diversity gradient.

*b) Intertidal organisms and their zonation.

4.3 Effect of physical factors on marine life

a) Light: photosynthesis, colouration, structural adaptations, bioluminescence.

b) Temperature: tolerance, geographical distribution, size, calcium precipitation, metabolism, bipolarity, tropical submergence and periodicity.

c) Salinity: tolerance and distribution, size, buoyancy and osmoregulation.

d) Currents: role in nutrition, transportation and propagation.

*e) Marine bacteria and their role.

Course III 18PS2ZOOCN3

Planktonology, Fisheries Science, Fish Immunology and Aquaculture practices

Module I: Planktonology 15L

1.1. Classification of Plankton. Adaptation to planktonic life. Factors influencing the distribution and abundance, plankton bloom, patchiness, vertical distribution and red tide.

1.2. *Diurnal migration of zooplankton. Inter-relationship between phytoplankton and zooplankton

Module II: Fisheries Science 15L

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

2.2. a) Major commercial fisheries: Elasmobranchs: shark and ray Teleosts: Sciaenoids, Indian salmon, Seer fish, Mackerel, Sardine, Carangids, Tuna, Sole fish, Harpodon, Ribbon fish fisheries.

b) *Crustacean fisheries: Prawns (penaeid and non penaeid), Shrimps, Lobster and Crab.

c) *Molluscan fisheries.

d) Impact of climate change on fishery production

Module III: Immunology of Fish 15L

3.1. Defence system: specific non specific

3.2. Response to pathogens and parasites

3.3. Fish vaccinations

3.4. Ontogeny of fish immune system

3.5. Fish Leucocytes

Module IV: Aquaculture Practices 15L

4.1. *History, scope and importance of aquaculture. Aquaculture practices in India. 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

Course IV 18PS2ZOOCN4

Microbial Oceanography

Module I: Marine Microbiology 15L

1.1 Ecology of coastal, shallow and deepsea microorganism - importance and their significance.

1.2 Diversity of microorganism - Archaea, bacteria, cyanobacteria, algae, fungi, viruses and actinomycetes in the mangroves and coral environment

Module II: Nutrient cycles in Ocean 15L

2.1 Role of microorganisms in carbon, nitrogen, phosphorous and sulphur cycles in the sea under different environments including mangroves.

Module III: Seafood Microbiology 15L

3.1 pathogenic microorganisms, distribution, indicator organisms prevention and control of water pollution, quality standards, International and National standards.

3.2 Microbiology of processed finfish and shellfish products. 3.3 Microbial diseases diagnosis and control.

Module IV: Marine Microbial biodegradation 15L

4.1 Natural and synthetic material in the marine environment- pesticide, cellulose degradation, hydrocarbon production.

4.2 Bioremediation of xenobiotics, oil, heavy metals, pesticides, plastics, etc. Mining and metal biotechnology.

Semester II Practical

Course I 18PS2ZOOCNP1

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

2) Preparation of LB agar plate, slant, butt & 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 & spreading technique.

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

5) To estimate the number of bacteria in the given culture by Nephelometry

6) Immobilize Yeast cells in calcium alginate & prepare a bioreactor column to demonstrate Invertase activity in the bioreactor column

Course II 8PS2ZOOCNP2

I) Physical and chemical oceanography:

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) Identification of foraminiferans and radiolarians from sand.

3) Estimation of primary productivity by light and dark bottle.

4) Textural features: Sediment analysis- size fraction (sand, silt, clay)

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.

Course III 18PS2ZOOCNP3

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, Zoeaporcelina, Copepods, Mysids, Echinoderm larvae, Nauplius, Sagitta, Doliolum, Salpa, Lusifer sp., Chaetognaths, Fish eggs and larvae, Jelly fish, Physalia, Porpita)

3) Study of fecundity-maturation studies.

4) Plotting the frequency polygon by ova diameter measurement.

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

6) Cells and tissues of Immune system of fishes

7) Identification and classification of Marine fishes List of Marine fishes Elasmobranchs

1. Family- CarcharidaeCarchariassps. Zygaena malleus
2. Family- RhinobatidaeRhynchobatusdjeddensis
3. Family- TrygonidaeTrygonuarnak Teleost
4. Family- Percidae, Lutianus johnii, Theraponsps., Pristipoma maculatum, Synagris japonicus, Gerres filamentosus
5. Family- Squamipinnes Scatophagus argus
6. Family – Mullidae Upenoides vittatus
7. Family- Polynemidae Polynemus tetradactylus
8. Family- Sciaenidae Pseudosciaena diacanthus, Sciaenas sp.
9. Family- Trichuridae Trichurus savala/ haumela
10. Family- Carangidae Caranx rottleri, Chorinemustoloo
11. Family- Stromatidae Pampus chinensis, Pampus argenteus
12. Family- Scombridae Rastrelliger kanagurta, Cybium guttatum
13. Family- Trachinidae Sillago sihama
14. Family- Cottidae Platycephalus punctatus
15. Family- Gobidae Periophthalmus sp., Boleophthalmus sp.
16. Family- Sphyraenidae Sphyraenaacutippinis
17. Family- Mugillidae Mugil sp.
18. Family- Gadidae Bregmacerossps.
19. Family- Pleuronectidae Psettodeserumei, Cynoglossuselongatus
20. Family- Siluridae Arius dussumieri
21. Family- ScopelidaeSauridatumbil, Harpodonnehereus
22. Family- SombresocidaeBelonestongylurus, Hemiramphussps.
23. Family- ClupeidaePellonafeligera, Clupealongiceps
24. Family- ChirocentridaeChirocentrusdorab
25. Family-MuraenesoxMuraenesoxsps.

Course IV 18PS2ZOOCNP4

1) Estimation of bacterial and fungal population of seawater

2) Isolation of pathogenic organism from seafood

3) Characterization-biochemical test- staining of marine bacteria

4) Comparative bacterial profile of processed and fresh seafood

5) Microbial disease in fishes

Reference books for semester II:

1. Austin. B, and D.A Austin 1999. Bacterial Fish pathogens- Diseases of Farmed and Wild Fish. Springer Publisher.

2. John Paul 1999. Marine Microbiology, Elsevier.

3. Munn and Munn 1996. Marine Microbiology: Ecology and Applications. BIOS Scientific publisher.

4. Atlas, R.M 1988. Microbiology, Fundamentals and applications Maxwell McMillan International Editions 5. Rheinheimer, G., 1980 Aquatic Microbiology-an Ecological Approach. Blackwell Scientific Publications

6. Kirchman, L Microbial Ecology of the Oceans 2000 John Wiley and Sons. Hans G. Truperet. al 1991.

7. The Prokaryotes: 1992 A Handbook on the biology of Bacteria. Vol. 1-4 Springer &Verlag New York

Semester III

COURSE – I 18PS3ZOOCN1:

Applied Biotechnology

Module I: Large scale culture & production from recombinant microorganisms & genetically engineered animal cells 15 L

2.1. Large scale culture & production from recombinant microorganisms:

2.1.1 Batch fermentation

2.1.2 Fed batch fermentation

2.1.3Continuous fermentation

2.1.4 *Maximizing the efficiency of fermentation process

2.1.5 Harvesting, disrupting & downstream processing

2.2. Large scale culture & production from genetically engineered animal cell cultures:

2.2.1Design of bioreactors for large scale animal cell culture-Batch, Fed batch

2.2.2 Mammalian cell lines & their characteristics

2.2.3 Media for the cultivation of mammalian cells

2.2.4 *Commercial products produced with mammalian cell culture

Module II: The Human Genome Project 15L

3.1 *The human genome, scope and goals of the 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

Module III: Agricultural Biotechnology 15L

3.1. Agricultural Biotechnology:

3.1.1 Nitrogen fixation

3.1.2Nitogenase-Component of nitrogenase; Genetic engineering of nitrogenase cluster

3.1.3 Hydrogenase-Hydrogen metabolism

3.1.4 Genetic engineering of hydrogenase gene

3.1.5 Nodulation-Competition among nodulation organisms, genetic engineering of nodulation gene

3.1.6 Microbial Insecticides -Toxins of Bacillus thuringiensis, mode of action & use of thuringiensis toxins, thuringiensis toxin gene isolation, genetic engineering of Bacillus thuringiensis strains and cloning of the toxin gene.

3.1.7 *Developing insect resistant, virus resistant & herbicide resistant plant

3.1.8 *Algal products: Fuels from algae, marine natural products & their medical potential-anticancer, antiviral compounds, antibacterial agents.

Module IV: Applications of Biotechnology in bioremediation 15L

4.1. Bio absorption of metals (Recovery from effluents and leachates from landfill)

4.1.1 *Bio absorption by fungi, algae, moss & bacteria

4.1.2 Mechanism of bacterial metal resistance & genetic engineering for specific proteins

4.1.3 Bioreactors for bio absorption-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

Course II 18PS3ZOOCN2

Oceanographic instrumentation, Marine Ecology, Marine Resources and Pollution

Module I: Oceanographic Instruments and Expeditions 15 L

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, Niskin Water sampler, Reversing thermometer, Salinometer, Secchi disc, Stempel's 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.

Module II: Marine Ecology15L

3.1 Coastal Ecosystem Estuaries, coral reefs and bays

3.2 Intertidal Ecology, different types of beaches and its fauna

3.3 Larval dispersion

3.4 Changing shore lines and erosion

3.5 Salt marshes

3.6 Mangroves

3.7 Marine eutrophication

Module III: Marine Pollution and Reclamation 15 L

3.1 Impact of anthropogenic activities:

3.2 Pollution- Domestic sewage, industrial/heavy metals.

3.3 Agricultural and pesticides pollutants

3.4 Oil pollution.

3.5 Ocean dumping.

3.6 Radioactive and Thermal waste.

3.7 Ocean acidification

3.8 Reclamation.

Module IV: Biological Resources 15 L

4.1 Resources from the sea:

A) Mineral resources:

B) Deep sea mud oozes and Poly metallic Nodules (manganese nodules).

C) Oil, gas and sulphur deposits and role of ONGC.

4.2 Scientific and economical and environmental aspect of seabed exploration and mining.

COURSE III 18PS3ZOOCN3

Marine Micro Flora, Fauna and Biodeterioration, Fish population and economics, Fish life processes

Module I: Marine Micro Flora, Fauna and Biodeterioration15L

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 Bio-deterioration: Fouling and Boring organisms.

Module II: Fish population and Economics 15L

2.1. Population Dynamics Abundance in population and fishery. Fishery catches and fluctuation. M.S.Y., Optimum Yield, Age Composition, Population Growth, Population Models.

2.2. *Socio-economics of fishermen

2.3 Entrepreneurial fishery

Module III: Fish Physiology and Endocrinology15 L

3.1 Hormones and endocrine glands of fishes, evolution of endocrine glands

3.2. Neuro endocrinological behaviour of fishes

3.3 Endocrinology of stress

3.4 Temperature regulation and osmoregulation in fishes

3.5 Endocrine control of energy balance

3.6. Hormone-induced colour changes

3.7 Feeding and metabolism in fishes

Module IV: Biological system in Ocean 15 L

4.1.1 Biology of Marine Organisms

4.1.2 Endogenous rhythms: biological clocks: lunar periodicity and tidal rhythms

4.2 Sense organs: types of organs and functions.

4.3 General account of reproduction in marine organisms

4.4. General account of different types of larvae in marine environment- Crustacea, Mollusca, Echinodermata and Teleosts.

COURSE IV 18PS3ZOOCN4:

Marine Biotechnology

Module I: Culturing Methodologies

1.1 Microalgae and fungi culturing

1.2 Protozoan and microscopic metazoan culturing

1.3 Culturing of live feed

Module II: Advanced in vitro techniques in marine cultures

2.1 Cell line development of Shrimp and Fish

2.2 Fish Anti-freeze technology

2.3 Germplasm preservation

2.4 Transgenic Fish

Module III: Marine Natural Products

3.1 Anti-inflammatory, anti-fungal, Anti-viral and anti-cancer products from the sea

3.2 Marine Toxins

3.3 Marine peptides

3.4 Marine Prostaglandins

3.5 Marine cosmetics

3.6 Probiotics from aquaculture

Module IV: Biotechnological Applications in Aquaculture

4.1 Chromosome manipulation

4.2 Cryopreservation

4.3 Inbreeding and sex control

4.4 Synthetic feed

4.5 Gene manipulation for strain improvement

4.6 Diseases in marine organisms – diagnosis, prevention, and gene probes

*marked topics are to be taken for seminar

Practical semester III

Course I 18PS3ZOOCP1

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

2) Demonstrate the western blotting technique for the given sample of protein.

3) To plot a growth curve for the microorganisms provided.

4) Demonstrate the effect of medium on growth curves of given microorganism, using two different media (minimal & enriched)

5) Observation of various bio-absorption materials.

Practical Course II 18PS3ZOOCP2

1) Oceanographic instruments: a) Nansen reversing bottle. b) Deep sea reversing thermometer. c) Bathy thermometer. d) Drift bottle. e) Ekman's current meter. f) Secchi disc. g) Plankton nets: IO Standard net, Hensen net and Clarke Bumpus net. h) Stemple 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) Food and feeding in fish. 3) Food and feeding in fish.

4) Identification of crafts and gears.

Practical Course III 18PS3ZOOCP3

1) Mounting of Zooplanktons and preparation of slides

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) Identification and classification of fresh water fishes (Rohu, Catla, Mrigal, Tilapia, Gourami) and fresh water giant 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,Crassostria sps., Xancus spyrum, Solen kempi, Cuttle fish and Gastropods).

8) Extraction of ascorbic acid from gonads of fish.

9) Preparation of histological slides to study fish glands

10) Study of sense organs- sting apparatus and electric organ in Elasmobranchs, Bioluminescence, lateral lines

11) Mounting of olfactory lobe of Shark

12) Effect of adrenaline and Acetyl Choline on fish chromatophores

13) Visit to aquaculture centres, boat building yards, processing plants and marine biological institutions (Excursions or study tours) Students Activity

a. Collection of molluscan shells

b. Preparing Herbaria from marine algae (atleast 5)

c. Preparation of shrimp pickle Note: Minimum number of animals to be used for experiment

Practical Course IV: 18PS3ZOOCP4

1) Preparation of marine culture media Isolation technique of microalgae
2) Culturing of Marine algae
3) Counting cultured cells with light microscope
4) Cryopreservation methods
5) Mariculture of Sea weeds

Reference Books Semester III

1. Svedrup et al., The Oceans.
2. Nair N.B. and Thampi D.H., Atextbook of marine ecology, T-M-H.
3. Harold Thurman, Introductory oceanography, Prentice Hall. London.
4. Qasim S.Z., Glimpses of Indian Ocean, Sangum Bodes Ltd. London. Navya Printers, Hyderabad.
5. Michael King, Fisheries Biology assessment and management, Fishing News Publishers, 1995.
6. R. Gordob Pirje, Oceanography
7. Newell and Newell, Marine Plankton.
8. Jhingran, Fish and fisheries
9. P. Michal, Ecologival methods for field and laboratory investigations.
10. R.V. Tait, Marine zoology, Oxford press.
11. David Ross, Introduction to Oceanography.
12. Carl Schliper, Research method in marine biology.
13. B.F. Chapgar, Sea Shore life of India, SIDGWICK and JACKSON, London
14. D.V. Bal and K.V. Rao, Marine fisheries of India, T-M-H.
15. Russel and Young, The Seas
16. Kurian and Sebastian, Prawn and prawn fisheries of India.
17. M. Krishna Pillai. Introduction to Planktology, Himalaya Publishing
18. A.A. Fincham. Basic marine biology, British Museum Natural History.
19. LathaShenoy. Course manual in fishing technology, CIFE, Versova, Mumbai.
20. Jefferey F. Raymond, Plankton and productivity, Vol. I and II.

21. J.S.Levington, Marine Biology, Function, biodiversity, ecology. Oxford University Press.
22. Wealth of India, Vol. IV, CSIR Publications.
23. S.P. Biswas, Manual of methods in fish biology, South Asian publishers private Ltd., New Delhi.
24. J.P. Rilcy and R, Chester, Introduction to marine chemistry, Academic Press, London and New Delhi.
25. American Public Health Association-2000.
26. J.V.R. Pillai, Aquaculture principles and plasia, Blackwell Scientific pub.
27. Das P. and Jhingran A.C.G., Fish genetics in India.
28. Colin E. Purdon, Genetics and Fish breeding, Chapman and Hall.
29. Schroder J.J., Genetics and Mutagenesis of fish, Chapman and Hall.
30. P. Bensam. Development of marine fishery sciences in India, Daya publishing House. N.B
31.The Fish Immune System: Organism, Pathogen, and Environment, 1st Edition from William Hoar, David Randall, George Iwama, Teruyuki
32.Fish Immunology by Margaret J. Manning and Mary F. Tatne
33.Techniques in fish immunology. By: Joanne S. Stolen, T.C. Fletcher, D.P. Anderson, B.S. Roberson, and W. B. van Muiswinkel .
34. Marine Biotechnology Vol 1David H. Attaway (2001) Pharma and bioactive marine natural products.
35. Biotechnology in Marine sciences, Rira R. Colwell (1984)
36. New Developments in Marine Biotechnology, Y.E Gal and H.O. Halvorson (1998), Springer.
37. Aquaculture, Oxford and IHB publication Co. Pvt. Ltd. New Delhi
38. Aquaculture, farming and husbandry &fresh and marine organisms. Wiley Interscience, New York

Semester IV

Dissertation / Internship of 6 months*

[* Subject to post COVID regulations, for 2020-21]