

**Master of Science
Zoology**

**PROGRAM STRUCTURE AND SYLLABUS
2019-20 ADMISSIONS ONWARDS**

(UNDER MAHATMA GANDHI UNIVERSITY PGCSS REGULATIONS 2019)



**BOARD OF STUDIES IN ZOOLOGY (PG)
MAHATMA GANDHI UNIVERSITY**

2019

7. THE PROGRAM STRUCTURE

Course Code	Title of the Course	Type of the Course	Hours per week	Credits
FIRST SEMESTER				
ZL010101	Animal Diversity: Phylogenetic and Taxonomic Approaches	Theory	4	4
ZL010102	Evolutionary Biology and Ethology	Theory	4	4
ZL010103	Biochemistry	Theory	4	4
ZL010104	Biostatistics and Research Methodology	Theory	3	3
ZL010105	PRACTICAL 1 Animal Diversity: Evolutionary, Ethological and Biochemical methods & Approaches	Practical	10	4
SECOND SEMESTER				
ZL010201	Field Ecology	Theory	4	4
ZL010202	Developmental Biology	Theory	4	4
ZL010203	Genetics and Bioinformatics	Theory	4	4
ZL010204	Microbiology and Biotechnology	Theory	3	3
ZL010205	PRACTICAL 2 Diversity of Life: Ecological, Embryological, Hereditary and Microbial Methods and Approaches	Practical	10	4
THIRD SEMESTER				
ZL010301	Animal Physiology	Theory	4	4
ZL010302	Cell and Molecular Biology	Theory	4	4
ZL010303	Biophysics, Instrumentation and Biological Techniques	Theory	4	4
ZL010304	Immunology	Theory	3	3
ZL010305	Practical 3 Molecular, Physiological and Immunological Methods and Approaches in Biosciences	Practical	10	4
FOURTH SEMESTER				
ZL80-830401	Elective 1	Theory	5	4
ZL80-830402	Elective 2	Theory	5	4
ZL80-830403	Elective 3	Theory	5	4
ZL80-830404	Practical	Practical	10	4
ZL010401	Project			5
ZL010402	Viva			2

ELECTIVES	COURSE CODE	COURSE TITLE
A – FISHERY SCIENCE	ZL800401	Nutrition, Growth and Physiology of fishes
	ZL800402	Fishery Resource Management
	ZL800403	Fishery Science and Technology
	ZL800404	Practical : Fishery Science – Methods and Approaches
B – ENVIRONMENTAL SCIENCE	ZL810401	Environmental Science: Concepts and Approaches
	ZL810402	Environmental Pollution and Toxicology
	ZL810403	Environmental Management and Development
	ZL810404	Practical : Environmental Science
C -ENTOMOLOGY	ZL820401	Morphology and Taxonomy
	ZL820402	Anatomy and Physiology
	ZL820403	Applied Entomology
	ZL820405	Practical : Morphology, Anatomy and Taxonomy, Insect Physiology and Applied Entomology
D- MEDICAL MICROBIOLOGY	ZL830401	General Microbiology and Parasitology
	ZL830402	Bacteriology, Virology and Mycology
	ZL830403	Clinical Microbiology
	ZL830404	Practical : Microbiology

FIRST SEMESTER COURSES

ZL010101	Name of the Course	1 Animal Diversity: Phylogenetic and Taxonomic Approaches
ZL010102	"	2 Evolutionary Biology and Ethology
ZL010103	"	3. Biochemistry
ZL010104	"	4 Biostatistics and Research Methodology
ZL010105	"	5 PRACTICAL 1 Animal Diversity: Evolutionary, Ethological and Biochemical methods & Approaches

ZL010101 ANIMAL DIVERSITY: PHYLOGENETIC AND TAXONOMIC APPROACHES

72 Hours (45+27) 4 hrs/week

Credit – 4

Objectives:

- To understand the phylogenetic relationships among the different groups of animals
- To provide the latest trend in animal taxonomy and phylogenetic systematics

PHYLOGENETIC APPROACHES

45hrs

Module 1

(20hrs)

Origin of Animals

(5hrs)

Progenote, Prokaryotes and Eukaryotes. Extant and ancient stromatolites. Unicellularity to metazoans – consequences and complexity.

Multicellular organisms – Ediacaran fauna, Burgess Shale Fauna. Cambrian explosion, Cropping and Red Queen Principle. Different hypothesis of metazoan origin – Gastraea hypothesis, Planula hypothesis.

Invertebrate Phylogeny

(15hrs)

Phylogenetic relationships among Porifera, Placozoa, Mesozoans; Cnidaria and Ctenophora; Platyhelminthes and other acoelomates.

Phylogenetic relationships among the protostome lineage – Mollusca, Annelida and Arthropoda. Evolutionary advantages of Symmetry, Metamerism and Coelom. Reasons for the success of Arthropod.

Adaptive radiation in Mollusca, Annelida, Arthropod and Echinoderms. Position and phylogeny of Hemichordates.

Module II

Vertebrate Phylogeny

(10hrs)

Affinity with invertebrates and protochordata. Pedomorphosis in vertebrate phylogeny. Jawless vertebrates – Ostracoderms and Cyclostomes. Properties and advantages of bone in vertebrate evolution. Evolution of jawed vertebrates – Acanthodian, Placoderm, Chondrichthyes, Osteichthyes. Actinopterygians and Sarcopterygians.

Module III

(15hrs)

Phylogeny of Herpetofauna

(8 hrs)

Amphibian phylogeny – Osteolepiforms, stem tetrapods and early amphibians. Lissamphibians – distribution, diversity, status and threats.

Reptilian phylogeny – amniotic egg, distinguishing features between amniotes from extant amphibians. Adaptive radiation in reptiles. Importance of skull in reptilian classification. Endothermy in Dinosaurs. Causes of extinction.

Phylogeny of Birds and Mammals (7 hrs)

Evidences for the origin of birds from reptiles. Mammalian phylogeny and therapsids – significance of teeth, jaws and hearing. Adaptive radiation in mammals. Phylogeny of mammalian orders. Rare, endangered and endemic birds and mammals of Indian subcontinent.

Prerequisite: Classification of mammals

TAXONOMIC APPROACHES 27hrs

Module IV (16hrs)

Biological Classification (9 hrs)

Hierarchy of categories and higher taxa. Taxonomic Procedures-collection, preservation, curation and process of identification (Brief and general account only). Taxonomic characters of different kinds and analysis of variation. Concept of species.

Zoological type – Principles of typification, different kinds of type.

International code of Zoological Nomenclature – features, principles and rules. Phylocode. Zoobank.

New trends in Taxonomy (7 hrs)

Modern methods – Morphological, embryological, ecological, behavioural, cytological, biochemical, numerical, molecular. Cytotaxonomy, Chemotaxonomy.

Barcode of life – basics of barcoding, application of barcode. Molecular operational taxonomic units (MOTU), Integrated operational taxonomic unit (IOTU). Global taxonomic initiative (GTI). Constraints of DNA taxonomy. Integrative taxonomy.

Microtaxonomy and macrotaxonomy. e-taxonomy. Cybertaxonomy. Significance of Taxonomy and biosystematics.

Module V (11 hrs)

Taxonomic Keys and Publications (4 hrs)

Different types of keys – single access keys, diagnostic and synoptic keys, dichotomous and polytomous keys. Taxonomic keys presentation. Computer aided keys. Merits and demerits of keys.

Types of taxonomic publications – atlas, catalogue, checklist, field guide, field book, hand book, manual, monographs. Zoological records. Ethics in taxonomy.

Molecular Phylogeny and Systematics (7 hrs)

Use of protein and nucleotide sequence in molecular phylogeny. Protein sequence – haemoglobin and cytochrome. Nucleic acid phylogeny. Importance of molecular phylogeny.

Cladistic analysis – Apomorphy, Plesiomorphy, Sympleiomorphy and Synapomorphy. Characteristic features of cladistics. Methodology of cladistics analysis – construction of cladogram. Significance of phylogenetic systematics. Phylogenetic trees. Different kinds – cladogram, phenogram, phylogram, dendrogram, curvogram, eurogram, swoopogram, chronogram.

Recommended Text Books/Reference Books

- Anderson, T.A. 2001. *Invertebrate Zoology* (2nd edn). Oxford University Press, New Delhi.
- Ashok Verma 2017. *Principles of Animal Taxonomy*. Narosa Publishing home Pvt. Ltd.
- Barnes, R. D. 1987. *Invertebrate Zoology*. Saunders College Publishing/Harcourt Brace; 5th Revised edition
- Barrington, E. J. W. 2012. *Invertebrate Structure and Functions*. Affiliated east-west press Pvt. Ltd. New Delhi, 2nd edition.
- David, M. H, Craig Moritz and K.M. Barbara. 1996. *Molecular Systematics*. Sinauer Associates, Inc.
- Hickman Jr., Cleveland, Larry Roberts, Susan Keen, Allan Larson, and David Eisenhour. 2011. *Animal Diversity*. McGraw-Hill Companies, Inc. NY
- Kapoor, V.C. 2017. *Theory and Practice of Animal Taxonomy*. 8th edition, Oxford and IBH Publishing Co., Pvt. Ltd. New Delhi.
- Margulis, Lynn and M.J. Chapman 2001. *Kingdoms and Domains: An Illustrated Guide to the Phyla of Life on Earth* (4th edn.). W.H. Freeman & Company, USA
- Mayer, E. 2014. *Principles of Systematic Zoology*. 2nd edition, McGraw Hill Book Company, Inc., NY.
- Narendran, T.C. 2008. *An introduction to Taxonomy*. Zoological survey of India.
- Strickberger, M.W. 2013. *Evolution*. Jones and Bartlett Publishers, London.
- Simson G. G. 2012. *Principles of animal taxonomy*. Scientific publishers, India.
- Winston, J.E. 2000. *Describing species: Practical Taxonomic Procedures for Biologists*. Columbia University Press, Columbia, USA.

ZL010102 EVOLUTIONARY BIOLOGY AND ETHOLOGY

72 Hours (44+28) (4hrs/week)

Credit- 4

Objectives:

- To describe the concept of relatedness and its connection to biological evolution
- To apply knowledge to new information and data, as well as the capacity to effectively communicate the principles of evolution and its application to human biology.
- To expose students to the basics and advances in ethology, and generate an interest in the subject in order to understand the complexities of studying animal behavior on every level of the biological hierarchy

EVOLUTIONARY BIOLOGY

44 hrs

Module I

(22hrs)

Concepts in Evolution

(6 hrs)

Concepts of variation, adaptation, struggle, fitness and natural selection-spontaneity of mutation and the evolutionary synthesis. Contributions of Margulis (Endosymbiotic theory), Eldredge and Gould (Punctuated equilibrium), Rose Mary and Peter Grant (Molecular evolution in Darwinian finches).

Origin and Evolution of Life

(5 hrs)

The RNA world, The First Cell. Evolution of Prokaryotes- origin of eukaryotic cells- evolution of unicellular eukaryotes. Anaerobic metabolism - origin of photosynthesis and aerobic metabolism.

Molecular Evolution

(11 hrs)

Neutral theory of molecular evolution; molecular divergence; molecular drive. Molecular clocks- genetic equidistance. Phylogenetic relationships- Homology; Homologous sequences of proteins and DNA - orthologous and paralogous; parsimony analysis; nucleotide and protein sequence analysis.

Module II

(13hrs)

Population Genetics

(8 hrs)

Gene pool, gene frequency, Hardy-Weinberg Law. Rate of change in gene frequency through natural selection, migration and random genetic drift, Founder effect and Bottleneck phenomenon, Isolation and speciation, Co-evolution

Developmental and Evolutionary Genetics

(5 hrs)

The idea of Evo-Devo, Heterochrony, Heterotopy, Heterometry and Heterotypy. Developmental genes and gene co-option. Evolution of plasticity and complexity.

Module III

Primate Evolution and Human Origins

(9 hrs)

Geological time scale, Mass extinction and its consequences, Stages in Primate evolution- Prosimii, Anthropoidea and Hominids. Factors in human origin – morphological, anatomical, hominid fossils. Cytogenetic and molecular basis of origin of man - African origin of modern man - Mitochondrial Eve, Y chromosomal Adam.

ETHOLOGY **28 hrs**

Module III **(13hrs)**

Introduction **(3 hrs)**

Definition, historical out line,
Terminologies : Sign stimuli, key stimuli, social releasers, displacement activities, ritualization, Ethograms, super normal stimuli, stimulus filtering, open and closed IRM, mimetic releaser, code breakers. JP Scotts categories of behaviour.

Neurophysiological Aspects of Behaviour **(4 hrs)**

Reflex action, Sherrington's neuro-physiological concepts in behavior – Latency, summation, fatigue. Fixed action patterns. Goal oriented drive, Psycho-hydrologic model of motivation. Studies of motivation in guppies.

Learning and Genetics **(3 hrs)**

Short and long term memory, Habituation, Sensitization. Conditioning, Reasoning. Genetic basis of behaviour.

Communication **(3 hrs)**

Evolution of communication, Sensory mechanisms: Electrical, Chemical, Olfactory, Auditory and Visual. Dance language of honey bees, Pheromonal communication (Ants and mammals).

Module IV **(15hrs)**

Reproduction and Behaviour **(3 hrs)**

Reproductive strategies, Mating systems, Courtship, Sexual selection- intrasexual and intersexual, good gene hypothesis, parental care and investment – significance of prolactin

Complex behavior/Biological rhythm **(4 hrs)**

Orientation, Navigation, Migration, Navigation cues. Biological rhythms – Circadian, Circannual, Lunar periodicity, Tidal rhythms. Genetics of biological rhythms.

Social Behaviour **(4 hrs)**

Sociobiology (Brief account only), Aggregations – schooling in fishes, herding in mammals, Group selection, Kin selection, altruism, reciprocal altruism, inclusive fitness, Hamilton's rule, co-operation, alarm call, social organization in insects and primates.

Foraging behavior: Habitat selection and optimality in foraging; social foraging, territoriality.

Stress and Behaviour **(4 hrs)**

Adaptations to stress- basic concept of environmental stress, acclimation, acclimatization, avoidance and tolerance. Adolescent behavior- emotions aggression. Hormones and behavior.

Recommended Text Books/Reference Books

Evolutionary Biology

Arthur, W. (2011). *Evolution – A Developmental Approach*. Wiley-Blackwell, Oxford, UK

Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007).

Evolution. Cold Spring, Harbour Laboratory Press.

- Camilo J.Cela - Conde and Francisco J. Ayala. (2007). *Human Evolution-Trails from the Past*. Oxford University Press.Oxford ,UK
- Campbell.B.G. (2009). *Human Evolution*. Transaction Publishers, NJ, USA
- Chattopadhyay Sajib. (2002). *Life, Origin, Evolution and Adaptation*.Books and Allied (P) Ltd. Kolkata, India.
- Dan, G. and Li,W.H. (2000). *Fundamentals of Molecular Evolution*. (2nd edn.). Sinauer Associates Inc. MA, USA
- Gould, S.J. (2002). *The Structure of Evolutionary Theory*. Harvard University Press, MA, USA.
- Hall, B. K. and Hallgrimsson, B. (2008), *Evolution*. 4th Edition; Jones and Bartlett Publishers
- Hall, B.K and Hallgrimsson, B. (2008). *Strickberger's Evolution* (4th edn). Jones and Bartlett Pub.London,UK
- Hall, B.K. and Olsen, W. M., (Ed). (2007). *Keywords and Concepts in Evolutionary Developmental Biology*. Discovery Publishing House, New Delhi,
- Jha A.P (2000) *Genes and Evolution* - Macmillan Publishers India
- Kimura,M. (1983). *The neutral theory of molecular evolution*.Cambridge University Press
- Lindell Bromham (2016) *An Introduction to Molecular Evolution and Phylogenetics*, 3rd edition, Oxford press
- Ridley, M. (2004), *Evolution* 3rd Edition. Blackwell Publishing
- Roderick Page, D.M. and Edward Holmes, C.(2009). *Molecular Evolution: A phylogenetic approach*, Willey Blackwell publisher.
- Strickberger, M.W. (2000) *Evolution*. Jones and Bartlett, Boston.

Web Resources

<http://www.talkorigins.org> <http://www.ucmp.berkeley.edu> <http://www.academicearth.org>

Ethology

- Alcock John (2009). *Animal Behaviour : An Evolutionary Approach* (8th edn). Sinauer Associates Inc. Sunderland, Massachusetts.
- Aubrey Manning and Mariam Stamp Dawkins (2000). *An Introduction to Animal Behaviour* (5th Edn). Cambridge University Press, U.K.
- Dawkins, M.S. (1995). *Unravelling Animal Behaviour*. Harlow: Longman.
- Fatik Baran Mandal (2009). *A Textbook of Animal Behaviour*. PHI Learning Private Limited, New Delhi.
- Gundevia J.S. and Singh H.G. (1996), *A Text Book of Animal Behaviour*. S. Chand and Company Pvt. Ltd., New Delhi.
- Hauser, M.(1998). *The Evolution of Communication*. MIT Press, Cambridge, Mass. USA.
- Judith Goodenough, Betty McGuire .2010. *Perspectives of Animal Behaviour*. John Wiley & Sons Inc. USA
- Lee Alan Dugatkin (2009). *Principles of Animal behaviour* (2nd edn). W.W. Norton and Company.
- Macfarland, D (1998). *Animal Behaviour – Psychobiology, Ethology and Evolution*. Pitman publication Ltd. London.
- Michael D. Breed and Janice Moore (2015) *Animal Behaviour*, Academic press, USA.
- Scott Graham (2005). *Essential animal behavior*. Blackwell Publications Company, Oxford ,UK
- Wilson, E.O. (2000). *Sociobiology: The new synthesis*. Harvard Univ. Press, Cambridge, Mass. USA.

Web Resources: www.animalbehavioronline.com/modestable.html

ZL010103 BIOCHEMISTRY

72Hours (4hrs/week)

Credit- 4

Objectives:

- To understand the chemical nature of life and life process
- To provide an idea on structure and functioning of biologically important molecules
- To generate an interest in the subject and help students explore the new developments in Biochemistry.
- To understand the importance of metabolism of bio macromolecules in normal physiology of a man
- To understand the abnormal metabolism of biomolecules and the resultant diseases.

Module I

18hrs

Carbohydrates

(6hrs)

Classification, Structure, nomenclature and Biological functions of carbohydrates. Glycoproteins and Mucoproteins. Isomerism – structural isomerism and stereoisomerism, optical isomerism, epimerism and anomerism. Mutarotation and inversion of sugars. Glycosidic bond.

Carbohydrate Metabolism

(9hrs)

Major metabolic pathways- Glycolysis, Citric acid cycle and its significance. Oxidative and substrate level phosphorylation. Gluconeogenesis, Cori cycle. Glycogen metabolism- Glycogenesis, Glycogenolysis, Regulation of carbohydrate metabolism, Role of insulin and glucagon. Adenylate cascade system, Ca²⁺ Calmodulin-sensitive phosphorylase kinase. Regulation of glycogen synthesis. Minor metabolic pathways of carbohydrates: Pentose Phosphate pathway, Glucuronic acid metabolism, Galactose metabolism.

Disorders of Carbohydrate Metabolism

(3hrs)

Diabetes mellitus, glucose and galactose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, Inborn errors associated with carbohydrate metabolism. Glycogen storage diseases, Lactose intolerance, Galactosuria, pentosuria, galactosemia.

Module II

18hrs

Proteins

(9hrs)

Structure, classification and properties of amino acids. Amphoteric properties of amino acids, pH, Buffer, pK value and iso-electric point of amino acids. Classification, properties and biological functions of proteins. Primary structure of protein (e.g. insulin). Conformation of proteins- chemical bonds that stabilise higher order structures. Secondary structure- Alpha helix, Collagen helix, Beta pleated sheet, Ramachandran angles and Ramachandran map. Fibrous proteins- examples (brief account on any two: Keratin, Collagen, Elastin, Resilin, Fibrous muscle proteins). Chaperons. Tertiary structure- e.g. Myoglobin. Quaternary structure – e.g. Haemoglobin.

Metabolism of Proteins

(7hrs)

Amino acid metabolism-Deamination, Transamination and Trans-deamination. Formation and disposal of ammonia. Urea cycle. Fate of carbon skeletons of aminoacids: glucogenic, ketogenic, partly glucogenic and ketogenic with examples. Synthesis of biologically significant compounds from different aminoacids with special reference to glycine, glutamic acid, phenylalanine, tyrosine and tryptophan.

Inborn Errors of Metabolism

(2 hrs)

Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, Histidinemia.

Module III

18hrs

Lipids

(9 hrs)

Classification of lipids: simple, compound and derived lipids. Biological importance of lipids. Fatty acids: classification, Geneva system of nomenclature. Simple fats: Triacylglycerol (Triglycerides) :-fats, oils and waxes. Physical properties. Reactions-Hydrolysis, Saponification, Rancidity. Acid number, Saponification number, Iodine number, Polenske number and Reichert-Meissl number of lipids. Compound lipids: Phospholipids- Lecithin, Phosphatidyl inositol, Cephalins, Plasmalogens. Glycolipids, Sphingolipids. Derived Lipids, Steroids: Biologically important steroids-cholesterol, Vitamin D, Bile acids, Ergosterol, Terpenes, Lipoproteins. Prostaglandins- structure, types and functions.

Metabolism of Lipids

(7hrs)

Beta oxidation, alpha oxidation and omega oxidation of fatty acids. De novo synthesis of fatty acids.

Lipid peroxidation. Free radicals and antioxidants, Generation of free radicals. Reactive oxygen species. Free radical scavenger systems. Preventive antioxidants and chain breaking antioxidants.

Disorders of Lipid metabolism

(2hrs)

Plasma lipoproteins, cholesterol and its clinical significance,, triglycerides & phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann-Pick disease, ketone bodies, Abetalipoproteinemia.

Module IV

8 hrs

Nucleic Acids

(6hrs)

Structure of nucleic acids, Structural organization of DNA (Watson –Crick model) Characteristic features of A, B, C and Z DNA. DNA topology of circular forms. Structural organization of tRNA; Protein-nucleic acid interaction. DNA regulatory proteins, folding motifs and conformation flexibilities, denaturation, renaturation, Biological roles of nucleotides and nucleic acids.

Nucleic Acid and Mineral Metabolism

(2hrs)

Catabolism of purines and pyrimidines.

Module V

10hrs

Enzymes: Classification- (I.U.B.system), co-enzymes, ribozyme. Enzyme specificity. Mode of enzyme action: Concept of Active site, Formation of enzyme substrate complex, Lowering of activation energy. Lock and key theory, induced fit theory, transition state and strain theory. Enzyme kinetics: Michaelis-Menten equation. Km value and its significance. Enzyme velocity and factors influencing enzyme velocity. Kinetics of enzyme inhibition, suicide inhibition, feedback inhibition- sequential, concerted and cumulative feedback control. Control of enzyme activity:-control of activity by changes in covalent structures of enzymes, control of activity by ligand induced conformational changes in enzymes. Enzyme regulation: Allosteric regulations- Monod-Wyman-Changuex model, Koshland-Nemethy-Filmer model Key enzymes, Flux analysis. Iso-enzymes and clinical significance.

Recommended Text Books/Reference Books

- Creighton, T.E. Protein Structure and Molecular Properties. 1993. W.H. Freeman & Co, NY.
- Deb, A.C. 2004. Fundamentals of Biochemistry. New Central Book Agency (P) Ltd. New Delhi.
- Elliott, W.H and C. Elliott, 2003. Biochemistry and Molecular Biology. Oxford University Press, Oxford, UK.
- Eric E. Conn, Paul K. Stumpf, George Bruening, Roy H. Doi, 2007. Outlines of Biochemistry. (5th edn). John Wiley & Sons Inc., NY.
- Garret, R.H. and C.M. Grisham. 1995. Biochemistry. Saunders College Publishers, USA.
- Lenhninger, A.L. 2008. Principles of Biochemistry. (5th edn). CBS Publishers and Distributors, New Delhi.
- Hanes, B. D. and N.M. Hooper. 1998. Instant notes: Biochemistry. University of Leeds, Leeds, UK.
- Horton, H.R., Morsan, L.A., Scrimgeour, K.G., Perry, M.D and J.D. Rawns. 2006. Principles of Biochemistry. Pearson Education International, New Delhi.
- Keith Wilson and John Walker. 2008. Principles and Techniques of Biochemistry and Molecular biology (6th edn). Cambridge University Press, UK.
- Murray, K., Granner, D.K., Maynes, P.A and V.W. Rodwell, 2006. Harper's Biochemistry (25th edn). McGraw Hill, New York, USA.
- Oser, B.L. 1965. Hawk's Physiological Biochemistry. McGraw Hill Book Co. New Delhi.
- Palmer Trevor. 2001. Enzymes: Biochemistry, Biotechnology & Clinical chemistry. Horwood Publ. Com., England.
- Rama Rao, A.V.S.S. 1986. Text Book of Biochemistry. L.K. & S Publishers, New Delhi.
- Stayer, L. 2011. Biochemistry. (7th edn). W.H. Freeman & Co. NY.
- Vasudevan, D.M. and S. Sreekumari. 2000. Text of Biochemistry for Medical Students. Jaypee Brothers, Medical Publishers (P) Ltd. New Delhi
- Voet, D and J.G Voet, 2004. Biochemistry. John Wiley & Sons., NY.
- Zubay, G, 1989. Biochemistry. McMillan Publishing Co., New York.

BIostatISTICS AND RESEARCH METHODOLOGY

54 hrs (30+24) 3 hrs/week

Credit – 3

Objectives:

- To impart concepts of statistics and research methodology, and create awareness about the gadgets, tools and accessories of biological research
- To help students improve analytical and critical thinking skills through problem solving
- To enable learners to effectively apply suitable statistical tests in research
- To sensitize students about the ethics involved in research and enable them to come up with innovative research designs
- To equip learners to prepare research papers and project proposals

BIostatISTICS

30 hrs

Module 1

(9hrs)

Basics of Biostatistics

(3 hrs)

Scope and Significance of Biostatistics. Steps in Statistical Investigation, Data and Variable (Collection, Types, Sources).

Statistical Analysis Tools - Parametric and Non-Parametric; Bivariate and Multivariate Analysis. Interpretation and Forecasting.

Measures of Central Tendency – mean, median and mode.

Measures of Dispersion

(6 hrs)

Introduction, Characteristics. Quartiles and Percentiles. Merits and Demerits of Range, Quartile Deviation, Mean Deviation and Standard Deviation. Relative Measures of Dispersion.

Calculations/Problems for frequency table. Standard error. Skewness and Kurtosis (Brief account only).

Module II

(11hrs)

Correlation Analysis

(3 hrs)

Correlation - types and methods of correlation analysis, Problems for Karl Pearson's correlation coefficient and Spearman's rank correlation.

Regression Analysis

(4 hrs)

Regression and Line of Best Fit, Types and methods of regression analysis.

Graphic Methods (Scatter method, Curve fitting). Algebraic method (Fitting of straight line through regression equation). Comparing correlation and regression.

Probit Analysis (Brief account only).

Theory of Probability

(4 hrs)

Measures of Probability and Theorems in Probability. Probability distributions – Binomial, Poisson and Normal (Brief Account only).

Module III (10hrs)
Testing of Hypothesis (7 hrs)

Hypothesis and types, Confidence Interval, Sampling, Methods and Errors.

Tests of significance (For large and small samples – Critical Ratio and P value).

Z Test (Problem for small samples), Chi- Square Test – test of independence and goodness of fit (Problem for 2×2 table only).

Student's 't' test (Problem for small samples comparing mean of two variable).

F-test, Analysis of Variance (ANOVA - One way), Kruskal Wallis test (Brief account only).

Mc Nemar and Mann Whitney U test (Brief account only).

Mathematical modeling in Biology (3hrs)

Introduction to mathematical modeling. Applications: Medicine - models to predict spread of infectious diseases, drug discovery, Systems Biology – Blue Brain project, Ecology – Lotka Volterra model. Length - Weight Relationship. Von- Bertalanffy's Growth (VBG) Model.

Statistical Software: MS Excel, SPSS; Introduction to 'R' (Basics only).

RESEARCH METHODOLOGY 24 hrs

Module IV (12hrs)
Concepts of Research (4 hrs)

Scientific temper, Empiricism and Rationalism. Knowledge, Information and Data. Science and Pseudoscience. Basic concepts of research -Meaning, Objectives, Motivation and Approaches.

Types of Research - Descriptive/Analytical, Applied/ Fundamental, Quantitative/Qualitative, Conceptual/Empirical. Research methods versus Methodology, Research Process.

Research Formulation (4 hrs)

Research formulation -Observation and Facts, Prediction and explanation, Induction, Deduction.

Defining and formulating the research problem, Selecting the problem and necessity of defining the problem. Literature review - Importance of literature review in defining a problem, Critical literature review. Theory, Principle, Law and Canon.

Research Designs (4 hrs)

Research Design -Basic principles, Meaning, Need and features of good design. Types of research designs.

Development of a research plan - Exploration, Description, Diagnosis, Experimentation, determining experimental and sample designs. Case-control studies and cohort studies.

Module V (12 hrs)
Scientific Documentation and Communication (6 hrs)

Structure and components of Scientific Reports – types of Report – Technical Reports and Thesis/dissertations.

Preparing Research papers for journals, Seminars and Conference; Impact factor, Citation Index, h-index. DOI. ISBN & ISSN.

Conventions and strategies of authentication – citation styles, bibliography, referencing and foot notes. Software for managing bibliographies - EndNote.

Presentation techniques - Assignment, Seminar, Debate, Workshop, Colloquium, Conference, Oral presentation, Poster Presentation.

Preparation of Project Proposal. Project funding agencies – UGC, DST, BDT, MoEF. Women Scientists schemes.

Global Information System – BIOSIS, Medline and Medlars, AGRIS, Pubmed, Google Scholar.

Information Science, Extension and Ethics (6 hrs)

Sources of Information - Primary and secondary sources.

Library - books, journals, periodicals, reference sources, abstracting and indexing sources, Reviews, Treatise, Monographs.

Online resources – INFLIBNET, e-libraries, e-Books, e-Encyclopedia, e-Journals, e-Thesis, Shodhganga, PG-Pathshala, TED Talk, Institutional Websites. MOOC - SWAYAM, NPTEL.

Networking platforms for researchers - Academia, ResearchGate.

Ethics in research - Plagiarism, Plagiarism checking softwares - Turnitin, Viper, Urkund; Citation and Acknowledgement.

Extension: Lab to Field, Extension communication, Extension tools.

Recommended Text Books/Reference Books

1. Chap T. Le.2003.*Introductory Biostatistics*. John Wiley & Sons, NJ, USA.
2. Clough, P. and C.Nutbrown.2002. *A Student's Guide to Methodology: Justifying Enquiry*. Sage, London.
3. Daniel W.W. 2006. *Biostatistics: A Foundation for Analysis in the Health Sciences* (7th edn). John Wiley & Sons, New York.
4. Freedman D. F., Pisani R. and Purves R. 2011. *Statistics*. Viva Books, New Delhi.
5. Dharmapalan Biju. 2012. *Scientific Research Methodology*. Narosa Publishing House, New Delhi.
6. Gupta S. P. 2014. *Statistical methods for CA foundation course*. Sultan Chand & Sons, New Delhi.
7. Kothari C. R. 2009. *Research Methodology: Methods and Techniques* (2nd edn.). NewAge International Publishers, New Delhi.
8. Paul Oliver. 2005. *Writing Your Thesis*. Vistaar Publications. New Delhi.
9. Rajathi A. and P. Chandran, 2010. *SPSS for You*. MJP Publishers, Chennai
10. Samuels M. L., Witmer J. A. and Schaffner A. 2016. *Statistics for Life Sciences* (5th edn). Pearson Education Inc., New delhi.
11. Sundar Rao P.S.S. and Richard J. 2006. *Introduction to Biostatistics and Research Methods* (4th edn). Prentice Hall, New Delhi.
12. Zar J. H. 2008. *Biostatistical Analysis* (3rd edn.). Pearson Education Inc., New Delhi

ZL010105: PRACTICAL 1

ANIMAL DIVERSITY: EVOLUTIONARY, ETHOLOGICAL AND BIOCHEMICAL METHODS & APPROACHES

180 Hours (10hrs/week)

Credit-4

Biosystematics, Evolutionary Biology and Ethology

60 hrs

- Study of museum specimens - 50 invertebrates and 20 vertebrates (List the studied items with brief descriptions enlisting at least five taxa or taxonomic rank (Diagrams not necessary))
- Larval forms - any 10 larvae from different taxa (emphasizing phylogenetic, morphological, ecological and pathological significance)
- Mounting and Submission of any three larval forms (Diversity should be maintained depending on the number of students and one specimen each should be submitted for the practical examination, Repetition should be avoided for examination)
- Preparation of dichotomous key up to the family of four specimens each from any of the three, from the following five groups (ie., from insects, spiders, fishes, amphibians and snakes) with necessary diagrams.
- Dichotomous key using appropriate software or online tools (students should be familiarized with the computer aided keys)
- Hardy Weinberg Law for calculation of gene frequency
- Preparation of Cladogram based on the specimens provided (at least five museum specimen) (OR software programmes can be used for construction with more number of specimens).
- Study on the skull pattern of reptiles/mammals.
- Behavioural study or activity pattern of any two organism (insects, fish, reptile, birds, mammals) based on field observation with respect to diurnal and seasonal. Viva based on behavioral observation reported. (Repetition of reports, organism and observations should be avoided on records)

Biochemistry

80hrs

- Study of structure of biomolecules (carbohydrate , aminoacids , cholesterol), using ball and stick models and Protein and Nucleic acid using software tools
- Preparation of Buffers of specific pH using pH meter
- Calculation of Molality, Normality, percentage W/V, serial dilution and preparation of standard solutions
- Preparation of standard curve for protein (by Lowry or Biuret methods) , glucose, cholesterol and/or creatinine and estimation of unknown concentration.
- Estimation of protein or cholesterol from fresh tissue
- Estimation of Enzyme activity from fresh tissue (alkaline phosphatase or acid phosphatase)

Biostatistics

40hrs

- Calculation of corrected mean, and standard deviation (Problems can be solved using scientific calculator).
- Derive regression equation for protein, cholesterol and creatine using Optical density and Concentration
- Drawing best line of fit for protein, cholesterol and creatine (Problems can be solved using scientific calculator).
- Calculation of Pearson correlation coefficient.
- Calculation of regression coefficient and regression equation (‘x’ on ‘y’ only)
- Calculation of Chi -square value (2x2 table only)
- Calculation of ‘t’ value (for small sample comparing two samples)
- MS Excel: Preparation of graphs (bar, histogram, frequency polygon, frequency curve, pie diagram and ogives)
- MS Excel/PH Stat/SPSS: Basic statistics (mean, median, mode, standard deviation), Correlation Analysis, Regression analysis , Test of significance (T test between two sample or sample and population), Chi-square test, Problems using one way ANOVA

SECOND SEMESTER COURSES

ZL010201	Name of the Course	1 Field Ecology
ZL010202	"	2 Developmental Biology
ZL010203	"	3. Genetics and Bioinformatics
ZL010204	"	4 Microbiology and Biotechnology
ZL010205		5. PRACICAL 2 Diversity of Life: Ecological, Embryological, Hereditary and Microbial Methods and Approaches

ZL010201 FIELD ECOLOGY

72 Hours (4 hrs./Week)

Credit – 4

Objectives:

- To provide the knowledge of animal adaptations to a variety of environment
- To learn the different aspects of population and its interactions
- To understand the natural resources and manmade issues on environment and its management

Module I

Animal and Physical Environment

(18 hrs)

Effect of cold and hot temperature on organisms. Global warming and change of species phenologies. Effect of soil development on nutrient level. Herbivore population and plant nutrient level. Availability of O₂ and CO₂ on growth and distribution of organisms. Water availability and abundance of organism. Significance of salt concentration in soil and water. Effect of soil and water pH on distribution of organisms.

Cybernetic nature of ecosystem, homeostasis and feedback systems.

Animals and nutrient acquisition – herbivory, carnivory, omnivory, detritus feeding.

Animal adaptations to thermal environment – thermal balance, poikilotherms, homeotherms, heterotherms. Animal adaptations to moisture environment – maintenance to water balance, response to drought and flooding. Animal adaptations to light environment.

Prerequisite: Ecosystem concept – structure and function, Productivity, Food chain and food web, Energy flow

Module II

Population Ecology

(15 hrs)

Properties – patterns of dispersion, dispersal movements, age structure, sex ratio, life table, survivorship curve, density, population growth-exponential and logistic growth, time lags, carrying capacity. Population growth and global warming.

Density dependent and density independent influences. Population fluctuations and cycle. Extinction – deterministic extinction and stochastic extinction.

Life history strategies – Reproductive strategies, *r* and *k* selection.

Human population growth. Concept of ecological foot print.

Population regulation – dispersal, social dominance, territoriality: types of territory, territorial defence, floaters, home range.

Aggregation, Allee's principle, Isolation

Metapopulation – Concept, Structure

Module III

(17 hrs)

Population Interactions: Competition and Predation

(10 hrs)

Interspecific competition – Competitive Exclusion Principle, Resource partitioning and utilization. Niche, Niche overlap, Niche width, Niche responses-niche compression and niche shift. Character replacement. Ecological and evolutionary effects of competition.

Predation – Antipredator adaptations.

Foraging theory – optimal diet, foraging efficiency, risk-sensitive foraging.

Animal prey defence – chemical defence, warning coloration and mimicry, cryptic colouration, armor and defence, behavioural defence, predatory sanitation.

Predator offence – hunting tactics, cryptic coloration and mimicry in predators, adaptations of hunting. Cannibalism, Intraguild predation (IGP).

Population Interactions: Parasitism and mutualism

(7 hrs)

Characteristics and life-cycle of parasite, host response to parasitism –biochemical, abnormal growth, sterility, behavioural change, mate selection. Social parasitism – Brood parasitism and kleptoparasitism.

Types of defence against parasites by host. Invasive parasite. Parasitism and climate change.

Non-native parasite and biological control.

Mutualism – Origin and types. Dispersive mutualism, defensive mutualism, resource based mutualism. Mutualistic relationship of human with crops.

Module IV

Applied Ecology

(10 hrs)

Air, water, soil and radioactive pollution – Sources, causes and consequences. Disposal of radioactive waste. Ecological indicators.

Concept of waste – types and sources of solid waste. Health and environmental implications. E-waste-types and management aspect. Environmental biotechnology and solid waste management – aerobic and anaerobic systems. Concept of bioreactors in waste management. Liquid wastes and Sewages.

Scope of bioremediation. Phytoremediation, bio-augmentation, biofilms, bio filters, bio scrubbers and trickling filters.

Module V

Resource Ecology

(12 hrs)

Currents status of forest resources and deforestation in India. Fresh water sources, water scarcity and water conservation measures. Wet lands, its importance, reclamation and conservation measures. Sand mining and its impacts.

Energy resources – solar, fossil fuels, hydro, tidal, wind, geothermal and nuclear. Recent issues in energy production and utilization. Green technology and sustainable development. Depletion of natural resources and its impacts on life.

Ecosystem monitoring – GIS and its application, Role of remote sensing in ecology. Environmental Impact Assessment (EIA)-Tools and technique. Ecosystem modelling (Brief account only).

Recommended Text Books/Reference Books

Abbasi, S.A. and Ramasami, E.V 1998. Biotechnological Methods of Pollution Control. Oxford University Press, Hyderabad.

Benton, A.H. and Werner, W.E 1976. Field Biology and Ecology. Tata McGraw Hill, New Delhi.

Boitani, L and T.K.Fuller2000.Research Techniques in Animal Ecology. Columbia University Press, USA

Daniel, C.D 2010.Environmental Science.(8thedn.).Jones and Bartlett Publishers.

Misra, S P and Pandey S. N.2009. Essential Environmental Studies. AneBooksPvt. Ltd.

Odum, E P. 2017.Fundamentals of Ecology, India edition.

Peter Stilling, 2012. Ecology: Global Insights and Investigations. The McGraw-Hill companies, New york

Peter, H.R., Berg, L.R., and Hassenzahl, D.M. 2008. Environment. (5thedn.).John Wiley Publishers.

Pianka, E. R. 1981. Competition and Niche Theory in "Theoretical Ecology". (2ndedn.).In: May, R.M. (Ed.). Blackwell, London.

Rana,S.V.S. 2009.Essentials of Ecology and Environmental Science.(4thedn.). PHI learning Pvt. Ltd., New Delhi

Simons, I.G. 1981. Ecology of Natural Resources. Edwin-Arnold Ltd., London.

Robert Leo Smith and Thomas M Smith 2001. Ecology and Field biology (6th Edition), New York

ZL010202 DEVELOPMENTAL BIOLOGY

72 Hours (4hrs/week)

Credit – 4

Objectives:

- To introduce the concepts and process in developmental biology
- To help students understand and appreciate the genetic mechanisms and the unfolding of the same during development
- To expose the learner to the new developments in embryology and its relevance to Man

Module I (24hrs)

Introduction: Basic Concepts of Development (14 hrs)

Potency of embryonic cells, Commitment, Specification (Autonomous and Conditional), Induction, eye lens induction, Regional specificity of induction, Genetic specificity of induction, Competence, Determination and Differentiation, Morphogenetic gradients, Cell fate and cell lineages. Genomic equivalence and Cytoplasmic determinants, DNA methylation, Genomic imprinting.

Fertilization and Early development (10 hrs)

Fertilization-(biochemical and molecular aspects, cell surface molecules in sperm-egg recognition), Polyspermy. Early development and axis specification in *Caenorhabditis elegans*, Vulval induction in *C.elegans*

Module II

Development of Model organisms—Drosophila (14 hrs)

Early development and axis specification in Drosophila (cleavage, midblastula transition, gastrulation). Anterior-posterior patterning in Drosophila (Maternal effect genes, zygotic genes, gap genes, pair rule genes, segment polarity genes; homeotic selector genes, realiser genes), Dorsal-ventral patterning and left-right patterning, Dorsal protein gradient.

Module III

Axis and Pattern Formation in Amphibians (16 hrs)

Axis formation in amphibia -- Anterior-posterior patterning in Amphibia. Hox code hypothesis. Nieuwkoop centre and mesodermal polarity. Molecular basis of mesoderm induction. Transcription factors induced in the organizer. Neural induction. Vertebrate limb development.

Module IV (14hrs)

Cellular Interactions in Development (6 hrs)

Paracrine factors - Hedgehog family, Wnt family, TGF, BMP. Surface receptors and signal transduction pathway - RTK pathway, Smad pathway, Wnt pathway, Hedgehog pathway and cell death pathway.

Metamorphosis and Regeneration

(8 hrs)

Metamorphosis of Amphibians and Insects; Hormonal control of metamorphosis. Heterochrony-neoteny, progenesis (Brief accounts); regeneration - different types of regeneration; Histological processes during regeneration; Polarity and Metaplasia in regeneration; Lens regeneration in amphibia.

Module V

Human Welfare and Developmental Biology

(4 hrs)

Stem cells and their applications, ethical issues. Malformations and disruptions, Gene – phenotype relationship, Autophenotype, Allophenotype and Pleiotrophy; Environmental oestrogens.

Recommended Text Books/Reference Books

Balinsky, B.I. 2004. An Introduction to Embryology. W.B. Saunders Co., Philadelphia.

Berril, N.J. 1979. Developmental Biology. Tata McGraw-Hill Pub. Co. Ltd., New Delhi.

Gilbert, S.F. 2016. Developmental Biology (11th edn). Sinauer Associates Inc., Publishers, Massachusetts, USA

Hopper, A.F. and Hart, N.H. 1985. Foundations of Animal Development. Oxford University Press, Oxford.

Lewis Wolpert. 2007. Principles of Development. Oxford University Press. Oxford Saunders,

J.W. 1982. Developmental Biology - Patterns, Principles and Problems. Macmillan Publishing Co., New York.

Subramanian, T. 2002. Developmental Biology. Alpha Science International Ltd., New Delhi

Sunstead, D.P., Simmons, M. J. and J.B Jenkins. 1997. Principles of Genetics. John Wiley and sons, New York.

Wolpert L. and C. Tickle. 2011. Principles of Development. (4th edn). Oxford University Press, Oxford.

ZL010203 GENETICS AND BIOINFORMATICS

72 Hours (54+18) (4 hrs/week)

Credit -4

Objectives:

- To learn and understand the principles and mechanism of inheritance
- To study the fine structure of genetic material and molecular basis of hereditary transmission
- To understand the significance of Genetics in Principle in inheritance of traits in Man
- To understand the role of genetics in evolution
- To explore the emerging field of bioinformatics and to equip the students to take up bioinformatics studies

GENETICS

54 Hours

Module 1

(14hrs)

Principles of Genetic Transmission

(4hrs)

(Prerequisites: The basic principles of inheritance: Alleles, Pseudo alleles, Dominance, Segregation, Independent assortment, Test cross and ratios)

Extensions of Mendelian Principles: Codominance, Incomplete Dominance, Gene interactions with Epistasis, Pleiotropy, Penetrance and Expressivity, Phenocopy,

Linkage, Recombination and Crossing over, Cytogenetic Mapping

(10hrs)

Linkage, Recombination, Stern's experiment, Crossing over as the physical basis of recombination, Molecular mechanism of crossing over and recombination, Holiday Model

Recombination mapping with a three point test cross in *Drosophila*, Interference and the Coefficient of Coincidence. Mitotic recombination, Evolutionary significance of recombination

Mapping genes using conjugation data, Fine structure Mapping of Phage genes: Complementation Mapping, Deletion Mapping,

Organization and mapping of mitochondrial genome

(Prerequisites: Mechanisms of genetic exchange in Bacteria)

Module II

16hrs

Molecular Organization of Chromosomes

(6hrs)

Genome size and C – value paradox, Chromatin Structure and levels of DNA packaging in Prokaryotic and Eukaryotic chromosomes, Molecular structure of Centromere and Telomere, Telomere shortening and Aging (Werner's syndrome), Repeated DNA sequences in Eukaryotic Genome: Highly repetitive, Moderately repetitive, Single copy, Kinetics of renaturation, Cot Curve.

(Prerequisites: DNA, Histone, Chromatin, Euchromatin and heterochromatin)

Gene Fine Structure

(10hrs)

Classical versus Molecular concept of the gene, Cis-Trans test for functional allelism, Fine structure of the phage T4 rII locus, Modern findings on the nature of gene: Interrupted genes in eukaryotes, Exons and introns, Genes with in genes in phage ϕ x174, Gene synthesis : in vitro synthesis - Works of Watson and Crick, Khorana, Kornberg and Nirenberg.

Transposable genetic elements

Transposable elements in Bacteria, Cut and Paste transposons in Eukaryotes, Retrotransposons Transposable elements in Humans. Genetic and evolutionary significance of transposable elements.

Module III

Replication and Mutation

(10 hrs)

Unidirectional replication, Bidirectional replication, Theta replication, Rolling circle replication, eukaryotic replication and Replication Machineries – prokaryotes and eukaryotes.

Mutagenesis and Molecular Mechanism of Mutation, Tautomeric shift, DNA Repair Mechanisms, Inherited Human Diseases with defects in DNA repair, Gene conversion, The Ames test.

(Prerequisites: Messelson and Stahl Experiment, Semiconservative replication, Somatic or germinal mutation, Spontaneous or induced Mutation, Conditional lethal mutation, *Variation in chromosome Number and Structure: Aneuploidy, Deletions and Duplications, Inversions, Translocations*)

Module IV

14hrs

Human Genetics, Quantitative Genetics and Population Genetics

(11hrs)

Karyotype, Chromosome banding techniques, Pedigree analysis, anticipation, Lod Score, Complex traits, Quantitative traits, Threshold traits. Analysis of quantitative traits: The Multiple Factor Hypothesis, Broad sense heritability, Narrow sense heritability. Artificial selection, Correlations between Relatives.

The theory of allele frequencies and allelic natural selection,

Applications of Molecular Genetics

Identification of human genes and diagnosis of human diseases. Uni parental Disomy, Huntington's disease, Fragile X syndrome, Cystic fibrosis. Gene therapy-SCID-Autosomal disease of immune system, DNA profiling, Micro RNA, Si RNA and their control in Genetic disorders. Mitochondrial gene in Aging and Human Disease

(Prerequisite: Sex chromosome and sex determination, Sex-linked genes in humans, Dosage compensation of X-linked genes, Sex limited and sex influenced characters in man.)

Epigenetics

(4 hrs)

Epigenetics, Histone code hypothesis. Chromatin modifications and their mechanisms of action: Modification of histone proteins-Acetylation, phosphorylation, methylation, ubiquitylation, sumoylation. Chromatin remodeling, Genomic imprinting, X chromosome inactivation, Gene Silencing.

Epigenetics in Drosophila: Position effect variegation (PEV),

Gene silencing - Polycomb Group Genes (PcG) - Yeast and Drosophila models

BIOINFORMATICS

18hrs

Module V

Biological Databases

(6 hrs)

Primary databases - Nucleotide sequence databases: GenBank, EMBL, DDBJ; Protein sequence databases: SWISSPROT, PIR; steps involved in use and interpretation of results

Structure databases: PDB, NDB; Secondary databases: PROSITE, Pfam, CATH; Composite databases: OWL; Literature database: PubMed; Database searching – Entrez; Database sequence submission – BankIt.

Sequence Analysis

(6hrs)

Types of sequence alignment, methods of sequence alignment, scoring schemes, gaps and gap penalties, Phylogenetic trees – CLUSTAL W and CLUSTAL ω , PHYLIP

Genomics and Proteomics and Systems Biology

(6hrs)

Structural genomics, functional genomics, comparative genomics, data mining, proteomics – Microarrays. Protein modeling and drug designing.

System Biology - metabolomics, gene network, synthetic biology.

Recommended Text Books/Reference Books

Concepts of Genetics, Pearson (Global Edition), 11 edition, William S Kug, Micheal R Cummings, Charlotte A Spenser, Machael A Palladino

Principles of Genetics, Wiley, 8th Edition, Eldon John Gardner, Michael J Simmons, D Peter Snustard

Genetics: Principles and Analysis, Daniel Hartel and Elizabeth W Jones

Lewin's Genes X, Jones and Bartlett, 10 Edition Jocelyn E Krebs, Elliott S Goldstein Stephen T Kilpatrick

Epigenetics CSH Press, Second Edition, C David Allis, Marie-Laure Capparro, Thomas Jenuwein, Danny Reinberg (E

Main references: *Principles of Genetics*, Gardner, Simmons, Snustad.

Principles of Genetics, Snustad, Simmons. *Genetics, A Conceptual Approach*, Benjamin A. Pierce

Bioinformatics

Alberghina, L and H.V. Westerhoff (Eds). 2008. *Systems Biology-Definitions & Perspectives*. Springer-Verlag, Berlin.

Attwood T.K. and Parry Smith, D. 2006. *Introduction to Bioinformatics*. Pearson Education.

Bourne P. E and Weissig H, 2003. *Structural Bioinformatics*. Wiley-Liss. USA

David W. M. 2004. *Bioinformatics, Sequence and Genome Analysis* (2nd edn). CSHP, New York

Krane, D. E and M.L. Raymer. 2006. *Fundamental concepts of Bioinformatics*. Pearson Education, New Delhi

Lesk A. M, 2005. *Introduction to Bioinformatics*. Oxford Press, New Delhi

Pengcheng Fu and Sven Panke, (Eds.) 2009. *Systems Biology and Synthetic Biology*. John Wiley & Sons, Inc. NJ, USA

Tisdall J. D, 2001. *Beginning Perl for Bioinformatics*. O'Reilly Media Inc. CA, USA

Masaru Tomita and Takaai Nishioka, 2005. *Metabolomics. The Frontier of Systems Biology*. Springer Japan

ZL010204 MICROBIOLOGY AND BIOTECHNOLOGY

54 Hours (18+27) (3hrs/week)

Credit- 3

Objectives:

- To provide an over view of the microbial world, its structure and function
- To understand the fundamental aspects of the basic biology of bacteria and viruses
- To give students an intensive and in-depth learning in the field of biotechnology
- To familiarize the student with emerging field of biotechnology
- To understand the modern biotechnology practices and approaches with an emphasis in technology application, medical, industrial, environmental and agricultural areas and nanomedicine
- To familiarize the students with public policy, biosafety, and intellectual property rights issues related to biotechnology

MICROBIOLOGY

18hrs

Module I

(10hrs)

General Characters and Classification of microbes

(4 hrs)

General characters of microorganisms- bacteria, virus, fungi, Outline classification of microorganisms

Functional Anatomy of Prokaryotic Cells - Cell structure, plasma membrane, cytoskeleton, cytoplasm, nucleoid, cytoplasmic inclusions. The prokaryotic cell envelope, peptidoglycan structure, gram positive and negative cell walls. Components outside the cell wall: capsules, slime layers, pili and fimbriae, flagella and motility.

Methods in Microbiology

(6 hrs)

Culture medium, methods of isolation, pure culture techniques, microbial strain identification – cultural and biochemical, Control of microorganism- physical, chemical and antimicrobial agents.

Module II

Microbial Growth and Interactions

(8 hrs)

Nutrient requirements, growth factors, uptake of nutrients by the cell. Growth curve. Physical requirements for bacterial growth and influence of environmental factors on growth. Microbes in nutrient cycling.

Symbiosis, commensalism. Mutualism between microbes, microbes and plants, microbes and animals. Cooperation, competition, predation, antagonism. Parasitism, plant parasites, animal parasites. Microbial communication system- Quorum sensing, Biofilms.

BIOTECHNOLOGY

36 hrs.

Module III

Recombinant DNA Technology - Tools and Techniques

(12 hrs)

Introduction – rDNA and cloning, Restriction enzymes and DNA modifying enzymes.

Vectors: cloning and expression vectors - Plasmids, Ti and Ri plasmids, cosmids, phagemids, bacteriophage, SV40, vectors with combination features; PUC19 and Bluescript vectors, shuttle vectors, viral vectors, BAC and YAC vectors. Adaptors, Linkers

Methods of gene transfer: chemical transfection methods: calcium chloride, PEG, polyplex, DEAE dextran. Physical methods: electroporation, microinjection, particle bombardment, ultrasonication, liposome mediated transfer. Biological methods: use of vectors, Selection and screening of recombinants, insertional activation- blue white screening, Generation of cDNA and genomic library.

Basic techniques in Biotechnology

Polymerase chain Reaction- different types and applications, Gene cloning, Chromosome walking, chromosome jumping, DNA foot printing.

DNA sequencing methods- Maxam and Gilberts chemical degradation method, Sanger and Coulson method, Automated DNA sequencers.

Protein sequencing methods

Module IV

Animal Biotechnology and health care

(12 hrs)

Cell and Tissue culture: Basic techniques of mammalian cell culture Growth media- types, biology and characterization of cultured cells. Measurement of viability and cytotoxicity, organ culture.

Cryopreservation and maintenance of cell line

Transgenic animals – production and its applications. Gene knockout and gene knock, Site directed mutagenesis, molecular chimeras

Gene therapy: Ex vivo, In vivo, In situ- Cell and tissue engineering, Gene products in medicine – Humulin, Erythropoietin, Growth Hormone/Somatostatin, tPA, Interferon. DNA vaccine

Biosensors and Biochip.

Module VI. Biotechnology in Industry, Agriculture and Environment

(5 hrs)

Fermentation technology – Stages of fermentation - Fermentation products (antibiotics, alcohol, amino acids, organic acids, vinegar, vitamins, and fuels). Enzyme engineering and applications.

Transgenic plants, Biological nitrogen fixation; Nif genes, Nitrogen fixers – Bio fertilizers (Rhizobium, Azotobacter, Azospirillum, VAM) - Bio pesticides (Bacterial, Fungal, Viral).

Terminator gene technology

Module V

Nanobiotechnology

(3 hrs)

Introduction, Nanobiotechnological devices, Types and applications of Nanobiosensors, Drug delivery technologies, personalized nanomedicine.

Intellectual Property Rights, Biosafety and Bioethics

(4 hrs)

Introduction to Intellectual Property Rights, Types of IP: Patents, Trademarks, Copyrights.

Basics of Patents Types of patents; Indian Patent Act 1970; Recent Amendments, Protection of New GMOs. IPs of relevance to Biotechnology and few Case Studies (Rice, Neem, Curcumin).

Introduction to History of GATT, WTO, WIPO and TRIPS.

Biosafety concepts and issues. Biosafety protocol 2000.

Bioethics: Principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity

Recommended Text Books/Reference Books

Microbiology

- Ananthanarayanan, R. and Jayaram Panikar, C.K. (2013). *Text Book of Microbiology*. University Press, Hyderabad.
- Arora, D.R. and Arora, B. (2008). *Text Book of Microbiology*. CBS Publishers and Distributors, New Delhi
- Atlas RM. (2005). *Principles of Microbiology*. 4th edition. WMT. Brown Publishers.
- Chakraborty, P. A. (2009). *Text Book of Microbiology*. New Central Book Agency. New Delhi
- Harma and Kanika (2009). *Manual of Microbiology Tools and Techniques*. Ane Books Pvt. Ltd. New Delhi
- Ingraham, J. L. and Ingraham, C. A. (2000). *Microbiology* (2nd edn). Brooks/Cole-Thomson Learning, MA, USA
- Pelczar MJ, Chan ECS and Krieg NR. (2010). *Microbiology*. 8th edition. McGraw Hill Book Company.
- Talaro, Park., Kathelee, N and Talaro, Arthur. (2002). *Foundations of Microbiology*. McGraw Hill Higher Education, NY
- Wheelis Mark (2010). *Principles of Modern Microbiology*. Jones and Bartlett Publishers, NY, USA.
- Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.

Biotechnology

- Sathyanarayana, U. (2009), *Biotechnology*, Books and allied (p) Ltd
- Singh, B.D. (2009). *Biotechnology*, Kalyani publishers.
- Click, B. R. and Pasternak (2002). *Molecular Biotechnology: Principle and applications of recombinant DNA*. ASM Press.
- Dale, Jeremy W and Schantz, Malcom V. (2002). *From Gene to Genomes*. John Wiley and Sons Ltd, NY, USA
- Das, H.K. (2007). *Text book of Biotechnology*. Wiley India Pvt. Ltd. New Delhi
- Doyle, Alan and Griffith Bryan J. (1999). *Cell and Tissue Culture- Laboratory Procedures in Biotechnology*. Wiley International, NY.
- Freshney, Ian, R. (2006). *Culture of Animal Cell* (5th edn). Wiley- Liss publications.
- Jenkins, N (Ed) (1999). *Animal cell biotechnology: Methods and Protocols*. Humana press, New Jersey.
- Pandian, T.T. and Kandavel, D. (2008). *Text Book of Biotechnology*. I.K International Publishing House, New Delhi.

PRACTICAL 2

DIVERSITY OF LIFE: ECOLOGICAL, EMBRYOLOGICAL, HEREDITARY AND MICROBIAL METHODS & APPROACHES

180 Hours (10hrs./week)

Credit-4

Ecology

70 Hrs

- Study of Pond/ Wetland/ River ecosystem (any one) – Separate work book should be maintained by each student specifying objectives and methods adopted based on field study.
- Ecological analysis - Estimation of following parameters
Water:- Salinity, Phosphates, Nitrate , pH & Conductivity
Soil:- Organic carbon and Chlorides.
- Separation and identification of soil arthropods using Berlese funnel
(A minimum of five specimens should be reported with the comments in practical record)
- Qualitative and Quantitative study of marine/freshwater planktons.
- Collection and temporary mounting of minimum 3 fresh water planktons (Group/Generic level identification is necessary) .
- Viva based on field study

Genetics

20 Hrs

- Culture, sexing and etherization of *Drosophila*.
- Study of Mutants in *Drosophila*.
- Genetics problems (Di hybrid cross, test cross and sex linked inheritance)
- Gene order mapping in three point cross (Data to be provided)

Bioinformatics

30 Hrs

- Data base search and data retrieval-using NCBI, SWISS-PROT, PDB, Expasy.
- Methods of sequence alignment-BLAST and ClustalW.
- Phylogenetic tree using MESQUITE/MEGA/ PHYLIP.
- Gene Prediction using GENSCAN/GRAI.
- Protein structure visualization using RASMOL.

Developmental Biology

30 Hr

- Study of the developmental stages of *Drosophila*
- Study of the developmental stages of frog (egg, blastula, gastrula, neurula, tadpole, with external gill and internal gill) using permanent slides/Diagrams.
- Study of serial sections of embryo (tadpole/chick).
- Vital staining of early gastrula of chick - Window method.
- Blastoderm mounting and age determination of chick embryo using vital stains.
- Morphological and histological details of different types of mammalian placenta.

- Sterilization, disinfection and safety in microbiological laboratory.
 - Preparation of culture media
 - liquid media – nutrient broth , peptone water
 - Solid media – Nutrient Agar, Mac Conkey' Agar.
 - Semi solid agar
 - Firm agar.
 - Culturing of microorganism –
 - broth culture
 - pure culture techniques- streak plate, pour plate culture, lawn culture, stab culture
 - serial dilution and standard plate count, calculation of Cfu/ml in water samples.
 - Isolation and preservation of bacterial culture.
 - Identification of microorganisms-
 - Staining techniques- gram staining of mixed cultures, negative staining and spore staining, oxidase test, catalase test
 - Oxidation/fermentation (O/F) test
 - Antibiotic sensitivity (different natural fluids)
 - Staining and enumeration of microorganisms:
 - (a)using haemocytometer
 - nephelometry/ Turbidimetry
 - Environmental sample analysis.
 - Coliform count in water
 - Isolation and enumeration of soil bacteria
 - Identification of symbiotic bacterioids from root nodules of leguminous plants
- Bacteriological analysis of milk- methylene blue reductase test

THIRD SEMESTER COURSES

ZL010301	Name of the Course	1 Animal Physiology
ZL010302	"	2 Cell and Molecular Biology
ZL010303	"	3. Biophysics, Instrumentation and Biological Techniques
ZL010304	"	4 Immunology
ZL010205	"	5 PRACTICAL 3 Molecular, Physiological and Immunological Methods and Approaches in Biosciences

ZL010301 ANIMAL PHYSIOLOGY

72 Hours. (4hrs/week)

Credit-4

Objectives:

- To study and compare the functioning of organ systems across the animal world
- To give an over view of the comparative functioning of different systems in animals
- To learn more about human physiology

Module I

Digestion and Absorption

(8 hrs)

Physiology of digestion and absorption (A brief account on vertebrates and invertebrates), Neural regulation of thirst and hunger, Events of absorptive and post absorptive states and their neural and endocrine regulation, Physiology of starvation and obesity, Leptin: synthesis, secretion and its role in adipogenesis

Module II

(16hrs)

Circulation

(8hrs)

Circulatory mechanisms in different animal groups, Haemodynamics, Blood volume and its regulation, Comparative anatomy of heart structure in different animals, Myogenic heart-Conducting system, Cardiac cycle, Cardiac output, stroke volume, Neural and chemical regulation of cardiac activity ECG - its principle and significance.

Respiration

(8 hrs)

Anatomy of respiratory organs and mechanism of respiration in invertebrates and vertebrates, Pulmonary ventilation, Neural and Chemical Regulation of respiration. Respiration in unusual environment – foetal and neonatal respiration, high altitude, diving.

Module III

(22 hrs)

Nerve Physiology

(6hrs)

Neuroanatomy of the central and peripheral nervous system, Modifications of synaptic transmission, Mechanism of excitatory and inhibitory pathway. Neuromuscular Junction- organization and properties, neuromodulators. Neural control of muscle tone and posture.

Sensory and Effector Physiology

(10 hrs)

Classification of somatic senses and somatic receptors, modality of sensation, exteroceptors, interoceptors, Chemo receptors: Mechanism of reception.

Mechanoreceptors: Mechanism of hearing and Equilibrium

Photo receptors: Structure of invertebrate and vertebrate eye. Physiology of vision.

Pain receptors: Headache, pain suppression (analgesia).

Tactile receptors: Mechanism of transmission of signals

Muscle Physiology

(6 hrs)

Skeletal muscle- ultra structure and molecular organization. Red and white muscles, Mechanism of muscle contraction and relaxation. Energetics of muscle contraction. Catch muscle and fibrillar muscle.

Module IV

(10hrs)

Osmoregulation and Excretion

(6 hrs)

Osmoregulation in fresh water, marine and terrestrial animals.

Comparative physiology of excretion in different animals, Hormonal regulation of urine

concentration, Role of kidney in maintaining homeostasis. Micturition, Dialysis, kidney transplantation.

Thermoregulation

(4 hrs)

Temperature compensation and temperature regulation in poikilotherms and homeotherms, Comfort zone, body temperature – physical, chemical, neural regulation, Adaptations for extreme environments, aestivation and hibernation.

Module V

(16hrs)

Endocrinology

(10 hrs)

Invertebrate and vertebrate endocrine glands, Synthesis(Peptide- Insulin, Steroid hormones, Amines- Thyroid) physiological role and mechanism of hormone action. Bioamines, Ecosanoids, Chalcones, Lumones, Phytohormones, Synthetic hormones, Pheromones

Reproductive physiology

(6hrs)

Anatomy and histology of Testis and Ovary, Hormonal regulation of gametogenesis, Physiology of implantation, pregnancy, parturition, and lactation.

Recommended Text Books/Reference Books

Bentley, P.J. 1998. *Comparative Vertebrate Endocrinology* (3rd edn). Cambridge University Press
Bray, J.J., Cragg, P. A, Macknight, A.D, Mills, R.S and Taylor, D.W 1986. *Lecture Notes on human Physiology*. ELBS, New Delhi.

William. S.Hoar, General and comparative physiology

C.L. Prosser, Comparative animal Physiology

Kenneth .S. Saladin 2011, Anatomy and Physiology Sixth edition

Brijlal Gupta and J.A. Ramsay, 1977. *Transport of Ions and Water in Animals*. Academic Press, New York.

Chatterjee, C.C. 1997. *Human Physiology*. Medical allied agency, Calcutta.

Ganong, W.F 1987. *Review of Medical physiology*. Appleton and lang, Norwalk.

Guyton, A.C. 1996. *Text Book of Medical physiology*. Prism Books Pvt.Ltd.Bangalore

ZL010202 CELL AND MOLECULAR BIOLOGY

72 Hours (4 hrs/week)

Credit- 4

Objectives:

- To help study the structural and functional details of the basic unit of life at the molecular level
- To motivate the learner to refresh and delve into the basics of cell biology
- To introduce the new developments in molecular biology and its implications in human welfare

Module I (24hrs)

Cell Membrane & Cell Interactions (8 hrs)

Membrane structure, chemistry and functions, dynamic nature of the plasma membrane, membranepotentials, ion channels.

Extracellular matrix: Basement membrane, Collagen, Proteoglycans, Fibronectin and laminin.

Interaction of cells with extracellular matrix: Integrins. Focal adhesion and hemidesmosomes.

Interaction of cells with other cells: Selectins, Immunoglobulins, Cadherins, Adherens.

Cell Junctions: Tight junctions, Gap junctions, Desmosomes and Plasmodesmata

Prerequisite: membrane models, membrane transport: Simple diffusion, Facilitated, Active & Bulk transport

Cell Organelles (8 hrs)

Endoplasmic reticulum – protein insertion, protein folding, signal sequences and signal hypothesis, Golgi complex-protein glycosylation and protein sorting, mechanism of vesicular transport, Lysosomes.

Prerequisite: Mitochondria, Peroxisomes, Glyoxysomes, Nucleus and Nuclear membrane.

Cell organization and Cell movement (8 hrs)

Structure and organization of Microtubules, Intermediate filaments & Microfilaments, Molecular motors, Non muscle motility and muscle contractility.

Module II

Cell Signaling (12 hrs)

Extracellular messengers (signaling molecules), role of Calcium and Nitric oxide (NO) as intracellular and intercellular messengers.

Receptors: G- Protein coupled receptors, Receptor tyrosine kinases (RTK), Ion channel receptors, Cytokine receptors (Tyrosine kinase linked receptors).

Second messengers: Cyclic-AMP, Cyclic-GMP, Inositol 1,4,5-trisphosphate (IP₃), Diacylglycerol (DAG). Signaling pathways: G-protein coupled receptor (GPCR) and cyclic AMP pathway – role of protein kinase A (PKA), GPCR pathway in rod cells, Receptor protein tyrosine kinase and Ras-MAP kinase pathway, JAK-STAT pathway, Calcium phosphatidyl- inositol pathway, Phosphoinositide 3-kinase (PI-3 kinase), Transforming growth factor (TGF) signaling pathway. Regulation of signaling pathways. Convergence, divergence and crosstalk among

different pathways.

Prerequisite: *Basic principles of cell communication*

Module III

Gene Expression

(12 hrs)

Transcription in prokaryotes and eukaryotes, Promoter, enhancer and silencer RNA processing in prokaryotes and eukaryotes, post transcriptional modifications, Translation in prokaryotes and eukaryotes, Genome engineering by the CRISPR/ Cas system

Pre-requisite: *Gene and Genetic code*

Module IV

Gene Regulation

(12 hrs)

Regulation of gene expression in *E. coli* :Catabolite repression, *Trp* operon in *E.coli*-repression and attenuation, *Ara* operon in *E.coli*-positive and negative controls. Riboswitches.

General introduction to gene regulation in eukaryotes at the level of chromatin structure, transcriptional - Transcription activators, coactivators and repressors, Activation and repression of transcription, post transcriptional, translational and post translational levels, methods to identify post translational modification: RNA editing, RNA interference (RNAi).

Pre-requisite: *Fundamentals of gene regulation, Lac operon, Monocistronic and Polycistronic mRNA*

Module V

(12hrs)

Cell Growth

(5 hrs)

Cell cycle: Stages in cell cycle, Control of cell cycle, Checkpoints in cell cycle. Control of cell division and cell growth. Apoptosis- extrinsic and intrinsic pathways, significance.

Prerequisite: *Mitosis, meiosis*

Cancer

(7 hrs)

Basic properties of a cancer cell: Metastasis, interaction of cancer cells with normal cells, Types of cancer, Causes of cancer, Genetics of cancer, Tumor suppressor gene, Oncogene.

New strategies for combating cancer: Immunotherapy, Gene therapy, inhibiting cancer promoting proteins, inhibiting formation of new blood vessels.

Pre-requisite: *benign and malignant tumour*

Recommended Text Books/Reference Books

Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. And Walter, P. 2017. *Molecular Biology of the Cell*. (6th edn). Garland Science.- Taylor and Francis group, USA.

Clark, D.P. 2010. *Molecular Biology*. Elsevier Publishers, London.

Cooper, G.M. and Hausman, R.E. 2018. *The cell: A Molecular Approach* (8th edn). Sinauer Associates, Inc, ASM Press, Washington DC.

Griffiths, A.J.F., Wesler, S.R., Carroll, S.B. and Doebley, J. 2008. *Introduction to Genetic Analysis*. W H Freeman and Company, USA

Hardin, J., Bertoni, G. 2018. *Becker's World of the Cell*. (9th edn). Pearson, England.

Hyde, D.R. 2010. *Genetics and Molecular Biology*. Tata McGraw Hill Education Private Ltd., New Delhi.

Karp, G. 2013. *Cell and Molecular Biology* (7th edn). John Wiley and Sons, Inc. NJ, USA.

Klug, W.S. and Cummings, M.R. 2004. *Concepts of Genetics*. Pearson International, New Delhi.

Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. 2017. *Lewin's Genes XII*. Jones and Bartlett publishers, NY.

Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Martin, K.C. 2016. *Molecular Cell Biology* (8th edn). W H Freeman & Company, U.S.A.

Pierce, B.A. 2008. *Genetics: A conceptual approach*. W H Freeman and Company.

Pollard, T.D. and Earnshaw, W.C. 2008. *Cell Biology*. Saunders Elsevier.

Snustad, D.P. and Simmons, M.J. 2010. *Principles of Genetics*. John Wiley and Sons.

Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. 2013. *Molecular Biology of the Gene* (7th edn). Pearson.

ZL010303 BIOPHYSICS, INSTRUMENTATION AND BIOLOGICAL TECHNIQUES

72Hours (18 + 54)4hrs/week

Credit – 4

Objectives:

To understand the biological system and processes based on physical principles

To provide and insight on the tools and techniques of various instruments available for biochemical and biophysical studies

To train the learner the operational skills of different instruments required in Zoology

BIOPHYSICS

18hrs

Module 1

Diffusion and Osmosis

(6hrs)

Diffusion – Kinetics of diffusion. Fick's law and diffusion coefficient. Gibb's Donnan equilibrium. Application of diffusion processes in biology: haemolysis. Vant Hoff's laws. Osmotic concentration, Osmotic pressure and osmotic gradient. Biological significance of osmosis in animals and plants.

Bioenergetics

(6hrs)

Reversible thermodynamics and irreversible thermodynamics; Systems – open, closed and isolated. Photo bioenergetics. Photosynthesis – light and dark reactions, Redox couple and redox potential. Chemo-bioenergetics: electron transport and oxidative phosphorylation, Chemiosmotic theory and binding change mechanism of ATP synthesis.

Radiation Biophysics

(6hrs)

Interaction of radiation with matter – Photoelectric effect, ion pair production, absorption and scattering of electrons. Biological effects of radiation: effect on nucleic acids, proteins, enzymes and carbohydrates. Cellular effects of radiation: somatic and genetic. Nuclear medicine: Internally administered radioisotopes. Radioiodine in thyroid function analysis.

INSTRUMENTATION & BIOLOGICAL TECHNIQUES

54hrs

Module II

Microscopy and Histological Techniques

(18hrs)

Microscopy

(10hrs)

Differential Interference contrast (Nomarsky) microscopy, Fluorescence microscopy, Confocal microscope, Scanning Tunnelling, Electron microscope - TEM, SEM, Specimen preparation- Shadow casting, Freeze fracturing, Freeze etching, Negative staining. Microphotography, Atomic force microscope

Histological Techniques

(8hrs)

Types of microtomes and microtomy. Fixation, preparation of temporary and permanent slides, whole mounts, smears, squashes and sections. Cytochemical and histological method, Histochemistry of nucleic acids, detection of carbohydrates, proteins and lipids.

Module III

Separation Techniques (20hrs)

Centrifugation (2hrs)

Basic principle and application. Differential, density and ultracentrifugation.

Chromatography (10 hrs)

Basic principles, working and applications of Thin-layer chromatography, Ion – exchange and Affinity chromatography; High performance liquid chromatography (HPLC), Fast protein liquid chromatography (FPLC), Gel permeation chromatography.

Electrophoresis (8 hrs)

Gel electrophoresis– PAGE, SDS and non SDS, 2D Gel electrophoresis, Isoelectric focusing, Density gradient gel electrophoresis, Disc electrophoresis, High voltage electrophoresis, Capillary gel electrophoresis, Electrophoretic mobility shift assay (EMSA).

Module IV

Advanced Techniques and Applications (12hrs)

Colorimetry (2 hrs)

Principle and applications of colorimetry and spectrophotometry- Beer Lambert law

Spectroscopy (10hrs)

Fourier-Transform infrared spectroscopy (FTIR), Raman spectroscopy, Circular dichroism spectroscopy, Flame emission spectroscopy, Atomic absorption spectroscopy, Nuclear Magnetic resonance spectroscopy (NMR) and Electron Spin Resonance (ESR) spectroscopy, Mass spectroscopy- Different types and applications: MALDI-TOF, LCMS, Tandem Mass Spectrometry.

Module V (4hrs)

Radioisotope Detection and Measurement (2hrs)

Dosimetry: Ionization chamber, GM counter, Solid and liquid scintillation counters, Autoradiography.

Biomimetics technology (2 hrs)

Principles and applications- Bio-Nanorobotics, Artificial muscles using Electroactive polymers, Multifunctional materials

Recommended Text Books/Reference Books

Alonso, A., and Arrondo, J.L.R. 2006. *Advanced Techniques in Biophysics*. Springer, UK

Arora, M. P. 2007. *Biophysics*. Himalaya Publishing House, New Delhi

Bar-Cohen, Yoseph. *Biomimetics: Biologically-Inspired Technologies*. 2006. CRC Press.

Das, D. 1991. *Biophysics and Biophysical Chemistry*. Academic Publishers, Calcutta

Edward, A.L. 1997. *Radiation Biophysics*. Academic Press, New York, USA

Ernster, L. (Ed.). 1985. *Bioenergetics*. Elsevier, New York, USA

Ghatak K.L. 2011. *Techniques and Methods in Biology*. PHI Learning Pvt. Ltd. New Delhi

Gupta A. 2009. *Instrumentation and Bio-Analytical Techniques*. PragatiPrakashan, Meerut

Hoope, W. et.al. 1983. *Biophysics*. Springer Verlag, Berlin

Keith Wilson and John Walker. 2010. *Principles and techniques of Biochemistry and Molecular Biology*. 7th Edition.

Lehninger, A.L. 1971. *Bioenergetics*. W.A. Benjamin, London, UK

Narayanan, P. 2000. *Essentials of Biophysics*. New Age International (P) Ltd. Publishers, New Delhi

Nelson D.L. & Cox, M.M., 2006. *Lehninger's Biochemistry*, W.H. Freeman and company, USA

Pradeep T. 2007. *NANO: The Essentials. Understanding Nanoscience and Nanotechnology*. Tata McGraw Hill Education Pvt. Ltd., New Delhi

Roy, R.N. 1996. *A Textbook of Biophysics*. New Central Book Agency (P) Ltd. Calcutta

Sandhu, G.S. 1990. *Research Techniques in Biological Sciences*. Anmol Publications, New Delhi

Srivastava, P.K. 2006. *Elementary Biophysics. An Introduction*. Narosa Publishing House, New Delhi

Trunk Dung Ngo. 2015. *Biomimetic Technologies: Principles and Applications*. Woodhead Publishing

Varghese, T. and Balakrishna, K.M. 2012. *Nanotechnology-An Introduction to Synthesis, Properties and Applications of Nanomaterials*. Atlantic Publishers and Distributors. (P) Ltd. New Delhi

ZL010304 IMMUNOLOGY

Total: 54 Hours. (3hrs. /week).

Credit- 3

Objectives:

- To provide an intensive and in-depth knowledge to the students in immunology
- To help the learner to understand the role of immunology in human health and well-being
- To familiarize the students the new developments in immunology

Module I (12hrs)

Overview of the Immune System

(4 hrs)

- Cells, tissues and organs involved in immune system.
- Haematopoiesis- B-cell and T-cell maturation and differentiation.
- Haematopoietic growth factors.
- B-Cell receptors.
- T-Cell receptors
- Toll-like receptors

Immunogenicity and Antigenicity (8 hrs).

- Factors that influence immunogenicity
- Haptens, Adjuvants, Epitopes.
- Properties of B-cell and T-cell epitopes
- Immunoglobulins-structure, classes and functions.
- Antigenic determinants of immunoglobulin - (a) Isotype (b) Allotype (c) Idiotype.
- Immunoglobulin genes- Multigene organization.
- Generation of antibody diversity.
- Monoclonal antibodies and clinical uses.
- Antibody engineering.

Module II (19hrs)

Antigen –Antibody Interactions

(6 hrs)

- Strength of antigen-antibody interaction- antibody affinity and avidity.
- Types of antigen-antibody reactions - Cross-reaction, Precipitation, Agglutination.
- **Immunological Techniques** - Immunoprecipitation. Immunofluorescence. Flow cytometry and fluorescence. Immunoelectron microscopy. Radio-allergosorbent Test (RAST). ELISA and RIA .

The Complement System (4 hrs)

- Complement activation-Classical, Alternate and Lectin Pathways.
- Terminal sequence of complement activation (MAC.)
- Regulation of complement system.
- Biological consequences of complement activation.
- Complement deficiencies .

Module III (9hrs)

Immune Effector Mechanisms

(5 hrs).

- Types of Inflammation- acute and chronic.
- Chemokines.
- Role of cytokines in immune system (Placed as independent topic).
- Properties and functions of Cytokines.

- Cytokine antagonists.
- Therapeutic uses of cytokines.

Hypersensitivity (4 hrs)

- Types of Hypersensitivity- IgE- mediated (type- I) hypersensitivity.
Antibody- mediated cytotoxic (type- II) hypersensitivity.
Immune complex- mediated (type- III) hypersensitivity.
Delayed type (type- IV) hypersensitivity.
Stimulatory (type V) hypersensitivity

Module IV (18hrs)

Major Histocompatibility Complex (8 hrs)

- General organization and inheritance of MHC.
- MHC genes. Genomic map of H-2 Complex in the mouse.
- HLA Complex in humans. MHC-peptide interaction.
- Expression of MHC molecules on different cell types.
- Biological significance of MHC. HLA typing
- Antigen processing and presentation

Immunity in Health and Disease (10 hrs)

- Congenital immunodeficiency diseases (SCID, WAS, CVI, Ataxia, CGD, LAD). Acquired Immunodeficiency Disease (AIDS).
- Autoimmunity. Organ- specific autoimmune diseases. Systemic auto-immune diseases.
- Immune response during bacterial (Tuberculosis), parasitic (Malaria) and viral (HIV) infections (include).

Vaccines –Whole organism vaccines, Purified macromolecules as Vaccines, Recombinant vector vaccines, DNA vaccines. Synthetic peptide vaccines, Multivalent subunit vaccines.

Module V

Transplantation immunology (5 hrs)

- Immunologic basis of graft rejection.
- Clinical manifestation of graft rejection.
- General and specific immunosuppressive therapy.
- Clinical transplantation.

Recommended Text Books/Reference Books

Abbas, A.K., Lichtman, A.K and Pober, J.S. 1997. *Cellular and Molecular Immunology*. W.B. Saunders Co. New York

Ashim K. Chakravarty. 1998. *Immunology*. Tata McGraw-Hill, New Delhi.

Chakraborty, A.K. 2006. *Immunology and Immunotechnology*. Oxford University Press, New Delhi

Darla, J, Wise & Gordeon, R. Carter. 2004. *Immunology- A Comprehensive Review*. Iowa State University Press. A Blackwell Science Co, USA

David Male, Jonathan Brostoff, David Roth and Ivan Roitt. 2006. *Immunology*. Mosby, Edinburgh, UK

Goldsby, R.A., Kindt, T.J. and Osborne, B.A. 2000. *Immunology* (4th edn.). W.H. Freeman and Co. NY, USA.

Hannigan, B. M., Moore, C. B. T. and Quinn, D. G. 2010. *Immunology*. Viva Books, New Delhi.

Helen Chappel and Mased Harney, 2006. *Essentials of Clinical Immunology* (5th edn.) Blackwell Scientific Publications

Ivan M. Roitt, 2002. *Essential of Immunology*. ELBS, New Delhi.

Khan.F.H. 2009. *The Elements of Immunology*. Pearson Education. New Delhi.

Kuby J, 2000. *Immunology* (7th edn.). WH Freeman & Co. New York.

Richard Coico and Geoffrey Sunshine. 2009. *Immunology: A short course*. Wiley-Blackwell, CA, USA

ZY3CP03: PRACTICAL 3

MOLECULAR, PHYSIOLOGICAL AND IMMUNOLOGICAL METHODS & APPROACHES IN BIOSCIENCES

180 Hours (10hrs./week)

Credit-4

Cell & Molecular biology and Biotechnology

72hrs

- Squash preparation of grasshopper testis to study meiotic stages.
- Squash preparation and identification of salivary gland chromosomes in *Drosophila* / *Chironomus* larva.
- Determination of mitotic index in the squash preparation of onion root tip.
- Effect of drugs on cell division (Colchicine or any other inhibitor)
- Live staining of cells using vital stains and viability study
- Cell fractionation and Differential Centrifugation to isolate mitochondria and nuclei
- Preparation of Microtome section & spreading
- Histochemical staining of carbohydrates (PAS), Protein (Bromophenol blue), lipids (Sudan Black), DNA (Fuelgen stain)
- Gel electrophoresis of protein and nucleic acid (Demonstration)
- Isolation of genomic and Plasmid DNA.

Biophysics/Instrumentation/Biological Techniques

36 hrs

- Micrometry- principle and measurement of microscopic objects: Low power and high power
- Camera Lucida – Diagrammatic representation of specimen using camera lucida
- Principle and working of phase contrast microscope, Micro-photographic equipment,
- Identification of absorption maxima of the given sample by colorimetry
- TLC using amino acids from purified samples and calculation of RF values
- Analysis of biological materials (Arthropodan perilymph) using TLC

Animal Physiology

72 hrs

- Rate of salivary amylase activity on starch (colorimetry)
- Effect of different pH on salivary amylase activity (colorimetry)
- Influence of temperature on salivary amylase activity – Calculation of Q₁₀
- Effect of drugs on the heartbeat of cockroach (Result with graphical representation corresponding to different concentration and time intervals expected)
- Oxygen consumption in fish (normal and stressed).
- Kymograph: working principle and applications.
- Virtual Practicals in Physiology
(Use of PhysioEX 9.0 : *Laboratory Simulations in Physiology* by P.Zao.,T.Stabler., L.A.Smith and E .Griff. 2011.is suggested) for muscle and nerve physiology practical for class room training and for practical examination in order to replace Frog as per UGC guidelines). Any four of the following:
Muscle Twitch and the Latent Period, The effect of stimulus Voltage on Skeletal Muscle Contraction, Tetanus, Fatigue, Receptor Potential, The Action Potential Threshold, Importance of Voltage –Gated Na⁺ Channels

- Differential count of Human WBC
- Haematocrit and ESR of Human blood
- Feeding activity of paramecium
- Effect of different concentration of NaCl solution (0.1%-2%) on the diameter of RBCs (preferably human) and determination of the concentration, which is isotonic to the blood from a plot of diameter of RBC against concentration of NaCl

Immunology

- Separation of lymphocytes from whole blood.
- Separation of T and B lymphocytes
- Blood Typing in Man.
- WIDAL Test and Western Blotting –Demonstration
- ELISA -Demonstration
- Rocket Immuno electrophoresis- Demonstration

Note:

Good laboratory practices and green protocol should be practiced in the lab. Virtual Practical developed by the Ministry of Human Resources, Govt. of India and available in the web site:www.vlab.ac.in can be availed for demonstration.

FOURTH SEMESTER COURSES

ELECTIVE A: FISHERY SCIENCE

ZL800401	Name of the Course	1 Nutrition, Growth and Physiology of fishes
ZL800402	"	2 Fishery Resource Management
ZL800403	"	3. Fishery Science and Technology
ZL800404	"	4 Practical : Fishery Science – Methods and Approaches

ZL800401 NUTRITION, GROWTH AND PHYSIOLOGY OF FISHES

90 Hours (5 hrs./Week)

Credit-4

Objectives:

- To impart knowledge on various aspects of fish biology
- To understand the basic principles of fish nutrition and the function of individual nutrients.
- To learn functional physiology of fishes.

Module 1 **S** **(14hrs)**

Food and feeding biology **(4 hrs)**

Components of balanced food, classification of fish food organisms, ingestion of food and feeding mechanism. Feeding adaptations.

Digestive system and physiology of digestion **(10 hrs)**

Digestive system in fin fish and shell fish. Anatomy, histology and functions of different parts of gastro-intestinal tract in herbivores and carnivores. Modification of digestive system in relation to age and growth.

Physiology of digestion, absorption and assimilation. Role of hormone in the regulation of digestion. Factors affecting digestion and transport of nutrients.

Module II **(27hrs)**

Fish Nutrition **(20 hrs)**

Energy nutrition – Definition, energetics, expression of energy value of feed – gross energy, digestible energy, metabolizable energy, net energy. Partitioning of energy, protein energy ratio. Protein nutrition of fish– source, function and deficiency symptom. Lipid nutrition – source, function and deficiency symptom. Carbohydrate nutrition – source and function.

Vitamin and mineral nutrition –source, functions, deficiency symptoms.

Larval nutrition – Importance of live feed and artificial feed, different types of feed available for larvae, larval gut morphology and mode of nutrition.

Brood stock nutrition – Nutrients required for reproduction, egg and sperm quality.

Feed additives – classification, function, specific use for economic and quality fish and shellfish production.

Growth **(7 hrs)**

Concept of growth, determination of age and growth, growth curve, length weight relationship. Metabolism (anabolism and catabolism) and growth. Biotic and abiotic factors affecting growth. Role of nutrients and hormones in the regulation of growth.

Module III

Reproductive physiology and endocrinology

(20 hrs)

Sexual dimorphism, primary and secondary sexual characters, bisexual reproduction, inter-sexes, hermaphroditism, sex differentiation and factors affecting sex differentiation. Sex reversal in fish and factors affecting sex reversal.

Development of gonad, oogenesis, Mechanism of oocyte maturation and ovulation, spermatogenesis, metabolic changes during oogenesis and spermatogenesis, vitellogenesis and gonadal steroidogenesis.

Modes of reproduction – oviparity, aplacentalviviparity and placental viviparity.

Annual reproductive cycle and breeding patterns in male and female, pheromones and reproductive behaviour, nest building and parental care. Hormonal and environmental regulations of reproduction.

Regulation of seasonal reproduction – Role of environment: temperature, photoperiod, rainfall. Role of hypothalamo-hypophyseal system and pineal gland, role of peripheral endocrine system.

Module IV

(19hrs)

Sensory Organs

(7hrs)

Structure and function of sense organs. Visual, chemoreception, statoacoustic, mechanoreceptors, thermoreceptors, electroreceptors.

Specialised Characters

(12hrs)

Gill structure and physiology of respiration. Accessory respiratory organs, mechanism of air breathing. Swim bladder, structure and function. Weberian ossicle. Electric organs, Luminescent organs. Sound production and detection. Acoustic communication. Venomous fishes.

Adaptations to special conditions of life – hill stream, cave, deep sea.

Chromatophore pigments and colouration. Physiology of colour change.

Module V

Physiology of behaviour

(10 hrs)

Concepts on fish behaviour and regulatory mechanism. Alarm reaction transduction mechanisms.

Domestication processes in communicative behaviour. Locomotive behaviour. Behaviour due to environmental partition.

Chemical signals to evoke feeding behaviour. Aestivation and hibernation. Migrations and orientation. Predatory avoidance. Adaptation mechanism in altered environment.

Recommended Text Books/Reference Books

Brown C, Laland KN & Krause J. 2006. *Fish Cognition and Behaviour*. Blackwell. Pitcher TJ. 1993. *Behaviour of Teleost Fishes*. Springer.

Chandrasekhar, Y.S. 2013. *Fish Nutrition in Aquaculture*. Swastick Publications, Delhi.

Cyrino EP & Bureau D & Kapoor BG. 2008. *Feeding and Digestive Functions in Fishes*. Science Publ.

- Evans, D.H and Claiborne, J.D 2006. *The physiology of fishes*. Taylor and Francis group, CRC Press, UK
- Guillame J, Kaushik S, Berqot P &Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.
- Holt, G.J. 2011. *Larval Fish Nutrition*. Springer-Verlag, New York
- Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.
- Hoar WS & Randall DJ.1988. *Fish Physiology*. Academic Press.
- Lovell, T. 2009. *Nutrition and Feeding of Fish*. Springer-Verlag, New York
- Lynwood S Smith, 1999. *Introduction to fish Physiology*. Narendra Publishing house, Delhi
- Rankin JC & Pitcher TJ.1983. *Control Processes in Fish Physiology*. Springer.
- Raghunath, M.R. 2013. *Nutrition and Feeding of Fishes*. Swastik Publishing House, Delhi.
- Smyth & Lynwood. 2003. *Introduction to Fish Physiology*. Narendra Publishing House, Delhi, 352pp.
- SurendraNath. 2002. *Food, Feeding habits and Alimentary canal of fishes*. Vinod Publishers and Distributors, India.

ZL800402 FISHERY RESOURCES AND MANAGEMENT

90 Hours (5 hrs./Week)

Credit – 4

Objectives:

- To impart knowledge in inland and marine fishery resources of India
- To educate the students on the oceanographic concepts related to fisheries
- To impart theoretical knowledge on application of remote sensing and GIS in fisheries
- To impart theoretical knowledge of benthic ecology.
- To impart knowledge on interactions between aquaculture and the environment.

Module I (30hrs)

Inland Fishery Resources (10 hrs)

Categorization of different fresh water and brackish water resources – Ponds, lakes, tanks, rivers, reservoirs, estuaries, brackish water lagoons, wetlands, mangroves and derelict water bodies. Important economically important fin and shell fish resources of Kerala. Scope of inland fishery in Kerala.

Riverine fishery resources – major riverine fisheries in India. Penninsular rivers and its fishery diversity with special reference to endemic species in Kerala. Present status of riverine fishery in Kerala.

Reservoir fisheries – Classification of reservoirs. Reservoir fishery of Kerala. Methods for enhancement of productivity.

Estuarine fisheries – Classification of estuaries. Status and potential of estuarine fisheries in Kerala. Status of mangrove fishery in India.

Inland Fishery – Problems, conservation and management (20 hrs)

Direct and indirect effects of human intervention and management challenges in riverine fishery. Present trend of dwindling riverine fishery resources. Habitat modification and improvement – restoration, rehabilitation of channels and flood plain. Stock enhancement strategies.

Methods for conservation, management and enhancement of productivity in reservoirs.

Effect of dam on riverine fishery. Protection and restoration of fish movements – different types of fish passes and enhancement of fish migration.

Strategies for the conservation and management of estuarine system.

Mangrove ecosystem – degradation and its problems on fisheries.

Derelict water bodies – problem and fishery management aspects.

Riverine sand mining and its effect on benthic biodiversity and fisheries.

Invasive species and its effect of indigenous species and fishery.

Activities of FIRMA. Matsyafed – objectives and different activities for the development of fishery of Kerala.

Module II (15hrs)

Marine fishery resources (7 hrs)

Major fishing regions of the sea. Important finfish and shellfish resources in demersal and pelagic system. Sea weeds.
Issues and challenges of managing multi-gear fisheries.
Mud bank formation and significance. Mud bank fishery in Kerala.

Marine Biodiversity and conservation

(8 hrs)

Marine biodiversity – threats, planning and management aspects.
IUCN criteria – Red list, Wild life Protection Act, International treaties and conventions, Marine protected areas, Sanctuaries and Biosphere reserves. Establishment of National marine parks, *in situ* and *ex situ* conservation. Coastal tourism.

Module III

Fisheries Oceanography

(20 hrs)

Oceanographic factors in fisheries – effects of physicochemical (Salinity, temperature, pH, light, pressure, dissolved gasses and nutrients) and biological oceanographic factors on adaptation, behaviour, abundance and production of organisms.
Synoptic oceanographic analysis – currents, waves, tides, amplitudes, stratification, related chemical factors, upwelling and circulation patterns.
Fisheries forecasts – Remote sensing, Global positioning system (GPS). Application of remote sensing in fisheries. Eco-sounders and Sonar – applications in fishery. Interpretation and use of thermal structure in fisheries.
Factors affecting coastal marine fishery – environmental factors influencing the seasonal variations in fish catches in the Arabian Sea. Potential fish zones (PFZ). Fishery trawling ban in Kerala.

Module IV

Aquaculture and Management Aspects

(20 hrs)

Fresh water fish farm – survey of site, layout, soil and water quality requirements. Pond fertilization. Different kinds of fertilizers and manures. Bio-fertilizers, use of treated sewage for pond fertilization.
Methods of culture fishes of Indian major Carps, exotic Carps, Catfishes, Murrels, Tilapia and Prawns.
Methods of culture of grey mullet, milk fish, crabs, shrimps. Traditional (Bheries, Pokkali) and modern methods of prawn culture. Culture of pearl oyster, edible oyster and sea mussels.
Integrated fish culture. Composite fish culture. Integrated farming and aquaponics. Benefits of aquaponics.
Ornamental fishery and its export from India. Aquarium fishes. Setting up and maintenance of an aquarium.
Management of hatcheries and farms. Methods for control and management of aquatic weeds in the system. Role of microorganisms in fish production, microbial load and algal bloom. Algal bloom control.

Module V
Fisheries Education

(5 hrs)

Objectives and functions of Fisheries Institutes – Central Institutes of Fisheries Education (CIFE), Central Inland Capture Fisheries Research Institute (CICFRI), Central Marine Fisheries Research Institute (CMFRI), Central Institute of Fisheries, Nautical and Engineering Training (CIFNET), Central Institute of fisheries technology (CIFT), National Institute of Oceanography (NIO), National Institute of Fisheries Post Harvest Technology and Training (NIFPHATT). Central Institute of Brackish water Aquaculture (CIBA), Fishery survey of India (Brief account only).

Recommended Text Books/Reference Books

- Aravind Kumar, 2004. *Fishery Management*. APH Publ. Corpn., New Delhi, 371 pp
- Badapanda, K.C. 2012. *Aquaculture* Vol.1 .Narendra Publishing House, Delhi, 496pp.
- Balakrishnan Nair N and Thampi D M 1980. *A text book of marine ecology*. Publisher Macmillan
- Carter RWG. 1998. *Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines*. Academic Press.
- Dholakia A D 2001. *Fisheries and Aquatic Resources of India*. Daya Publishing House, New Delhi.
- De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.
- Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ. Corp.
- Laevastu T & Hayes ML. 1981. *Fisheries Oceanography and Ecology*. Fishing News Books.
- Lalli CM & Parsons TR. 1993. *Biological Oceanography: An Introduction*. Elsevier.
- Long, A.C. 2012. *Fish feeding and integrated fish farming*. Cybertech Publications, Delhi.
- Miller CB. 2004. *Biological Oceanography*. Blackwell.
- Patro & Lingaraj. 2012. *Fisheries & Aquaculture*. Sonali Publication, Delhi, 473pp
- Pillay TVR & Kutty MN. 2005. *Aquaculture: Principles and Practices*. 2nd Ed. Blackwell.
- Pillai N.G.K 2011. *Marine fisheries in India*, ICAR, New Delhi
- Pandey N & Davendra SM. 2008. *Integrated Fish Farming*. Daya Publ. House.
- Reddy MPM. 2007. *Ocean Environment and Fisheries*. Science Publ.
- Sakhare, V.B. 2012. *Inland fisheries*. Daya publishing house, Delhi, 326pp.
- Sharma A.P. 2012. *Management issues in Inland Fisheries and Aquaculture*. Narendra Publishing House, Delhi, 243pp.
- Sugunan, V.V. 1995. *Riverine Fisheries of India*. FAO Publication, 423 pp.
- Sugunan V.V. 1997. *Reservoir Fisheries of India*. Daya Publ. House.
- Welcomme RL. 2001. *Inland Fisheries: Ecology and Management*. Fishing News Books.
- Society of Fisheries Technology (India), 2000. *Riverine and Reservoir fisheries of India*. Proceedings of the National Seminar on Riverine and Reservoir Fisheries – Challenges and Strategies, 2001, Cochin.

ZL800403 Fishery Science and Technology

90 Hours (5 hrs./Week)

Credit-4

Objectives:

- To understand the advances in aquaculture
- To outline an overview on the potential marine resources for bioactive compounds and pharmaceuticals
- To give detailed insight into various aspects of freezing of fish and thermal/heat processing.
- To understand various aspects of quality assurance system, quality management and national/international certification system.
- To learn factory sanitation and hygiene, water quality and standard
- To provide information on various fish by-products and fishing methods

Module I

(27hrs)

Aquaculture Biotechnology

(20 hrs)

Fish breeding – Induced breeding and hypophysation: synthetic and natural hormones, cryopreservation of gametes and artificial fertilization. Application of biotechnology for accelerating gonadal growth and manipulation of the duration of spawning.

Transgenesis – methods of gene transfer in fishes, screening for transgenics, applications, regulation of GMOs, IPR, evaluation of GFP transgenics.

Gene bank and conservation – conservation of gametes and embryos.

Algal technology – microalgae: indoor and mass culture methods, biotechnological approaches for production of important microalgae, single cell protein from Spirulina, raceway system of micro algae culture, vitamins, minerals and omega3 fatty acids from micro algae, enrichment of micro algae with micronutrients.

Post harvest biotechnology – delaying spoilage, detection of toxic substances and pathogenic microbes, biosensors for toxins.

Marine Biotechnology

(7 hrs)

Marine resources – biodiversity, marine natural products, valuable chemicals, biomedical and bioactive compounds from marine organisms, commercial bio-products from marine organisms, green fluorescent protein from jelly fish and its application, marine organisms as a sources of polysaccharides, antiviral, anticancer and anti-inflammatory compounds. Commercially important enzymes-xylanase, agarase, proteases, chitinases, lipases, cellulase and phytase.

Module II

Advances in Feed Technology

(15 hrs)

Feed formulation – least cost formulation, linear programming. Quality of feed ingredients and their biochemical composition. Protein and energy supplements. Premixes of vitamins and

minerals. Antioxidants in diets. Toxins in feeds. Exogenous enzymes. Feed probiotics and their role. Feed additives. Water stability of diets.

Feed technology – micro encapsulated feeds, micro coated feeds, micro particulate feeds and bio capsulated feeds, mycotoxins and their effects on feeds.

Feed manufacture – processing of feed mixtures, steam pelleting. Stability of nutrients. Factors affecting feed manufacture. Effects of processing on the nutritional value of feeds. Process of reducing anti-nutritional factors. Feed mills. Quality control of feed. Storage of feed and feed deterioration.

Module III

Technology of fish freezing

(12 hrs)

Crystallization, homogeneous and heterogeneous nucleation, super cooling, crystal growth eutectic point, location of ice crystals in tissue, physical changes during freezing.

Technological aspects of freezing: slow and rapid freezing, methods of freezing, comparison of various freezing methods, selection of a freezing method, product processing, packaging and different types of freezers.

Chemical treatments prior to freezing: antioxidants, cryoprotectants and other additives, theories of cryopreservation, glazing

Frozen storage: physical and chemical changes, freezer burn and recrystallization, different types of recrystallization.

Different methods of thawing frozen fish, advantages and disadvantages. Recent advances in fish thawing.

Module IV

(21hrs)

Thermal processing of fishery products

(8 hrs)

Principles of thermal processing. Mechanism of heat transfer: conduction, convection, radiation and dielectric and microwave heating, heat resistant of bacteria and spores. Thermal death time. Significance of thermal death curve. Heating equipment.

Canning process, steps involved, process flow, additives, HTST processing and aseptic canning, principles and process details, canning machinery and equipment.

Spoilage of canned food, physical, chemical and microbial. Thermo bacteriology, death of bacteria, auto sterilisation bacteriology of canned/heat processed fishery product, examination of canned and seams.

Fishery By-products

(5 hrs)

Traditional fishery by-products: fish meal and fish oil – preparation and uses. Processing of wastes – prawn heads, chitin, chitosan, fish protein concentrate (FPC) preparation. Uses of shell, isinglass, glue, guano, fins and leathers. Packaging, storage and transport of fish products.

Quality control in processing industry

(8 hrs)

Plant sanitation and hygiene. Water quality and standard. Inspection system.

Quality assessment of fish and fishery products – physical, organoleptic and microbiological quality standards. National and International standards. Integrated food law.
Sensory evaluation of fish and fish products, basic aspect, different methods of evaluation.

Module V

Fishing Methods

(15 hrs)

Crafts and gears used for fishing in inland and marine waters. Gears – types and designs, operation and efficiency. Destructive and prohibited fishing practices. Recent advances in fishing method. Fishing using electricity, light. Bycatch reduction devices: definition, types of bycatch reduction devices and the principles of operation. Fish finders – ecosounders and sonar and their use. Different type of turtle excluder devices (TEDs). Advanced communication systems – VHF, SSB, Inmarsat system. Vessel monitoring systems (VMS): Important uses, role in fisheries management.

Fishing harbours – classification, facilities, layout of a typical fishing harbour. Fishing harbours of Kerala coast.

Recommended Text Books/Reference Books

- Balachandran KK. 2001. *Post-harvest Technology of Fish and Fish Products*. DayaPubl.House.
- Fingerman M, Nagabushana M & Thompson R. 1998. *Recent Advances in Marine Biotechnology*. Vol.II. Science Publ.
- Fingermann, Milton, Nagabhushanam&Rachakonda. 2000. *Recent Advances in Marine Biotechnology*. Oxford & IBH publishing Co. Pvt. Ltd., Delhi, 382pp
- Fusetani N. 2000. *Drugs from Sea*. Karger Publ.
- Gopakumar K. (Ed.) 2002. *Text Book of Fish Processing Technology*. ICAR
- Huss HH, Jakobsen M & Liston J. 1991. *Quality Assurance in the Fish Industry*. Elsevier.
- Lakra WS, Abidi SAH, Mukherjee SC &Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.
- Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.
- Nagabhushanam R, Diwan AD, Zahurnec BJ &Sarojini R. 2004. *Biotechnology of Aquatic Animals*. Science Publ.
- Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes.
- Ninawe A. S &Khedkar G D, 2009. *Nutrition in Aquaculture*. Narendra Publishing house, Delhi
- Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.
- Reddy PVGK, Ayyappan S, Thampy DM &Gopalakrishna. 2005. *Text Book of Fish Genetics and Biotechnology*. ICAR.
- Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.
- Venugopal V. 2006. *Seafood Processing*. Taylor & Francis.
- Vincent K &Omachonu JER. 2004. *Principles of Total Quality*. CRC Press.
- Zeathen P. 1984. *Thermal Processing and Quality of Foods*. Elsevier.
- Training Programme on Seafood quality Assurance*. Central Institute of Fisheries Technology (ICAR).
- Quality Assurance in seafood processing*, 2000. Published by CIFT and Society of Fisheries Technology.

PRACTICAL 4

FISHERY SCIENCE: METHODS & APPROACHES

180 Hours (10 hrs/week)

(Credit – 4)

Taxonomy

Study of distinguishing features (morphometric and meristic)

- Identification of bony and cartilaginous fishes using manuals (marine and freshwater – any 10 fishes)
- Identification and classification of distinguishing features of commercially important shell fishes (crustaceans and molluscs – any 5 shell fishes)

Anatomy

54 Hrs

Study of anatomy of a teleost fish

- Studies on gills, scales, pharyngeal teeth and brain of fishes (Mounting and/or spotters)
- Dissection and display of
 - Digestive system, (Minor)
 - Urinogenital system (Minor)
 - Swim bladder (Minor)
 - Weberian ossicles, (Minor)
 - Branchial Blood vessels and Blood supply to air breathing organs
 - Cranial nerves – V, VII, X
- Study of skeletal system – skull and vertebrae

Physiology

36 Hrs

- Determination of haemoglobin content in fish blood
- Identification of blood cells in teleost fish
- Determination of the rate of ammonia excretion in fish
- Estimation of total protein in fish muscles
- Identification of amino acids in fish muscles by TLC

Fishery biology

36

Hrs.

- Study of feeding habits of fish through qualitative and quantitative analysis of gut contents of herbivore, carnivore and omnivore species.
- Determination of gonadosomatic index
- Estimation of fecundity
- Measurement of ova diameter
- Length – weight relationship

Fishery technology

18 Hrs.

- Fishing crafts and gears –
- identification of various components of a mechanized fishing craft from actual specimen/model/drawing (Inland and Marine)
- Study of principal types of fishing gears from actual specimen/model/drawing
- Identification of fishing gear materials: twine, ropes, floats, sinkers, buoys and anchors.
- Identification of fishery by-products
- Formulation and preparation of artificial fish food

Fishery Resources

18 Hrs.

- Identification of exotic and indigenous aquarium fishes (any 10 fishes)
- Setting up an aquarium tank – fresh water
- Identification of aquarium plants (any 5)
- Breeding trials on selected aquarium fishes: Breeding and rearing of any three ornamental fishes (one each from live bearer, egg scatterer and bubble nest builder)
- Collection and identification of aquatic weeds and aquatic insects.
- Identification of pathogenic organism or parasites
- Treatment of fish diseases

Group activity

18 Hrs.

- Setting up a freshwater aquarium by 4 or 5 students (Individual evaluation during practical).

Field work and study tour

- Two to three days tour to study various fishery activities at selected centres/sites. Visit to a fish seed production farm. Fresh water and brackish water aquaculture. Fishing operations, fish landing centres, packing, and transport. Fish preservation and processing chain. Boat building yard and net making plant. CMFRI, CIFT, CIFNET, NIFPHATT, NIO, KUFOS.
- Report the study conducted and submit a 10 page write up/printout giving dates, methodology, results and references including photographs of the field study.
- Viva