



Fatima Mata National College
(Autonomous)
Kollam

Scheme & Syllabus of
Post Graduate Degree in Zoology
2019 Admission Onwards

Course structure, Scheme of Instruction & Evaluation

Semester I						
Course Code	Course Title	Instructional Hours per Week		Duration of ESE Exam	Evaluation	
		T	P		CE	ESE
19PZO11	Biosystematics, Taxonomy and Evolutionary Biology	5		3 Hrs	25%	75%
19PZO12	Biochemistry	5		3 Hrs	25%	75%
19PZO13	Biophysics, Instrumentation and Computer Science	5		3 Hrs	25%	75%
19PZO14	Practical I		10			
Semester II						
Course Code	Course Title	Instructional Hours per Week		Duration of ESE Exam	Evaluation	
		T	P		CE	ESE
19PZO21	Advanced Physiology and Functional Anatomy	5		3 Hrs	25%	75%
19PZO22	Genetics, Quantitative Analysis and Research Methodology	5		3 Hrs	25%	75%
19PZO23	Cell Biology, Molecular Biology and Bioinformatics	5		3 Hrs	25%	75%
19PZO14	Practical I			4 Hrs	25%	75%
19PZO24	Practical II		10	4 Hrs	25%	75%
Semester III						
Course Code	Course Title	Instructional Hours per Week		Duration of ESE Exam	Evaluation	
		T	P		CE	ESE
19PZO31	Microbiology & Biotechnology	5		3 Hrs	25%	75%
19PZO32	Ecology, Ethology and Biodiversity Conservation	5		3 Hrs	25%	75%
19PZO33	Immunology and Developmental Biology	5		3 Hrs	25%	75%
19PZO34	Practical III		10			
Semester IV						
Course Code	Course Title	Instructional Hours per Week		Duration of ESE Exam	Evaluation	
		T	P		CE	ESE
19PZO41	Ichthyology	8		3 Hrs	25%	75%
19PZO42	Fisheries and Aquaculture	7		3 Hrs	25%	75%
19PZO34	Practical III			3 Hrs	25%	75%
19PZO43	Special Paper- Practical I		5	4 Hrs	25%	75%
19PZO44	Special Paper- Practical II		5	4 Hrs	25%	75%
19PZO45	Project					100%
19PZO46	Comprehensive Viva-Voce					100%

SEMESTER-I

19PZO11: BIOSYSTEMATICS, TAXONOMY AND EVOLUTIONARY BIOLOGY

Total hours: 100

Course outcome:

CO1: To have a thorough understanding of basic concepts of biosystematics and taxonomy

CO2: To familiarize students with the various taxonomic tools and techniques including online tools.

CO3: To understand cosmic evolution and origin of life.

CO4: To have an in-depth understanding of biochemical, genomic and molecular evolutionary aspects.

CO5: To have an insight into origin of higher categories.

Module 1. Definition and basic concepts of Biosystematics and taxonomy (5 hrs)

1.1. Historical resume of Biosystematics

1.2. Importance and application of Biosystematics in biology

1.3. Material basis of Systematics

Module 2. Taxonomic tools and techniques (18 hrs)

2.1 Taxonomic Procedures-collection, preservation with special reference to taxidermy, curation and process of identification. (self-study).

2.2 Online taxonomic tools- concepts and applications, Royal BC Museum, GIS, GPS, WikIT

2.3 Taxonomic characters of different kinds- quantitative and qualitative analysis of variation, process of typification, different zoological types (holotype, paratype etc) and their significance.

2.4 Taxonomic keys- different kinds of taxonomic keys, their merits and demerits.

2.4 Systematic publications- preparation of taxonomic publications.

2.5 International code of zoological nomenclature, its operative principles. Interpretation and application of important rules.

2.6 Zoological nomenclature-formation of scientific norms of various taxa (Homonymy & Synonymy)

Module 3. Taxonomic characters and dimensions of speciation (15 hrs)

3.1 Taxonomic characters- different kinds, origin of reproductive isolation, mechanism genetic incompatibility

3.2 Speciation, Dimensions of speciation- types of lineage changes. Production of additional lineages.

3.3 Species concept- species category, different species concepts, sub species and other intra specific categories, hierarchy of categories

3.4 Evolution of Biodiversity Indices- Shannon Weiner index, Dominance index

Module 4. Trends in Systematics (12 hrs)

4.1 Chemotaxonomy, Cytotaxonomy, Molecular Taxonomy, Micro and Macro taxonomy.

4.2 Recent trends based on proteomics and genomics.

4.3 DNA bar coding.

4.4 Phylogeny in systematic -phylogenetic taxonomy including incorporation of fossils; Phylocode (BDM).

Evolutionary Biology (50 Hrs)

Module 5. Cosmic evolution and origin of life (5 hrs)

5.1 Cosmic evolution: origin of the universe, matter-time-space continuum. Theory of oscillating universe. Origin of galaxies, stellar systems, planets and earth 5.2 Origin of life -Physical basis of life, extra terrestrial life.

Module 6. Molecular evolution (15 hrs)

6.1. Ancient DNA, Gene evolution

6.2. Evolution of gene families, phylogenomics; evo-devo (BDM,) molecular drive

6.3. Amino acid sequence divergence in proteins

6.4. Nucleotide sequence divergence in DNA.

Module 7. Biochemical and genomic evolution (15 hrs)

7.1. The evolutionary history of proteins and concepts of molecular clock

7.2. Outline of origin of prokaryotic and eukaryotic genomes

7.3. The C Value paradox

7.4. Evolutionary history of neural integration

7.5. Evolution of endocrine systems, Hormones and evolution

Module 8. Origin of Higher categories

(15 hrs)

8.1. Theories of Evolution, Lamarckism, Darwinism (self-study). Origin of metazoan, Origin, evolution and extinction of Trilobite.

8.2. Phylogenetic gradualism and punctuated equilibrium, Micro and macro evolution (self-study).

8.3. Origin and evolution of vertebrate groups – Pisces, Amphibia, Reptilia, Aves and mammals.

8.4. Stages in Primate Evolution - Prosimii, Anthroproidea and Hominids. Factors in human origin-Hominid fossils. (Self-study).

8.5. Cytogenetic and Molecular basis of origin of man-African origin of modern man- Mitochondria Eve, Y chromosomal Adam, - early migration, hunter-gatherer societies.

8.6. Evolution of human brain- communication, speech and language, Evolution of culture.

References

- A Functional Evolutionary Approach. Thomson/Cole, Singapore
- Alfred J.R.B and Ramakrishna.2004. Collection, Preservation and Identification of Animals. Zoological Survey of India Publications.
- Arthur,W. 2011. Evolution — A Developmental Approach. Wiley-Blackwell, Oxford,UK Benton,M.J.2005 (3rd edn). Vertebrate Paleontology. Blackwell Publishing Com.Oxford,Uk
- B.K and Hallgrimsson, B. 2008. Strickberger’s Evolution (4th edn). Jones and Bartlett Pub.London, UK
- Benjamin Cummings Publ. NY, USA David, M.H, Craig Moritz and K.M. Barbara 1996. Molecular Systematics. Sinauer Associates, Inc.
- Benton, M.J.2005 (3rd edn) Vertebrate Paleontology. Blackwell Publishing Com.Oxford, UK Campbell, N.A and J.B. Reece 2009. Biology (8th edn).
- Birkhauser, Basel, Switzerland Strickberger, M.W. 2005. Evolution. Jones and Bartlett Publishers, London.
- 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
- Carroll, SB. 2005. Endless Forms Most Beautiful: The New Science of Evo-Devo. WW Norton, New York
- Charles W. Fox and Janson B.Wolf . 2006. Evolutionary Genetics-Concepts and Case Studies. Oxford University Press, NY. USA
- Cleveland P.Hickman, Jr., Larry S. Roberts and Allan Larson. 2001. Integrated Principles of Zoology.(11th edn). McGraw-Hill, NY, USA
- Darwin, C.D. 1859. On the Origin of Species by Means of Natural Selection
- Elliott, Sober.2008. Evidences and Evolution: The logic behind the science. Cambridge University Press,UK
- Functional Evolutionary Approach. Thomson/Cole, Singapore
- Futuyma, D.J.1986. Evolutionary Biology .Sinauer Associates Inc. MA, USA
- Gould, S, J. 2002. The Structure of Evolutionary Theory. Harvard University Press, MA, USA Hall,
- Hall, B.K. and Olsen, W. M., (Ed). 2007. Key Words and Concepts in Evolutionary Developmental Biology. Discovery Publishing House, New Delhi
- Hall, B.K., Pearson, R. and Muller, G.B. 2003. Environment, Evolution andDevelopment: Toward a Synthesis. MIT Press,Cambridge MA, USA
- Hickman Jr. Cleveland, Larry Roberts, Susan Keen, Allan Larson, David Eisenhour 2011. Animal Diversity. McGraw-Hill Companies, Inc. NY
- John Murray, London. Dan, G. and Li,W.H. 2000. Fundamentals of Molecular Evolution. (2nd edn). Sinauer Associates Inc. MA, USA
- Kapoor, V.C. 1991 Theory and Practice of Animal Taxonomy. Oxford and IBH Publishing Co Pvt. Ltd. New Delhi.
- Kimura,M . 1983. The neutral theory of molecular evolution.Cambridge University Press • Margulis, L and Michael J. C.1998. Kingdoms & Domains: An Illustrated Guide to the Phyla of Life on Earth (4th edn). W. H. Freeman and Company,USA
- Margulis, Lynn and M.J. Chapman (4th edn) Kingdoms and Domains: An Illustrated Guide to the Phyla of Life on Earth. W.H.Freeman & Company, USA

- Mayr, E.1967. This is Biology: The Science of Living world. Universities Press Ltd.
- Mayr, E.1969. Principles of Systematic Zoology. McGraw Hill Book Company Inc., NY.
- Narendran, T.C. 2008. An introduction to Taxonomy. Zoological survey of India.
- Niles Eldredge.2000.Life on earth: an encyclopedia of biodiversity, ecology and evolution (V ol.1&I1). ABC-CLIO,Inc.CA,USA
- Pat Willmer. 1996. Invertebrate Relationships-patterns in animal evolution. Cambridge University Press
- Richard E. M and Levin, R B.1988. The Evolution of sex: an examination of current ideas. Sinauer Associates Inc. MA, USA
- Rupert E.Edward., R.S.Fox and R.D.Barnes.2006.Invertebrate Zoology:
- Rupert E.Edward., R.S.Fox and R.D.Barnes.2006. Invertebrate Zoology:
- Stearns C.S.1987. The evolution of sex and its consequences.
- Waterman.A.J.1971. Chordate Structure and Function. Macmillan Co. London
- Web Resources- <http://www.talkorigins.org> , <http://www.ucmp.berkeley.edu> , <http://www.academicearth.org>
- West- Eberhard M.J. 2003. Developmental Plasticity and Evolution. Oxford University Press, Oxford, UK
- Winston, J.E.2000. Describing species: Practical taxonomic procedures for biologists. Columbia University Press, Columbia
- Young, J.Z. 1950. Life of Vertebrates. Clarendon Press, Oxford,UK

MODEL QUESTION PAPER

19PZO11: BIOSYSTEMATICS, TAXONOMY AND EVOLUTIONARY BIOLOGY

Time: 3 hrs

Max.Marks: 75

I. Answer any TEN of the following questions. Each question carries two marks.

1. What is Gradualism?
2. Write a note on Macro evolution.
3. What is C value paradox?
4. What do you mean by Barcode of life?
5. Define species.
6. What is mitochondrial eve?
7. Write on Neanderthal man.
8. What is curation?
9. Illustrate monophyly with the help of an example.
10. What is a phylocode?
11. What does the theory of the oscillating universe state?
12. What is Molecular clock?
13. Write a note on Chemotaxonomy.
14. What is meant by genetic Incompatibility?
15. What are Demes?

(10 x2 =20)

II. Answer any SIX of the following . Each question carries four marks.

16. Write a note on ancient DNA.
17. Distinguish between Darwinism and Lamarckism.
18. Explain taxonomic key briefly.
19. Comment on extra terrestrial life.
20. Comment on the Big Bang Theory.
21. Discuss the duplication of genes.
22. Briefly discuss multigene family.
23. Briefly explain Proteomics,
24. Describe allopatric speciation.
25. Explain Shannon Weiner Index.

(6x4 =24)

III. Answer any THREE of the following. Each question carries seven marks.

26. Elaborate on the applications of systematics in our life.
27. Discuss the evolution of the Endocrine system.
28. Briefly explain the molecular evolution of haemoglobin in vertebrates.
29. Describe the organization of prokaryotic and eukaryote genome.
30. Elucidate the procedure for taxonomic publication.

(3X7=21)

IV. Answer any ONE of the following. The question carries 10 marks.

31. Elaborate on the evolution of gene families.
32. Discuss Molecular Taxonomy.

(1x10=10)

19PZO12: BIOCHEMISTRY

Total hours: 100

Course outcome:

- CO1: To understand the various biomolecules structure and function.
CO2: To have an insight into abnormal biomolecules and its role in health and disease
CO3: An in-depth understanding of energy metabolism and energy requirements.
CO4: To have a thorough understanding of stress and detoxification mechanism.
CO5: To familiarize the concept of clinical biochemistry.

Module 1. Introduction

(12hrs)

- 1.1 Forces underlying Bimolecular Interactions covalent and - electrovalent bonds, ionic bond, hydrogen bond, Glycosidic bond, ester bond, peptide bond, Phosphodiester bond.
- 1.2 Water: Biological importance, pH and Acid - base balance. Buffers Biological Importance.
- 1.3 Unique solvent properties, electrolytic dissociation in to cations and anions, Henderson- Hasselbalch equation
- 1.4. Nano particales
- 1.5 Biomaterial

Module 2. Carbohydrates

(12hrs)

- 2.1 Classification
- 2.2 Monosaccharide: Biological Importance (**Self Study**) Structural representations of Sugars; Acetal and hemi acetal, ketal an hemiketal linkages Glucose,fructose, galactose mannose and ribose.Isomerism structural isomerism and stereoisomerism,optical isomerism Epimerism and Anomerism.
- 2.3 Reactions Monosaccharide:Oxidation,reduction,esterformation,Qsazone Formation.
- 2.4 Disaccharides: Sucrose, Lactose~maltose, Isomaltose, Cellobiose and Trealose (**Self Study**)
- 2.5 Polysaccharides:Homo polysaccharides- Starch, glycogen, cellulose,chitin, Dextrans, Inulin, Pectin. Heteropolysaccharides- Hyaluronicacidheparin chondroitinsulphate, Keratansulphate, Dermatansulphateand Agaragar.Glycoproteins & Mucoproteins.

Module 3. Proteins

(10hrs)

- 3.1 Amino acids: Structure, classification and properties of aminoacids.pK Value and iso- Electric Point of amino acids. Peptide and peptide synthesis. Reactions due to carboxyl Group, amino group and side cains Colour reaction of aminoacids and proteins
- 3.2 Proteins - structure and Classification-Primary structure of protein (eg. insulin), Secondary structure- Alpha helix, Collagenhelix, Beta pleated sheet, Ramachandran angles and Ramachandran map.
- 3.3 Fibrous proteins-examples (Keratin, Collagen, Elastin, Resilin, Fibrous muscle proteins) Chaperons.
- 3.4 Tertiary structure – Globular protein – eg. Myoglobin, Quaternary structure – eg. Haemoglobin
- 3.5. Tissue protein in health and diseases, - Collagen, structure and synthesis, abnormal collagens, elastin, keratins, muscle proteins, lens proteins and cataract.

Module 4. Lipids (10 hrs)

4.1 Classification of Lipids: Simple, Compounds and derived Lipids. Biological importance of Lipids.

4.2 Fatty acids: Classification, nomenclature. (Self-study)

4.3 Simple fats: Triacylglycerol (Triacylglycerides) – physical properties, Reactions - Hydrolysis, Saponification, Rancidity. Acid number, Saponification number, Iodine number oxidation, Ketosis, Reichert-Meissl-Wollny value

4.4 Compound lipids: Phospholipids - Lecithin, Phosphatidyl inositol, Cephalins Plasmalogens. Glycolipids, Sphingolipids.

4.5 Steroids: Biologically important steroids-cholesterol, Vitamin D, Bile acids, Ergosterol, Terpenes. Prostaglandins- Structure, types, synthesis and functions.

4.6 Lipoproteins

Module 5. Nucleic Acids (8hrs)

5.1 Structure of nucleic acids and nucleotides: Structural organization of DNA (Watson –Crick model) Characteristic features of A, B, C and Z DNA. Structural organization of t RNA and microRNA stability of proteins and nucleic acids.

5.2. Protein-nucleic acid interactions. Electrostatic interaction, hydrogen bonding stacking interactions. (Self-study).

5.3. DNA binding proteins- DNA regulatory proteins, folding motifs, finger motifs, Zipper motifs, Helix turn motifs, Leucine zipper motifs conformation flexibilities.

5.1.4 Biological roles of nucleotides and nucleic acids.

Module 6. Enzymes (10 hrs)

6.1 Classification- (I.U .B. system) co -enzymes; iso-enzymes specificity.

6.2 Mechanism of action of enzymes. Formation of enzyme substrate complex. Various theories. **(Self study)**

6.3. Enzyme kinetics: Michaelis-Menten equation. Km value and its significance. Enzyme velocity and factors influencing enzyme velocity. Enzyme inhibition-inhibition and feedback inhibition.

6.4. Enzyme regulation: Types of regulation, Allosteric regulations- Key enzymes, modification. Covalent Modification.

Module 7. Carbohydrate Metabolism (10 hrs)

7.1 Major metabolic pathways: Glycolysis- Fate of pyruvate. Citric acid cycle and its significance; Oxidative & substrate level phosphorylation. Pentose phosphate pathway (self-study).

Gluconeogenesis, Cori cycle.

7.3 Glycogen metabolism: Glycogenesis, Calmodulin- sensitive phosphorylase.

Glycogenolysis, adenylate cascade. System Ca⁺} kinase Regulation of glycogen synthesis.

Module 8. Metabolism of Proteins, Amino acids and nucleic acids (10 hrs)

8.1 Amino acid metabolism: Deamination, Transamination and Trans deamination, decarboxylation, Formation and disposal of ammonia. Urea cycle. **(Self-study)**

8.2 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. Catabolism of purines and pyrimidines Heme synthesis and break down- Structure, biosynthesis, porphyrins, bilirubin metabolism, plasma bilirubin, jaundice.

Module: 9 Metabolism of Lipids (6 hrs)

Beta oxidation, alpha oxidation and omega oxidation of fatty acids.

Formation of ketone bodies, ketosis and keto acidosis

De novo synthesis of fatty acids and fatty acid metabolism

Biosynthesis and regulation of cholesterol, Metabolism of cholesterol.

Metabolism of Triglycerides

Module 10. Energy metabolism (5 hrs)

10.1. Principles of energy, energy transduction, high energy compounds, standard free energy of hydrolysis of ATP. Mitochondria - ultrastructure, electron transport chain, components and different complexes in detail. Mobile electron carriers. Proton transport during electron flow, inhibitors of electron transport chain.

10.2 Mitochondrial electron transporters and shuttle systems. Functions of ATP, substrate level phosphorylation,

oxidative phosphorylation - mechanisms - energy coupling, chemical and chemiosmosis, conformational coupling, inhibitors and uncouples, control of oxidative phosphorylation.

Module 11. Oxidative stress and Antioxidants

(4 hrs)

11.1 Formation of toxic compounds and detoxification- oxidation, reduction, hydrolysis and conjugation.

11.2 Free radicals: definition, formation in biological Systems.

11.3 Natural anti-oxidants, defense against free radicals. Role of free radicals and antioxidants in health and disease.

11.4 Determination of free radicals, lipid peroxides and antioxidants.

11.5 Antioxidant enzymes and their role.

Module 12. Clinical Biochemistry

(3 hrs)

12.1 Introduction to Clinical Biochemistry

12.2 Analysis of body fluids: Urine: Normal composition of urine –Abnormal constituents – glucose, albumin, ketone bodies, variations in urea, creatinine, pigments and their clinical significance in brief.

12.3 Blood: Normal constituents of blood and their variation in pathological conditions.

References

- Creighton, T.E. Protein Structure and Molecular Properties. W.H. Freeman & Co, NY
- Deb, A.C.2004. Fundamentals of Biochemistry. New Central Book Agency (P) Ltd. New Delhi
- Elliott, W.H & .C. Elliott. 2003. Biochemistry & Molecular Biology. Oxford University Press, UK
- Eric E. Conn, Paul K. Stumpf, George Bruening, Roy H. Doi. 2007. Outlines of Biochemistry. (5th edn.) John Wiley & Sons, Inc.
- Garret, R.H. and C.M. Grisham. 1995. Biochemistry. Saunders College Publishers
- Lehninger., A.L. 2008. Principles of Biochemistry. (5th edn). CBS publishers & distributors, Delhi
- Hanes; B. D. and N.M.-Hooper. 1998. Instant notes: Biochemistry. University of Leeds, UK-
- Horton, H.R., MOi-san, L.A., Scrimgeour, K.G .,Perry, M:13 and J.D.Rawn. 2006. Principles of Biochemistry,Pearson Educations, International, New Delhi
- Jermy M. Berg, John”, Tymoczko, Lubert Stryer, 2012, Biochemistry. W H Freeman –
- 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. - 13 - (25th edn). McGraw Hill, New York
- Oser, B.L.1965. Hawk's Physiological Biochemistry. Mc Graw Hill Book Co
- Palmer Trevor.2001.Enzymes: Biochemistry, Biotechnology & Clinical chemistry. HorwoodPubl .com. England
- Rama Rao, A.V.S.S. 1986. Text Book of Biochemistry. L.K. & S Publishers
- Stayer, L. (latest) Biochemistry. II edition, W.H. Freeman & Co. NY
- Vasudevan, D.M. and S.Sreekumar. 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.

MODEL QUESTION PAPER 19PZO12: BIOCHEMISTRY

TIME 3 HRS

MAX MARKS 75

I. Write short notes on any ten of the following. Each question carries two marks

1. What are biomolecules?
2. What are isomers?
3. Define deamination.
4. Define Km value.
5. What is meant by micro RNA?
6. Define chaperons.
7. Write on electrostatic bonding.

8. What are reslins?
9. What is meant by isoelectric point?
10. What is rancidity?
11. What is meant by saponification?
12. What are zipper motifs?
13. What is plasma bilirubin?
14. Define antioxidants.
15. What is meant by detoxification?

10X2=20 marks

II. Answer any six of the following. Each question carries 4 marks

16. Discuss on Ramachandran map.
17. Write on colour reaction of amino acids.
18. What are the biological importance of water?
19. Write on Henderson- Hasselbalch equation.
20. Discuss on the ester formation of monosaccharide.
21. Write on the structure and function of vitamin D.
22. What are the factors influencing enzyme velocity?
23. Differentiate between ketosis and ketoacidosis.
24. Comment on energy coupling.
25. Discuss on functions of ATP

6X4=24 marks

III. Answer any three of the following. Each question carries 7 marks

26. Write on the role of free radicals in health and disease.
27. Explain on the mitochondrial electron transporters and shuttle system.
28. Comment on DNA binding proteins.
29. Explain cori cycle.
30. Write a short note on Watson and Crick model.

3X7=21 marks

IV. Answer any one. Each question carries 10 marks

31. Write an essay on enzyme regulation.
32. Discuss on the abnormal and normal constituents of urine.

1X10=10 marks

19PZO13: BIOPHYSICS, INSTRUMENTATION AND COMPUTER SCIENCE

Total hours: 100

Course Outcome:

- CO1: To familiarize the concepts of thermodynamics and electromagnetic spectrum.
 CO2: To understand the development of nanotechnology and its applications.
 CO3: To have a thorough exposure to various instruments used in biological research.
 CO4: To understand the evolution of computers in different generations.
 CO5: To provide the basic knowledge about the functional units of computer system
 CO6: To familiarize the operating system and network.

BIOPHYSICS

(25hrs)

Module 1. Thermodynamics

(5 hrs)

- 1.1. Introduction- Concept of energy and laws of Thermodynamics.
- 1.2. Matter and energy-Life as an energy system-order, disorder, Entropy, Enthalpy.
- 1.3. Photo bioenergetics: Photosynthesis — light and dark reactions, Redox couple and redox potential
- 1.4 Chemo-bioenergetics: electron transport and oxidative phosphorylation, Chemi- osmotic theory and binding change mechanism of ATP synthesis. .
- 1.5 Life as an autocatalytic system.

Module 2. Electromagnetic spectrum	(4 hrs)
2.1. Cosmic radiation, Gamma radiation, visible spectrum, Infrared SN”rays, microwaves and radio waves.	
2.2. Biological applications	
Module 3. Radiation Biophysics	(12 hrs)
3.1. Radioactivity, Detection and measurement of radiation	
3.2. Radio-labelling methods, - detection and measurement of different types of radioisotopes and their applications in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material and safety guide lines, Ionizing radiation and induced mutations	
3.3. Fluorescence	
3.4. Nuclear medicine-[Internally administered radioisotopes. Radioiodine in thyroid function analysis. Renal, liver and lung function analysis.	
3.5 Radio Pharmaceuticals – Properties of ideal diagnostics and therapeutic radio pharmaceuticals	
3.6 Mechanism of localization of radio pharmaceuticals	
Module 4. Nanotechnology	(4 hrs)
4.1. Introduction to Nano biology	
4.2. Nano sensors and Nano medicines.	
INSTRUMENTATION	(50 hrs)
Module 5. Methodology and working of microscopes	(20 hrs)
5.1. Differential interference contrast microscope, Laser microscope, Multiphoton excitation microscope, structured illumination microscope.	
5.2. Total internal reflection fluorescence microscope.	
5.3. Electron microscope- SEM and TEM, different fixation techniques for EM, Freeze etc. and freeze fracture methods for EM, Atomic Force Microscope (AFM), Scanning Near field optical Microscope (SNOM)	
5.4. Laser scan confocal microscope	
5.5. FTIR	
Module 6. Centrifugation	(4 hrs)
6.1. Ordinary, high speed centrifuges.	
6.2. Density gradient centrifugation	
6.3. Ultracentrifugation	
Module 7. Electrophoresis	(7 hrs)
7.1. Principles.	
7.2. Gel electrophoresis- SDS PAGE, Agarose Gel Electrophoresis.	
7.3. High voltage electrophoresis.	
7.4. Immuno electrophoresis- principle and application.	
Module 8. Chromatography	(4 hrs)
8.1. Principles	
8.2. Column chromatography, Ion exchange chromatography, HPLC, Gas chromatography	
Module 9. Biophysical methods	(15 hrs)
9.1. Colorimeter, spectrophotometer, flame photometer (self-study)	
9.2. Atomic absorption spectrophotometer, fluorescent spectrometer	
9.3. Infra-red spectrophotometer, NMR and EMR spectroscopy, Different types of Mass spectrometry and surface plasma resonance methods	
9.4. Molecular analysis using UV /visible light, fluorescence, circular dichroism,	
9.5. Molecular structure determination using X ray diffraction –	
9.6. Electrophysiological methods- simple neuron recording, patch clamp recording, ECG, Brain activity recording (EEG), Lesions and stimulation of brain, pharmacological testing, PET (Positron emission tomography), MRI, FMRI, CAT scanning methods	

COMPUTER SCIENCE (25 hrs)

Module 10. Introduction to computers (self-study)

- 10.1. Basic organization of a computer- hard ware and software,
- 10.2. Hardware-input output devises, processor Modules, storing, controlling
- 10.3. Characteristics of computers

Module 11. Computer generations (6 hrs)

- 11.1. Classification -first to 5th generation (Self-study)
- 11.2. Notebook, laptops, PCs, workstations, mainframe system, Supercomputers, client and server computers, hand held computers, tablet PC, PDA, pocket PC, smart phone.
 - 11.2.1. Artificial intelligence
- 11.3. Number systems binary, octan, hexadecimal

Module 12. Software (4 hrs)

- Relationship between hard ware &software, system software & application soft ware
- 12.2 Acquiring software - buying, pre written software, ordering customized software, developing customized software, down loading public domain soft ware, software development steps- firmware, and middle ware

Module 13. Operating systems (4 hrs)

- 13.1. Windows, DOS, Linux (self-study)
- 13.2. Concept of free software

Module 14. Computer Programming (4 hrs)

- 14.1. Low level languages
- 14.2. High level languages
 - 14.2.1. Programming language C++

Module 15. Computer- and Communications (2 hrs)

- 15.1. LAN (local area net Work) WAN (wide area network, MAN (Metropolitan area network)
- 15.2. Internet, email, www, social network groups etc.

Module 16. System Maintenance (5 hrs)

Installation - Operating System, CD-ROM Drive, Sound Card, printer, Control panel -Display properties, Adding and removing software, setting date and time, screen saver, appearance. Antivirus installation, Formatting, Disk clean up, Disk defragmenter. Configure and Connect Dial-Up Networking, Configure a Peer-to-Peer Network, Writing data on disc- CD/DVD Burning, Customize the Windows Desktop, Use Files and Folders Core.

References

- Ackerman, E. 1962. *Biophysical Science*. Prentice hall Inc.
- Alonso, A., and Arrondo, J.L.R.2006. *Advanced Techniques in Biophysics*. Springer
- Arora, M. P. 2007. *Biophysics*. Himalaya Publishing House
- Baker, E.J. and Silyerton R.E. 1978. *Introduction to Medical Laboratory Technology*. ELBS.
- Das, D. 1991. *Biophysics and Biophysical Chemistry*. Academic Publishers, Calcutta Edward, A.L. 1997. *Radiation Biophysics*. Academic Press, NY
- Ernster, L. (Ed.). 1985. *Bioenergetics*. Elsvier, NewYork
- 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. Lehninger, A.L.1971. *Bioenergetics*. W.A. Benjamin, London
- Narayanan, P. 2000. *Essentials of Biophysics*. New Age International (P) Ltd. Publishers, New Delhi.
- Nicholls, D.G. And Ferguson S J (1992)*Bioenergetics*, Academic press Newyork
- 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 Delhi Varghese,

- T. and Balakrishna, K.M. 2012. *Nanotechnology-An Introduction to Synthesis, Properties and Applications of Nanomaterials*. Atlantic Publishers and Distributors
- Weesner, F.M. 1960. *General—Zoological Microtechniques*. The Williams & Wilkins Co., Baltimore.

MODEL QUESTION PAPER

18PZO13 : Biophysics, Instrumentation & Computer Science

Time: 3hrs

Total Marks:75

I. Write short notes on any TEN of the following: (Each question carries 2 marks)

1. What do you mean by Magnification of a Microscope?
2. What is Isoelectric point?
3. What is OCTAL number system?
4. Comment on colorimeter.
5. Explain social network groups
6. Comment on nuclear medicine.
7. Differentiate between low level and high level languages.
8. Describe Nano medicines.
9. Comment on entropy.
10. Explain RF Value.
11. What are microwaves?
12. Comment on Cache memory.
13. Comment on Infrared SN² rays
14. Comment on WINDOWS and DOS.
15. Explain Half life period.

(10×2=20 marks)

II. Answer any SIX of the following. Each question carries 4 marks.

16. What is Resolving power of a Microscope?
17. Write short notes on any three output devices.
18. Explain Chemiosmotic hypothesis.
19. Briefly explain gas chromatography.
20. Describe Polarization microscopy.
21. Explain CAT scanning.
22. Write a note on the medical applications of X –rays.
23. Explain SDS page and its applications.
24. Describe SNOM.
25. Comment on radio Pharmaceuticals

(6X4=24 marks)

III. Answer ANY three of the following. Each question carries 7 marks.

26. Explain the Principle of Electron Microscope? Write a detailed account of Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM).
27. Describe the Principle of FTIR? Comment on its applications.
28. Briefly explain the principle and working of HPLC.
29. Discuss the applications of radioisotopes in biology.
30. Discuss electron transport and oxidative phosphorylation.

(3×7=21 marks)

IV. Answer ONE of the following. Each question carries 10 marks.

31. Describe in detail the recent advancements in nanotechnology.
32. Elaborate the principle and types of centrifugation techniques.

(1×10=10 marks)

PRACTICAL I

19PZO14: SYSTEMATICS, EVOLUTIONARY BIOLOGY, BIOCHEMISTRY, BIOPHYSICS, INSTRUMENTATION AND COMPUTER APPLICATION

A. Systematics and Evolutionary Biology

1. Collection and identification of the following using standard keys: -
 - a. Insects (5 nos.)
 - b. Prawn (2 nos.)
 - c. Crab (2 nos.)
 - d. Fishes (5 nos.)
2. Study of preservation media and tools and materials for taxidermy
3. Comparative study of prokaryotic and eukaryotic cells by staining and mounting with reference to evolutionary significance
4. Study of Phylogenetic tree/ or study of homology and analogy
5. Study on the reduction in regeneration capability of animals during evolution
6. Pattern of evolution from museum study

B. Biochemistry

1. Titration curve of acetic acid. Titration of a measured volume of acetic acid with sodium hydroxide (NaOH) to determine the amount of acid in the given solution and pKa of acetic acid.
2. Extraction and purification of DNA and RNA from animal tissue.
3. Estimation of glycogen of a tissue
4. Estimation of blood glucose by Anthrone method.
5. Estimation of Serum/ tissue protein by Lowry method
6. Determination of acid value of the given fat
7. Estimation of Cholesterol in blood by spectrophotometer
8. Determination of enzyme activity Acid/ alkaline phosphatase from a biological sample
9. Estimation of inorganic phosphate
10. Determination of the Michaelis constant (KM value) for the digestion of casein by trypsin
11. Estimation of amino acid tyrosine
12. Pesticide residue analysis of vegetable/water using TLC

C. Biophysics, Instrumentation and computer Application

1. Micrometry: Measurement of microscopic objects using micrometer
2. Isolation of mitochondria from fish liver by differential centrifugation
3. Determination of molecular mass of proteins/ nucleic acid by SDS-PAGE/Agarose gel.
4. Sketching of biological specimens using Camera Lucida

COMPUTER SCIENCE

1. Preparation of tables and bar diagrams using suitable softwares from the data provided.

References

- Hardd Varley - Practical clinical Biochemistry
- Ranjana Chawla, - Practical Clinical Biochemistry - Methods and interpretations.
- Hawk's Practical Physiological Chemistry.
- Jayaraman, Practical Biochemistry.

SEMESTER – II

19PZO21: ADVANCED PHYSIOLOGY AND FUNCTIONAL ANATOMY

Total hours: 100

Course outcome:

CO1: To understand in depth physiological aspects of nutrition, movement, circulation, nervous, coordination, respiration, excretion and reproduction.

CO2: To have a comprehensive view of endocrinology in relation to hormonal imbalances and disorders.

CO3: To understand students with fundamental concepts of stress physiology.

CO4: To have a conceptual exposure to sports physiology.

Module 1. Introduction (self-study)

1.1 An overview of Physiology and Anatomy.

1.2 Fluids in the cell environment

1.3 Resistance of the cell to acidity and alkalinity

Module 2. Support and Movement

(10hrs)

2.1. Cellular movements, Cytoskeleton, Hydrostatic skeleton

2.2. Terrestrial, aquatic and aerial locomotion

2.3. Muscular skeletal system - Bones and muscles- structure and its role in locomotion with reference to humans.

2.4. Catch muscle and Fibrillar muscle, Clinical implications.

Module 3. Nutrition

(10 hrs)

3.1. Feeding mechanism in animals (self-study)

3.2. General principles of Gastro-intestinal function, Factors that regulate quantity of food, Gastro -intestinal disorders

3.3. Secretary function of the alimentary canal-hormones and enzymes

3.4. Absorption Mechanism of digested nutrients

3.5. Obesity- causes and consequences

Module 4. Circulation

(12 hrs)

4.1 Body fluids in invertebrates and vertebrates (**self-study**)

4.2. Types of heart, anatomy of heart (human) and Haemopoiesis, Heart valves and Heart sounds

4.3. Circulations-systemic, pulmonary and coronary, Control of blood pressure and blood flow.

4.4 Circulatory Shock, Cardiac failure.

Module 5. Respiration

(10 hrs)

5.1. Respiratory organs of invertebrates,vertebrates and its functions, Respiratory pigments, Mechanism of Pulmonary ventilation

5.2. Respiration in unusual environment - Aviation, High altitude, Deep sea diving, Foetal respiration.

5.3 Regulation of respiration

5.4 Respiratory disturbance; Oxygen therapy, Artificial respiration

Module 6. Excretion and Osmoregulation

(10 hrs)

6.1. Types of Excretion, Structure of kidney, Basic renal process (self-study)

6.2. Osmo regulation in fresh water, marine and terrestrial animals

6.3. Regulation of sodium and water balance, Primary sodium ion re absorption, Urine concentration

6.4. Diuretics and kidney diseases. Creatine clearance- Plasma creatine –**Medical implications**

6.5. Haemodialysis, Peritoneal dialysis and transplantation

6.6. Regulation of acid-base balance, blood volume and extra cellular volume

6.7. Respiratory regulation of acid base balance

Module 7. Nervous Coordination

(10 hrs)

7.1. Neurons, Types of Neurons, transmission of Nerve impulse (self-study)

7.2. Giant nerve fibres in invertebrates-**Application**

7.3. Development of neurons and neuronal functionality

- 7.4. Factors leading to neuronal death
- 7.5. Neuro transmitters, neuro modulators and mechanism of neuro transmitter release
- 7.6. Neuronal disorders-strokes, excitotoxicity and NMDA receptors

Module 8. Endocrinology

(10 hrs)

- 8.1. Endocrine system (self-study) Classification of Hormones and nature of hormonal action.
- 8.2. Structure and function of different hormones
- 8.3. Neuro-endocrine feedback and response to various stimuli.
- 8.4. Endocrinology and metabolic syndrome, endocrine disorders.
- 8.5 Endocrinology test- diabetics test, thyroid test, bone test, reproduction test and growth test.

Module 9. Somatic and Special senses

(10 hrs)

- 9.1. Structure of Invertebrate and Vertebrate eye (self-study)
- 9.2. Tactile, Position, Pain, Thermal and taste Senses.
- 9.3. Visual pathways- organization of visual cortex. Analysis of visual information, detection of colour.
- 9.4. Auditory pathways- Functions of cerebral cortex in hearing.
- 9.5. Neuronal mechanism of sound detection and direction.

Module 10. Reproduction

(10 hrs)

- 10.1. Male and female reproductive system (self-study)
- 10.2. Endocrine control of male and female reproductive function.
- 10.3. Control of ovarian function. Uterine changes in menstrual cycle, effects of estrogen and progesterone. Androgen in women
- 10.4. Pregnancy - ovum transport, sperm activation, implantation and placentation. (*Self-study*)
- 10.5. Hormonal and other changes during pregnancy- Parturition, Lactation.
- 10.6. Reproductive disorders and STDs, Birth control measures. Pre-natal diagnostic tests. (*Self-study*).
- 10.7. Adjustments of the infants to extra uterine life

Module 11. Stress physiology

(6hrs)

- 11.1. Introduction to stress physiology-concepts and applications.
- 11.2. Heat exchange, Thermal strategies, Thermogenesis.
- 11.3. Xenobiotics- stress response
- 11.4. Stress hormones and its health implications.

Module 12. Sports Physiology

(2 hrs)

- 12.1. Muscles in exercise
- 12.2. Dope test, drugs and athletes
- 12.3. Fitness test. Bio energetic fuel for muscle work

References

- Clarke,R.K---2010. Anatomy and Physiology. Jones and Bactlett publishers, London.
- Franklyn, F. and Bolander. 2004. Molecular Endocrinology. Academic press.
- Ganong, W.F.2003. Review of Medical Physiology.Mc Graw Hill Co.
- Ghas,C.L. 2007. A Text Book of Practical Physiology. Medical Publishers Ltd., New Delhi.
- Guyton,A.C. and Hall,J.E. 2007. Text Book of Medical Physiology. Elsevier.
- Hadley,M.E. 2005. Endocrinology, Pearson Education • Hill, W.R., Wyse. G.E. and Anderson,M. 2007, Animal Physiology, Sinauer Associates, Inc.U.S.A.
- Hoar. W.R. 2004. General and Comparative Physiology, Pearson Education.
- Nagabhushanam., Kudarkar and Sarojini, 2002. Text Book of Animal Physiology, Oxford IBH Publishing Co. Pvt. Ltd.
- Prosser,C.L. Comparative Animal Physiology, Saunder College, Philadelphia.
- Ranganathan.T.S. 2008. A Text Book of Human Anatomy, S. Chand and Co.
- Singh,D.P. 2003. Stress Physiology, New Age international Publishers.
- Tortora,G.J. and Derickson,B. 2007. Principles ofAnatomy and Physiology.
- John Wiley & Sons inc. Tortora,G.J and S.R.Grabowski. 1996. Principles of Anatomy and Physiology. Harper Collins College Publishers.

MODEL QUESTION PAPER
19PZO21: ADVANCED PHYSIOLOGY AND FUNCTIONAL ANATOMY

Time: 3 Hrs

Max. Marks: 75

I. Write short notes on ten of the following. Each question carries 2marks.

1. Define the term Homeostasis.
2. What is Vasodilator.
3. Explain the term Nutrition.
4. Define cardiac cycle.
5. Define para sympathetic nervous system
6. Give any two functions of lymph
- 7.
- 8.
9. What is spermatogenesis?
10. What is the composition of saliva?
11. What is Eco physiology
12. Comment on Parturition
13. What is Dope test?
14. Comment on Diuretics
15. Difference between Neuron and Nephron

(10×2 =20 Marks)

II. Answer six of the following. Each question carries 4 marks.

16. Give the structure and functions of lymphatic systems.
17. Define blood pressure. What are the factors governing blood pressure?
18. Give the secretion, composition, and functions of bile.
19. Mention Birth control measures. Give examples.
20. Explain a normal ECG.
21. What are the pancreatic enzymes involved in digestion? Explain.
22. Explain the mechanism of blood coagulation.
23. How do you assess obesity?
24. Write the consequences of sickle cell anaemia.
25. Give the structure of the male reproductive system.

(6X4=24 Marks)

III. Answer three of the following. Each question carries 7 marks.

26. What are the various functions of minerals? Explain the causes, symptoms, and prevention of mineral deficiency.
27. Explain the mechanism of respiration.
28. Write a short essay on hormonal regulation of exercise and explain various Fitness tests
29. Give the structure and functions of glomerulus.
30. Define a synapse. Draw and explain its importance.

(3x7=21 Marks)

IV. Answer one of the following. The question carries 10 marks.

31. Give the hormonal control of menstruation, pregnancy and lactation
32. Compare Invertebrate and Vertebrate endocrine system and explain Neuro-endocrine feedback and response to various stimuli

(1×10=10 marks)

19PZO22: GENETICS, QUANTITATIVE ANALYSIS AND RESEARCH METHODOLOGY

Total hours: 100

Course outcome:

CO1: To give in depth understanding of principles genetics with emphasis on legal and **ethical issues** therein

CO2: Understand the concepts of Mendelian genetics and its applications.

CO3: To understand the basics of epigenetics and its role in population genetics.

CO4: To have a conceptual exposure to recent developments in the field of metagenomics and its applications.

CO5: To augment statistical skills in research area using online tools and to address ethical and plagiarism issues in research.

Genetics

(70hrs)

Module 1. Introduction

(5 hrs)

1.1. Genetics and modern agriculture

1.2. Genetics and medicine

1.3. Legal and ethical issues in genetics

Module 2. Mendelian Genetics and its Application

(15 hrs)

2.1. Gene mapping- Mapping genomes - physical maps, EST, SNPs as physical markers, radiation hybrids, FISH, optical mapping, gene maps, integration of physical and genetic maps;

2.2. Sequencing genomes: high-throughput sequencing, strategies of sequencing,

2.3. Recognition of coding and non-coding regions and annotation of genes,

2.4. Quality of genome-sequence data, base calling and sequence accuracy.

2.5. General effects of inbreeding and out breeding; hybrid vigour.

2.6. Expressivity, penetrance

2.7. Modern concept of Mendelism

Module 3. Population genetics and Epigenetics

(15hrs)

3.1 Introduction to population genetics (self - study)

3.2. Epigenetics- from phenomenon to field, a brief history of epigenetics - overview and concepts;

3.3. Chromatin modifications and their mechanism of action, concept of 'histone-code' hypothesis, epigenetics in *Saccharomyces cerevisiae*, position effect variegation,

3.4. Heterochromatin formation, and gene silencing in *Drosophila*, fungal models for epigenetic research: *Schizosaccharomyces pombe* and *Neurospora crassa*; epigenetics of ciliates; RNAi and heterochromatin assembly, role of noncoding RNAs.

Module 4. Metagenomics

(15 hrs)

4.1. Introduction - from genomics to metagenomics

4.2. Pioneering projects in metagenomics - the acid mine drainage project, sea metagenomics survey and community profiling, the human-micro biome project, viral metagenomics.

4.3. Ecological inference from metagenomics - symbiosis, competition and communication; microbial community - genomics in ocean.

4.4. Application of metagenomics - application in human health, agriculture, industry and environment remediation.

Module 5. Microbial Genetics

(12 hrs)

5.1. Bacterial genetics

5.2 Retrovirus, viral genome and multiplication - HIV genome and multiplication

5.3 Reproductive cycle of RNA viruses

5.4 Plasmids - Vector DNA - Insert DNA

5.5 Lambda Phages

5.6 Microbes in genetic engineering

Module 6. Genetics in Medicine and Forensics

(8 hrs)

6.1 Human Genome Project:

6.2 Human gene therapy

6.3 DNA fingerprinting:

6.4 Applications in forensic science

6.5 Applications in paternity testing

6.6 Application of genetic engineering in gene expression studies and gene knockout technologies to study molecular biology, chromosome engineering.

QUANTITATIVE ANALYSIS

(15 hrs)

Module 1. Introduction

(2 hrs)

1.1. Definition, history, scope of biostatistics and applications of statistics in biology (self-study).

1.2. Descriptive and inferential statistics

1.3. Preliminary concepts - population and sample, statistic and parameter, variables, sampling (self-study).

1.4. Collection of data- primary and secondary data, methods. Use of software in statistics.

Module 2. Descriptive Statistics

(2 hrs)

2.1 Processing and classification of data, presentation of data-tabulation and graphical and diagrammatic representation (self-study).

2.2. Measures of Central Tendency, problems (self-study).

2.3. Measures of Dispersion-problems, Skewness and Kurtosis 2.4. Correlation and Regression, problems (self-study).

Module 3. Probability and distribution

(3 hrs)

3.1. Definition, important terms and concepts

3.2. Theorems in probability

3.3. Important theoretical distributions- Binomial, Poisson, and Normal probability distributions.

Module 4. Parametric test

(4 hrs)

4.1. Basic idea - hypothesis testing, types of errors

4.2. Tests of-significance for large and small samples- Z-test, Chi- Square Test, Student's t' test, F-test - problems -and ANOVA

Module 5. Non-parametric tests

(2 hrs)

5.1. Characteristics, advantages and disadvantages

5.2. Types of non-parametric tests (Brief account only)

Module 6. Vital statistics

(2 hrs)

6.1. Introduction, uses, methods of collection

6.2. Measures of Vital Statistics, life tables

RESEARCH METHODOLOGY

(15 hrs)

Module 1. Introduction

(2 hrs)

1.1. Definition, meaning, objectives, and significance of research, Research methods vs. Methodology.

1.2. Types of research - Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical.

1.3. Characteristics of good research, steps of research

Module 2. Research Formulation

(2 hrs)

2.1. Formulation and defining a research problem, techniques involved

2.2. Literature survey-Journals, conference proceedings, books, government reports, etc,

2.3. Problem selection, formulation of working hypothesis

Module 3. Research design

(2 hrs)

3:1. Meaning-, need and features a good research design

3.2 Different types of research design (exploratory, descriptive, diagnostic and hypothesis-testing research studies)

3.3. Developing a research plan.

Module 4. Execution of research plan

(2 hrs)

4.1. Data collection methods-primary and secondary, sampling design (self-study), measurements etc. LC 50 & Dose Response.

4.2. Analysis of data (self-study).

4.3. Interpretations - advantages and techniques-and generalizations of the findings

Module 5. Scientific documentation

(3 hrs)

5.1. Significance of report writing, types of reports

5.2. Research report writing (thesis, dissertations, research articles, etc) characteristics and format

5.3. Writing and preparation of articles for publication and for oral and poster presentation

5.4. Project proposal and report writing.

Module 6. Research, extension and ethics

(4 hrs)

6.1. Publications-abstracting and indexing journals, books, conference / seminar proceedings, periodicals, reference sources, reviews, monographs. Extension tools, impact factor, citation, h-index.

6.2. Online libraries, e-journals, e-books, e-encyclopedia, institutional websites, TED Talk.

6.3. Intellectual property Rights-copy right, patents, trademarks, geographical indications, industrial design.

6.4. Research misconduct: fabrication, falsification and plagiarism

6.5. Precaution-- ISO standards for safety, lab protocols, lab animal uses, IACUC, control of hazards

6.6. Ethical norms, codes and policies for research ethic, laws in India

References

Genetics

- Daniel- - Fairbanks - and- -W-.R - -Anderson- - (MOO) Genetics The Continuity of Life. Brooks Cole Publishing Co., N.Y.
- J. Herbert Tayleur, Molecular Genetics Part I & II: Eldon. J., Gardner Principles of Genetics.
- Sinnot, Dunn, Dobzhansky, Principles of Genetics: TMH Edn. • John D Hawkins, Gene Structure and Expression. Cambridge University Press- Edinberg Buildings - Cambridge CBZ//ZRU UK
- PKU Nair and K. Prabhakar Achar, A Text Book of Genetics and Evolution: Konark Pubs.
- Robert M Horton and Robert C.Jait, Genetics Engineering with PCR: Horizon Scientific Press, Wymondham Norfolk NR 19 –OEH- UK
- R. World and S.B. Primrose, Principles of Gene Manipulation: Black Well Scientific Publishers, Melbourne, Paris.
- Samuel Karlin Eviatar Nevo, Population Genetics and Ecology, Academic Press NY. • A Franklin Shull, Heredity. Mc.Graw Hill Book Co, London.
- George W Bums, The Science of Genetics, Mae Milian CO New York.
- A Gib De Busk, Molecular Genetics, Mae Milian CO New York.
- Edgar Altenberg, Genetics, Oxford and IBH Publisher, New Delhi
- Janeway, Travens, (1996), Immunobiology Current Biology Ltd., Middle Sex House- 34-42 Cleveland Street, London
- Gunther S. Stent & Richard Calender, Molecular Genetics, CMS Publishers, 485 Jain Bhawan, Bholanath Nagar, Shandra, New Delhi
- Benjamin Lewin, Genes, V Oxford University Press, New York.
- James D. Watson, Tania.A.Baker, Stephen.P.Bell, Alexander Gann, Michael Levine, Richard Losick, (2004) Molecular Biology& Genes, Pearson Education.
- Strickberger, M.W. Genetics, Macmillan Publishing Co., Inc., New York.
- J.M. Walker and R. Rapley, (2002), Molecular Biology and Biotechnology, Purnima Publishing Corporation, New Delhi. Quantitative Analysis
- Fisher.R.A., Statistical Methods for Research
- Biometrical Genetics - Dover Publication, New York
- Ostle B, Statistics in Research.
- Agarwal, B.L. (1996) Basis Statistics. New Age International (P) Ltd. Publishers, New Delhi.
- Bailey, N.T.J (1981). Statistical Methods in Biology. Hodder and Stongtton, London.
- Finney, D.J. (1980). Statistics for Biologists. Chapman and Hall, London
- . • Caswell, F. (1982). Success in Statistics. John Murray Publishers Ltd., London. • Gupta, S.P. (1996). Statistical Methods. Sultan Chand & Sons Publishers, New Delhi.
- Arora, P.N. and P K Malhan. 1996. Biostatistics, Himalaya Pub. House
- Bailey,N.T.J. 1994. Statistical Methods in Biology, (3 edn). Cambridge University Press. London

- Dania', W. 2006. Biostatistics : A foundation for Analysis in Health Sciences, John Wiley and Sons Inc., New York.
- Dharmapalan, B. 2012. Scientific Research Methodology, Narosa Publishing House;. New Delhi.
- Finney, D.J. 1980. Statistics for Biologists. Chapman and Hall, London
- Kothari C.R., 2009. Research Methodology: Methods and Techniques. Nev:i Age International Publishers, New Delhi.
- Oliver; P:2005. Writing Your Thesis. Vistar Publications. New Delhi.

MODEL QUESTION PAPER

19PZO22 : Genetics, Quantitative Analysis& Research Methodology

Time: 3hrs

Total Marks:75

I. Write short notes on TEN of the following. Each question carries 2 marks

1. Comment on Variables.
2. Explain Chi-square test.
3. Briefly describe Plagiarism.
4. Comment on impact factor.
5. Explain gene silencing.
6. Comment on penetrance.
7. Explain retroviruses.
8. Describe RNA viruses.
9. Comment on germ line gene therapy.
10. Explain life tables.
11. Comment on online libraries.
12. Comment on IACUC.
13. Define plasmids.
14. Importance of genetic counseling.
15. Comment of radiation hybrids

(10×2=20 marks)

II. Answer SIX of the following. Each question carries 4 marks.

16. Define IPR and its importance.
17. Differentiate descriptive and inferential statistics.
18. Comment on skewness and kurtosis.
19. Briefly explain coefficient of correlation.
20. Advantages of DNA fingerprinting.
21. Explain genomics in ocean.
22. Write an account on lambda phages.
23. Explain modern concept of Mendelism.
24. Comment on concept of histone code hypothesis.
25. Explain GMO.

(6×4=24 marks)

III. Answer Three of the following. Each question carries 7 marks.

26. Briefly explain the components of research paper.
27. Write an account on human genome project.
28. Explain microbes in genetic engineering.
29. Comment on fungal models for epigenetic research.
30. Discuss mapping genomes.

(3×7=21 marks)

IV. Answer ONE of the following. Each question carries 10 marks.

31. Explain the applications of metagenomics.
32. Explain the legal and ethical issues in genetics.

(1×10=10 marks)

19PZO23: CELL BIOLOGY, MOLECULAR BIOLOGY AND BIOINFORMATICS

Total hours: 100

Course outcome:

CO1: To impart in-depth understanding of the basic and advanced level of knowledge about the structural and functional aspects of cell at cytological and molecular level.

CO2: To expose the students to the emerging field of bioinformatics and equip them to take up bioinformatics studies.

CO3; to equip the students to carry out original research in cell and molecular biology.

CELL BIOLOGY, MOLECULAR BIOLOGY AND BIOINFORMATICS (100 hours)

Module 1. *Biological membrane and Cell cycle* (18 hrs)

1.1 Biomembranes: Chemical composition and structure; membrane fluidity; micelles; liposomes.

1.2 Transmembrane transport: Diffusion (simple and facilitated), Active transport (ATP powered pumps), Carrier proteins (uniport, symport and antiporters), Channel proteins (voltage and ligand gated), pinocytosis, phagocytosis and exocytosis; Vesicular traffic, secretion and endocytosis.

1.3 Nongated ion channels and membrane potential.

1.4 Chromatin, chromosomes and nucleosomes: Types of Chromatin and chromosomes; detailed structure of nucleosome; higher order chromatin structure and the role of histones, H1, scaffold proteins, and radial loop model.

1.5 Cell division and cell cycle: Phases of cell cycle, cyclin and cyclin - dependent kinases, regulation of CDK Activity, check points in the cell cycle, role of Rb and p53.

Module 2. *Cell- signaling and cellular communication* (12hrs)

2.1 Cell surface receptors (G protein-coupled receptors, receptor tyrosine kinases) and intracellular messengers (second messenger system).

2.2 Signal transduction pathways (cyclic AMP, cyclic GMP, Ras, Raf and MAP kinase pathways).

2.3 Apoptosis (extrinsic and intrinsic pathways), Aging and cell senescence, signaling cell survival.

2.4 Cell adhesion and roles of different adhesion molecules, tight junction, desmosome, hemidesmosome, gap junctions; extracellular matrix, cadherins, integrins and selectins; Immunoglobulin like molecules; neurotransmission and its regulation.

Module 3. *Biology of cancer* (8 hrs)

3.1 Cancer types, stages and causes, tumor suppressor genes, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, regulation of cell cycle in malignant cells, therapeutic interventions of uncontrolled cell growth.

Module 4. *Structure of DNA and RNA* (5 hrs)

4.1 DNA topology: Linking number and writhing number.

4.2 DNA Super coiling in prokaryotes and eukaryotes; role of topoisomerases.

4.3 RNA structure and types (mRNA, rRNA, tRNA).

Module 5. *Organization of the genome* (5hrs)

5.1 Genomic size and complexity (prokaryotic and eukaryotic).

5.2 Intragenic sequences -exons, introns; split gene organization; regulatory sequences.

5.3 Intergenic sequences (unique and repetitive).

5.4 Repetitive sequences: Highly repeated sequences - satellite, minisatellite and microsatellite DNAs; moderately repeated sequences (SINEs and LINEs), transposable (mobile) DNA elements.

5.5 DNA denaturation-renaturation kinetics and genome complexity; in situ hybridization.

5.6 Organelle genomes-mitochondrial and plastid DNAs.

Module 6. *DNA Replication, repair and recombination* (12hrs)

6.1 Prokaryotic and Eukaryotic DNA replication.

6.2 DNA replication machinery.

6.3 Enzymes and accessory proteins involved in replication.

6.4 DNA damage and repair, Direct reversal; photo reactivation, adaptive response Excision repair, Mismatch repair, SOS repair and mutagenesis, Recombination repair; Rec A and other recombinases.

6.5 Damage signaling and checkpoints.

6.6 DNA repair-associated disorders.

Module 7. Transcription and RNA processing

(8 hrs)

7.1 Prokaryotic and eukaryotic transcription.

7.2 Binding the transcription complex-promoters, factors and RNA polymerases.

7.3 Regulation of transcription.

7.4 Sigma factor and its role in prokaryotic transcription.

7.5 Post-transcriptional processing of RNA precursors, RNA splicing, spliceosomes; RNA editing.

Module 8. Translation-gene expression

(10hrs)

8.1 Prokaryotic and Eukaryotic translation.

8.2 The translation machinery.

8.3 Mechanism of initiation, elongation and termination.

8.4 Co-and post translational modifications of proteins.

8.5 Hormonal regulation of protein synthesis.

Module 9. Gene Regulation Mechanisms

(10hrs)

9.1 Gene regulation in prokaryotes (lac operon, araBAD Operon and tryptophan operon), layers of regulation in bacteriophage λ .

9.2 Gene regulation in eukaryotes at various levels (DNA, histone, replication, transcriptional and translational, micro RNA).

9.3 Gene expression studies with cloned DNA fragments, DNA microarrays, cluster analysis of multiple expression, transient transfection, stable transfection, retroviral expression systems, gene and protein tagging, In vitro mutagenesis and deletion techniques.

BIOINFORMATICS

(12 hrs)

Module 10. Bioinformatics

10.1 Introduction to Bioinformatics, Definition, Difference between Computational Biology & Bioinformatics, Bioinformatics as one of the views in life, Major areas of Bioinformatics and their nature and scope.

10.2 Biological databases, their purpose, primary, secondary, curated and uncurated databases types of databases (DNA, protein, RNA, functional and structural databases),

10.3 Uploading and downloading of data; FASTA format, data retrieval from databases, analysis tools, softwares and their applications, Overview of pair wise and multiple sequence analysis, use of BLAST

10.4 Construction of rooted and un-rooted phylogenetic trees, their interpretation and use in analyzing evolutionary trends, steps in phylogenetic analysis, Phylogenetic softwares- ClustalW, Mega, Phylml, RaxML.

10.5 Brief overview of Computer Aided Drug Discovery: Review of basic biological concepts- diseases and their causes, molecular basis of diseases, immune system, antigens & antibodies, immune response, vaccines, molecular targets, Characteristics of a drug compound, Drug docking software basics.

References

- A Gib De Busk, (2000), Molecular Genetics, Mae Millan Co. New York.
- B.Albert's, D. Bray, J. Lewis, M. Raff, K, Roberts and J.D. Waton, (2004), Molecular Biology of the Cell- Garland Publishing in New York.
- Becker W.M, Kleinsmith Er and Hardin. I. (2003), The World of the Cell. Pearson Education, Singapore.
- Benjamin Lewin, (2006), Genes IX - Oxford University Press.
- Devlin, T.M., (2002), Text book if Biochemistry, John-Wiley and Sons, Ine., Publication.
- Elliot, H.E. and Elliott, D.C. (2001), Biochemistry and Molecular Biology, OUP.
- Gerald Karp, (2005), Cell and Molecular Biology, John Wiley and Sons, Inc. USA.
- Gunther S. Stnet and Richard Calender, (2000), Molecular Genetics, CMS Publishers, 485 Jain Bhawan, Bholanath Nagar, Shandara, Newdeli.
- Harvey Lodish, Arnold Berk, Sipursky, Matsudaria and David Baltimore, (2008), Molecular Cell Biology, W.W. Freman and Company.Darnell.
- Herbert Taylor, Molecular Genetics, Part I & II. • Daniel Fairbanks and W R Anderson, (2000), Genetics - The Continuity of Life. Brooks/Cole Publishing Co., N.Y.
- John Ringo, (2004), Fundamental Genetics. Cambridge University Press, UK.

- Richard Lodivk, (2004), Molecular Biology & Genes, Pearson Education.
- Snustad, D.P. and Simmons, M.J. (2002), Principles of Genetics, John Wiley and Sons, Inc. New York.
- James D Watson, Tania A Baker, Stephen P Bell, Alexander Gann, Michael Levine, Richard Losick, (2009), Molecular Biology of Genes, Pearson Education.
- Strickberger, M, W. (2000), Genetics, Macmillan Publishing Co., Inc., New York.
- M. Walker and R. Rapley, (2002), Molecular Biology and Biotechnology, Pumima Publishing Corporation, New Delhi.
- David. E.Sadava, (2004) Cell Biology. Panima Publishing Corporation, New Delhi.
- Pollard, T. D. and Eamshaw W.O. (2002), Cell biology. Elsevier Science, USA.
- Wilson, K. and Walker, J. (2006), Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, N.Y.
- Andrew Read and Dian Donnai, (2007), New Clinical Genetics. Scion Publishing Ltd.
- Harvey Lodish, Arnold Berk, Sipursky, Matsudaria, David Baltimore and (2002) Molecular Cell Biology, W.W. Freeman and Company.Darnell,
- Gerald Karp (2005),Cell and Molecular Biology, John Wiley and Sons, Inc. USA • Richard Lodivk, (2004), Molecular Biology & Genes, Pearson Education
- B.Albert's, D. Bray, J. Lewis, M. Raff, K, Roberts and J.D. Waston, (2004) Molecular Biology of the Cell-Garland Publishing in New York.
- Devlin, T.M. (2002) Text book if Biochemistry, John-Wiley and Sons, Inc., Publication. • Becker W.M, Kleinsmith Er and Hardin I (2003) The World of the Cell. Pearson Education, Singapore
- John Ringo (2004), Fundamental Genetics. Cambridge University Press, UK.
- Herbert Taylor, Molecular Genetics, Part I & II.
- Daniel Fairbanks and W R Anderson (2000), Genetics - The Continuity of Life. Brooks/Cole Publishing Co., N.Y.
- Snustad, D.P. and Simmons, M.J. (2002), Principles of Genetics, John Wiley and Sons, Inc. New York.
- Elliot, H.E. and Elliott, D.C. (2001). Biochemistry and Molecular Biology, OUP. • John D Hawkins, Gene Structure and Expression. Cambridge University "Press - Edinberg Building -. Cambridge CBZ/ZRU UK.
- PKU Nair and K. Prabhakar Achar, A Text Book of Genetics and Evolution, Konark Pub.
- A. Franklin Shull . (2001). Heredity, Me.. Graw.Hill. Book .Co, -London.
- George ,Bums (1999) The Science of Genetics, Mac Millian Co, New York.
- A Gib De Busk (2000) Molecular Genetics, Mae Millan Co. New York.
- Gunther S. Stnet and Richard Calender (2000) Molecular Genetics, CMS Publishers, 485 Jain Bhawan, Bholanath Nagar, Shandara, New Delhi.
- Benjamin Lewin, (2006) Genes IX - Oxford University Press.
- James D Watson, Tania A Baker, Stephen P Bell, Alexander Gann,. Michael Levine, Richard Losick, (2004) Molecular Biology of Genes, Pearson Education.
- Strickberger, M, W (2000) Genetics, Macmillan Publishing Co., Inc., New York
- M. Walker and R. Rapley, (2002), Molecular Biology and Biotechnology, Pumima Publishing Corporation, New Delhi.
- David E Sadava (2004) Cell Biology. Panima Publishing Corporation, New Delhi.
- Pollard T D and Eamshaw W.O (2002) Cell biology. Elsevier Science, USA.
- Wilson K and Walker J (2006) Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, N.Y
- Andrew Read and Dian Donnai. (2007) New Clinical Genetics. Scion Publishing Ltd.,

MODEL QUESTION PAPER

19PZO23: CELL BIOLOGY, MOLECULAR BIOLOGY AND BIOINFORMATICS

TIME 3 HRS

MAX MARKS 75

I. Write short notes on any ten of the following. Each question carries two marks

1. What are biomembranes?
2. What are liposomes?
3. Define apoptosis.
4. Define desmosomes.
5. What is meant by database?
6. Define computational biology.
7. Write on DNA microarrays.
8. What are lac operons?
9. What is meant by protein tagging?
10. What is splicosomes?
11. What is meant by metastasis?
12. What are gap junctions?
13. What are cadherins?
14. Define vesicular traffic.
15. What is meant by neurotransmitters?

10X2=20 marks

II. Answer any six of the following. Each question carries 4 marks

16. Discuss on tumour suppressor genes.
17. Write on cell surface receptors.
18. Differentiate between linking number and writhing number.
19. Write on the structure of mRNA.
20. Discuss on plasmid DNAs.
21. Write on RNA editing.
22. Write on multiple sequence analysis
23. Discuss on DNA repair associated disorders.
24. Comment on prokaryotic translation.
25. Discuss on rooted and unrooted phylogenetic analysis.

6X4=24 marks

III. Answer any three of the following. Each question carries 7 marks

26. Write on the hormonal regulation of protein synthesis.
27. Explain on the drug docking software.
28. Comment on signal transduction pathways.
29. Explain the super coiling of DNA.
30. Write a short note on FASTA and BLAST.

3X7=21 marks

IV. Answer any one. Each question carries 10 marks

31. Write an essay on gene regulation in prokaryotes.
32. Discuss on the biology of cancer.

1X10=10 marks

PRACTICAL II

19PZO24: ADVANCED PHYSIOLOGY AND FUNCTIONAL ANATOMY

1. Effect of salivary amylase on starch (colorimetric) a) Influence of temperature and calculation Of Q 10 b) Influence of pH
2. Transport of glucose through intestinal wall (everted gut sac) of a suitable animal
3. Recording of heart beat and the effect of drugs (acetylcholine and adrenaline) in fowl.
4. Effect ph different concentrations of NaCl (0.1 % to 2%) on the diameter of RBCs using micrometry.
5. Estimation of RBCs and WBCs in vertebrate blood
6. Blood histology of earthworm/cockroach/fish and chick.
7. Studies on feeding-Mounting of mouth parts of housefly, honey bee and mosquito in relation to food and feeding
- 8. Observe and compare the inherent rhythmicity of the different parts of the heart (fish).**
- 9. Dissection of endocrine system in crustaceans (prawn/crab) (neurohaemal organ).**

PRACTICAL II

19PZO25: CELL BIOLOGY MOLECULAR BIOLOGY AND BIOINFORMATICS

1. **Effect of drugs/chemical on cell division (mitosis).**
2. Histochemical detection of protein- Mercury Bromophenol Blue method
3. Histological detection of glycogen- per iodide acid Schiff's reagent reaction.
- 4. Observation of DNA fragmentation in apoptotic cells.**
5. Squash preparation of salivary gland of Drosophila to study polytene chromosomes.
- 6. Isolation of Goat/ fish RBC Plasma membrane and estimation of Na⁺ /K⁺ ATPase.**

BIOINFORMATICS

1. **Use of excel sheet for data processing.**
2. **Use of search engines like Scopus, Science direct for reference material collection and management.**
3. **Nucleic acid and protein sequence databases.**
4. **Data mining for sequence analysis- BLAST, FASTA, UNIPROT, RASmol MSA**
5. **Primer designing for gene amplification and gene cloning.**
6. **Annotations: ORF finder, Use of ARTEMIS or any other suitable software.**
7. **Construction of rooted and unrooted phylogenetic trees for DNA and proteins-Mega, Phylml, ClustalW, RaxML**
- 8 **Identification of peptide finger print by nano LC- MS/MS and database search using MASCOT and OMSSA.**

GENETICS, QUANTITATIVE ANALYSIS AND RESEARCH METHODOLOGY

Genetics

1. Preparation of testis squash of Grass hopper to study the different stages of meiosis.
2. Statistical analysis –Chi-square, t-test, correlation coefficient, regression, standard deviation and standard error of the given data using suitable software. Eg.PH stat.
3. Preparation of following using suitable software
 - a) Histogram
 - b) Frequency polygon
 - c) Pie diagram.

SEMESTER III

19PZO31: MICROBIOLOGY & BIOTECHNOLOGY

Total hours: 100

Course Outcome:

CO1 : Understand the microbial diversity, nutrition, growth and its cell structure and function

CO2 : Explain the scope of industrial, environmental and medical microbiology.

CO3 : Understand the techniques in biotechnology and molecular cloning; bioethics and recent trends in biotechnology

MICROBIOLOGY

(50 hrs)

Module 1. Introduction to Microbiology

(6hrs)

1.1. Scope and history of Microbiology - mention the contributions of important

Scientists who developed Microbiology as a major discipline (e.g. Pasteur, Koch, **Alexander Fleming**, etc).

1.2. Microbial Diversity including Extremophiles – brief account.

1.3. Characteristic Features of microorganisms - Bacteria, Virus, Fungi & Protozoa. Microalgae. Classification of Bacteria, Virus, Fungi & Protozoa.

1.4. Classification Bacteria, Bergy's manual (**self- study**)

Module 2. Bacterial Cell Structure & Function.

(6hrs)

2.1. Ultra-structure of bacteria –cell membrane, cytoplasmic inclusions, nucleoid etc

2.2. Bacterial Cell Wall-structure, differences between gram positive and Negative cell wall, gram staining.

2.3. External components & their functions- pili, flagella, fimbriae, capsules, slime layers etc.

Module 3. Microbial Nutrition & Growth

(8 hrs)

3.1. Common nutritional requirements of microorganisms - autotrophy and heterotrophy.

3.2. Types of culture media.

3.3. Microbial growth - overview of cell growth, generation time, measurement of growth.

3.4. Typical growth curve, continuous culture, effect of environmental factors on growth
Stress response

Module 4. Industrial and Environmental Microbiology

(10 hrs)

Industrial Microbiology

4.1. Concept of fermentation. Types of fermentation - submerged, solid state - Mention briefly.

4.2. Basic design and types of fermenters.

4.3 **Microbial fermentation and production of micro and macro molecules** such as Alcohol, Antibiotics (e.g. Penicillin), Organic acids (e.g. Acetic acid, Lactic acid).

4.4. Microbiology of milk & foods. Preservation of milk - Pasteurization techniques, Probiotics.

4.5. Microbial spoilage of different types of foods & Food borne diseases (self-study)

4.6. Beneficial activities of microbes in food (self-study)

4.7. Microbial quality control and safety of food (self- study)

Environmental Microbiology

(10 hrs)

4.8. Introduction to terrestrial and aquatic microbiology. Principles of Microbial Ecology.

Potential uses of microbial biodiversity.

4.9. Microbiology of waste treatment. Brief account of microbial treatment of waste water and solid wastes.

4.10. Bioremediation - microbial treatment of radioactive wastes and xenobiotics; Biosensors.

4.11. Microbes in decomposition and recycling process -Biogeochemical cycles (self - study)

Module 5. Medical Microbiology

(10 hrs)

Host-microbe interaction - process of infection, pathogenicity, virulence & infection, microbial adherence, penetration .of epithelial cell layers and events in infection following penetration, Infection of blood, lymphatic system.

Exotoxins - classification, mechanism of action of exotoxins e.g. Diphtheria, Botulinum, Tetanus, and Cholera toxins.

Control of Microorganisms - various physical & chemical methods.

Use of antibiotics and other antimicrobial drugs.

Drug resistance and emergence of multiple drug resistance - recent cases of TB (XDR, TDR); NDM etc.

A survey of harmful and beneficial microbes (self - study)

BIOTECHNOLOGY

(50 hrs)

Module 6. Introduction to Biotechnology

(10 hrs)

History of Biotechnology (self-study). Broad areas of BT - traditional and modern; types - plant biotechnology, animal biotechnology and microbial biotechnology.

Techniques in biotechnology -brief description of common techniques such as tissue culture. Genetic engineering, cloning etc.

Module 7. Molecular Cloning

(15 hrs)

Gene cloning — basic steps in gene cloning. Mention enzymes used in gene cloning. (Self-study)

Vectors — types and characteristics e.g. plasmids, phages, hybrid vectors, artificial chromosomes.

Techniques of gene transfer – calcium chloride transformation, microinjection, electroporation, shotgun cloning, Agrobacterium mediated transfer etc

7.4 Tissue and cell culture methods for animals.

7.5 Practical application of genetic engineering - useful products. Application in Medicine, Agriculture, Aquaculture and Animal Husbandry, Environment etc. Biotechnology Industry.

Module 8. Recent Trends in Biotechnology

(18 hrs)

8.1. Synthetic Biology – description and developments in the area.

8.2. Artificial life – concept and achievements

8.3 Protein engineering Metabolic Engineering, site directed mutagenesis.

8.4. Microbial warfare bio-weapons and bioterrorism

8.5. Biogeotechnology: Bioleaching of metals, biobeneficiation, microbially enhanced oil recovery, bio desulfurization of coal.

Module 9. Bioethics

(5 hrs)

9.1. Ethical, legal and social issues of biotechnology.

Module 10. Biotechnology in India

(2 hrs)

10.1. History of biotechnology research in India.

10.2. Biotechnology Regulatory Agencies in India.

References

Microbiology

- Prescott, Harley and Klein, 6th Edition.
- *Microbiology: An Introduction*. Tortora, Funke & Chase. 10th edition (2009). Benjamin Cummings. ISBN: 0321550072.
- *Bacteria: The Benign, the Bad, and the Beautiful*. Trudy M. Wassenaar. ISBN: 978- 1-1181-0766-9. 2011, WileyA3Jackwell
- *Microbiology*. Pelczar, Reid and Chan. Tata-McGrawHill. Reprint 2008. ISBN 0074623206, 9780074623206.
- *Introductory Food Microbiology*. H. A. Modi 2007. ISBN 8179102213.
- *Food Microbiology An Introduction* by Thomas J Montville, Karl R. Mathews
- *Microbiology* by Edward Alcamo Wiley publishing inc ISBN 0-8220-5333-0
- Alamo, E.I. (2001). *Fundamentals of Microbiology* (6th Ed.). Jones & Bartlett Publishers, Inc., MassachuseKUSA..ISBN: 0 7637 1067 9
- Madigan, M.T., Martinko, J.M., Dunlap, P.V. & Clark, D.P. (2009). *Biology of Microorganisms* (12th Ed.). Pearson Benjamin & Cummings, New York; USA. ISBN: 0 321 53615 0, 978 0321 53615 0

Biotechnology

- Benjamin Lewin – *Genes X* (2011).
- James D Watson - *Molecular Biology of the Gene* (6th Edition)
- George W Bums, *The Science of Genetics*, Mae Milian CO New York.
- A Gib De Busk, *Molecular Genetics*, Mae Milian CO New York.
- Edgar-Altenberg, *Genetics*, Oxford and IBH Publisher, New Delhi.

- Janeway, Travençolo, (1996) *Immunobiology* Current Biology Ltd., Middle Sex House- 34-42 Cleveland Street, London.
- Gunther S. Stern & Richard. Calender *Molecular Genetics*, CMS Publishers, 485 Jain Bhawan, Bholanath Nagar, Shandra, Newdeli
- Richard Losick, (2004) *Molecular Biology & Genes*, Pearson Education.
- Strickberger, M.W. *Genetics*, Macmillan Publishing Co., Inc., New York.
- J.M. Walker and R. Rapley, (2002), *Molecular Biology and Biotechnology*, Purnima Publishing Corporation, New Delhi.
- **Useful websites**
- <http://www.microbeworld.org>
- <http://www.ncbi.nlm.nih.gov>
- <http://www.accessexcellence.org/RC/AB/BA/>
- <http://www.accessexcellence.org/RC/AB/IE/>
- <http://bacteriamuseum.org>

MODEL QUESTION PAPER
19PZO31: MICROBIOLOGY & BIOTECHNOLOGY

Time: 3 hrs

Max.Marks: 75

I. Answer any TEN of the following questions. Each question carries two marks.

1. What are cosmids?
2. Write a note on anaerobic bacteria.
3. What are Inclusion bodies?
4. What are exonucleases?
5. Define Fermentation.
6. What is lipofection?
7. Write on antibiotics.
8. What is bacteriocin?
9. Write a note extremophiles.
10. Name two selection markers used in plasmid vectors.
11. What is RAPD?
12. What are Xenobiotics?
13. Write a note on the contributions of Alexander Fleming.
14. Define pasteurization.
15. What are actinomycetes?

(10 x2 =20)

II. Answer any SIX of the following . Each question carries four marks.

16. Draw the structure of a bacterial cell wall.
17. What is gene targeting?
18. What are the ideal properties of an ideal vector?
19. Differentiate between pili and fimbriae.
20. Explain alcoholic fermentation.
21. Explain chromosome jumping.
22. Explain gram staining to distinguish different bacteria.
23. Describe the Sanger-Coulson method of DNA sequencing.
24. Differentiate between autotrophs and heterotrophs.
25. What are site specific mutagens?

(6x4 =24)

III. Answer any THREE of the following. Each question carries seven marks.

26. Describe the various steps involved in electroporation.
27. Briefly explain the bacterial growth curve.
28. Elaborate on bacterial classification.
29. Explain Genomic library and cDNA library.

30. Explain the nitrogen cycle with stress on the microbes involved.

(3X7=21)

IV. Answer any ONE of the following. The question carries 10 marks.

31. Describe the various molecular probes and markers used in biotechnology.

32. Elaborate on drug resistance.

(1x10=10)

19PZO32: ECOLOGY, ETHOLOGY AND BIODIVERSITY CONSERVATION

Total hours: 100

Course Outcome:

CO1 : Develop a positive attitude towards environment and Biodiversity conservation.

CO2 : Understand ecological energetic, concepts of habitat and niche.

CO3 : Understand the mechanism of transition and stability in communities

CO4 : Understand the aspects of learning and behavior.

CO5 : Understand biodiversity status, strategies of conservation, treaties and conventions for biodiversity conservations.

ECOLOGY

(26 hrs)

Topics for self-study

1. Biotic and abiotic factors and their interactions.

2. Structure, basic components, their interactions and inter-relations. Fundamental concepts relating to energy - first and second laws of thermodynamics, entropy.

3. Gaseous-and-sedimentary cycles

4. Characteristics of population: density, natality, mortality, biotic potential

5. Environmental resistance, growth forms, immigration, emigration and migration. Characteristics: Species diversity, stratification, dominance, boundaries, ecotone and edge effect.

Module 1. Ecological Energetics

(7 hrs)

1.1 Solar energy and photosynthetic production, efficiency of energy capturing, chemosynthesis.

1.2 Energy flow - features of energy flow (unidirectional flow and loss of energy as heat) and pathways of energy flow.

1.3 Productivity - primary production and production efficiency, secondary production, standing crop.

1.4 Food chain (grazing, detritus and auxiliary food chains), food webs, trophic levels and ecological pyramids (pyramid of numbers, pyramid of biomass and pyramid of energy [self-study]).

1.5 Classification of ecosystems based on energy input (natural unsubsidised and subsidized solar powered ecosystems, human subsidised solar powered ecosystem and fuel powered urban and industrial systems).

Module 2. Concepts of Habitat, Niche and Guild

(5 hrs)

2.1 Habitat, microhabitat and niche. Different types of niches: spatial niche, trophic niche, species niche, multidimensional niche, fundamental and realised niche.

2.2 Niche overlap, Gause's principle-Lotka -Volterra model, resource partitioning, competition hypothesis, concept of Guild, character displacement, ecological equivalents.

Module 3. Species Interactions

(7 hrs)

3.1. Intra and interspecific interactions, Types of Interspecific interactions - (Positive, Negative and Neutral).

3.2. Positive interactions (commensalism, proto-cooperation, mutualism and pollination).

3.3. Negative interactions (competition, parasitism, amensalism, predation, herbivory, carnivory).

3.4. Co-evolution

3.5 *r*-selection, *k*-selection.

Module 4. Transition and Stability in Communities

(7 hrs)

4.1. Succession — Basic types (Primary succession, Secondary succession, Autogenic succession, Allogenic succession, Autotrophic succession, Heterotrophic succession).

4.2. Trends in succession

4.3. Stages of succession - (Nudation, Invasion, Competition and co-action, Reaction, Climax), pulse stability.

4.4. Examples of Succession — (Succession in aquatic and terrestrial ecosystems).

4.5. Relevance of ecosystem development theory to human ecology, prospects for detritus agriculture, the compartment model.

ETHOLOGY

(35 hrs)

Topics for self study

History, development and applications; Motivation and models of motivation; reflexes, imprinting, habituation; neural mechanisms in behaviour; hormones and behaviour; Sociobiology: social groups - merits and demerits, features of organized groups; social groups in mammals, social stress; pheromones and chemical communication.

Module 5: Learning

(5 hrs)

5.1 Classification of learning: Imprinting, habituation, imitation (self- study), classical conditioning, instrumental/operant conditioning, cognitive learning, latent learning, insightful learning.

Module 6. Nervous System and Behaviour

(12 hrs)

6.1 Stimulus filtering, sign stimulus, innate release mechanism and fixed action plans (FAPs).

6.2 Neural centers (hypothalamus and limbic system) and mechanisms in behaviour: drinking, feeding, learning, memory and cognition.

Module 7. Complex Behaviour Patterns

(10 hrs)

7.1 Orientation, Navigation and homing.

7.2 Migration (Fishes and birds).

7.3 Biological rhythms – biological clock, circadian, circannual, lunar, tidal and seasonal periodicities, sleep and arousal, genetics of biological rhythms.

Module 8. Environment, genetics and Evolution of behaviour

(8 hrs)

8.1 Habitat selection and territoriality.

8.2 The Evolution of communication; Development of bird song.

8.3 The evolution of reproductive behaviour and mating systems.

BIODIVERSITY

(39 hrs)

Module 9. Biodiversity

(15 hrs)

9.1 Introduction: Definition, levels of biodiversity (genetic diversity, species diversity and ecosystem diversity), values of biodiversity (self- study), Ecosystem services.

9.2 Diversity indices: Alpha diversity, Beta diversity and Gamma diversity; the species diversity and ecosystem stability.

9.3 Biodiversity in India: Major biogeographic zones of India; India as a mega diversity nation; hot spots of biodiversity – characteristics; an outline of the features and biodiversity of hot spots in India (Western Ghats and Eastern Himalayas).

9.4 Features, structure and biodiversity of some of the Indian ecosystems: Terrestrial ecosystems (forest, grassland, desert), Aquatic ecosystems fresh water, marine, estuarine).

Module 10. Conservation Biology

(13 hrs)

10.1 Depletion of biodiversity: Current estimates of species loss, causes of biodiversity loss, effect of invasive species on biodiversity, impacts of biodiversity loss, Strategic species concepts: Keystone species, indicator species and umbrella/flagship species

10.2 Strategies of conservation: *in situ* and *ex situ* conservation, Gene Banks, establishment of protected areas, habitat conservation, captive breeding, pollution control, legislative conservation, creating public awareness and other relevant measures.

10.3 An evaluation of the “Project Tiger” and “Project Elephant” programmes.

10.4 World conservation strategy (1980)

10.5 National and State biodiversity conservation agencies, National Biodiversity Action Plan 2008: A brief outline of objectives & plans

10.6. Biodiversity evaluation for developmental process.

Module 11. International Conventions & Treaties for Conservation of Biodiversity (11hrs)

11.1 Stockholm declaration on human Environment (1972), Convention on Regulation of Antarctic Marine Resources Activities (RAMRA, 1986), Moduleed Nations World Charter for Nature (1982), Kyoto Protocol and Framework Convention on Climate Change (UNFCCC). Brundtland Report (1987).

11.2 Earth summit (1992) – detailed study - Rio Declaration on Environment and Development, Agenda 21, Forest Principles, Convention on Biological Diversity.

11.3 Species based treaties: Migratory Bird Treaty Act (MBTA) of 1918, International Convention for the Regulation of Whaling (ICRW), Washington, 1946, Convention for the Conservation of Antarctic Seals, 1972, Convention on International Trade on Endangered Species (CITES, 1975),

11.4 Ecosystem based treaty: Ramsar Convention (1971) – Ramsar sites in India and Kerala

References

Ecology & Biodiversity

- Beck, W.S., Liem, K.F. & Simpson, G.G. (1991). Life: An Introduction to Biology (3rd Ed.). Harper Collins Publishers, New York, pp 1361. ISBN: 0 06 500009 9.
- Bharucha, E. (2005). Textbook of Environmental Studies. Universities Press (P) Ltd, India, pp 276. ISBN 81 7371 540 8.
- Chapman, J.L. & Reiss, M.J. (). Ecology: Principles and Applications (2d Ed.). Cambridge University Press, UK. ISBN: 0 521 00575 2.
- Charry, S.N. (2008). Environmental Studies. MacMillan India Ltd. ISBN: 10: 0230 63531 8, 13: 987 0230 6351 9.
- Cunningham, W.P. & Cunningham, M.A. (2003). Principles of Environmental Science inquiry and Applications. Tata McGraw Hill Publishing Company Ltd, New Delhi. ISBN 0 07 058112 6.
- Donald Van DeVeer & Christine Pierce (). The Environmental Ethics & Policy Book (3rd Ed.). Wadsworth-Thomson Learning, Canada. ISBN: 0 534 56188 8.
- Emmel, T.C. (1976). Population Biology. Harper & Row Publishers, New York. ISBN 0 06 041904 0.
- Gaston, K.J. & Spicer, J.I. (1998). Biodiversity: An Introduction. Blackwell Science Ltd., London. ISBN 0 632 04953 7.
- Hickman, C.P., Roberts, L.S., Larson, A. & Anson, H. (2004). Integrated Principles of Zoology. McGraw Hill Company, New Delhi, pp 872. ISBN: 0 07 243940 8.
- Kormondy, E.J. (2008). Concepts of Ecology. Dorling Kindersely (India) Pvt. Ltd., pp 576. ISBN 81 317 0744 X.
- Odum, E.P & Barrett, G.W. (2006). Fundamentals of Ecology. Thomson/Brooks and Cole, India, pp 598. ISBN: 81 7648 552 7.
- Pianka, E. R. (2000). Evolutionary Ecology. Sixth Edition. Benjamin-Cummings, Addison-Wesley-Longman, San Francisco, pp 528. ISBN: 10: 0321042883.
- Rajalekshmi. V. (2004). Environment and Sustainable development. APH Publishing Corporation, New Delhi, ISBN: 81 7648 552 7.
- Richard Brewer (). The science of Ecology (2nd Ed.). Saunders College Publishing, USA. ISBN: 0 03 096575 6.
- Russell, P.J., Starr, C., Wolfe, S.L., Hertz, P.E. & Mcmillan, B. (2009). Ecology. Cengage Learning Private Limited, pp 532. ISBN-13: 9788131508503.
- Townsend, C.R., Harper, J.L. & Begon, M. (2000). Essentials of Ecology. Blackwell Scientific Publishers, Massachusetts, pp 552. ISBN: 0 632 04348.
- Eldon, D.E. & Bradley, F.S. (2006). Environmental Science – A study of Interrelationships (12th Ed). McGraw-Hill Higher Edition. ISBN: 007252829x.
- Molles Jr. (2009) Ecology: Concepts and Applications (5th Ed). McGraw-Hill International Education. pp 604. ISBN-13: 9780070171688

Ethology

- Alcock, J. (2001): Animal Behaviour- An Evolutionary Approach (7th Ed.) Sinaur Associates, Inc. ISBN-10: 0878930116
- Bear, F.M., Connors, B.W. & Paradiso, M.A. (2001). Neuroscience, exploring the brain (2nd Ed). Lippincott Williams & Wilkins, Baltimore, pp 855. ISBN: 0 683 30596 4

- Gleitman, H., Fridulund, A.J. & Reisberg, D. (1998). Psychology (2nd Ed.). W.W Norton & Company, Inc., New York, pp 849. ISBN: 0 393 97364 6.
- Bradbury, J.W. & Vehrencamp, S.L. (1998). Principles of animal communication (2nd Ed). Sinauer Associates, Inc., Sunderland, Massachusetts, USA.
- Clutton-Brock, T.H. (1991). The evolution of parental care. Princeton University Press, Princeton, NJ, USA. Pp 368. ISBN: 9780691025162
- Eibl-Eibesfeldt, I. (1970). Ethology: The Biology of Behavior (1st Ed). Holt, Rinehart and Winston, Inc., New York. ISBN-10: 0030731305
- Gould, J.L. (1982). Ethology: The mechanisms and Evolution of Behaviour. W. W. Norton & Company, Inc., New York. ISBN-10: 0393014886
- Gadagkar, R. (1998). Survival Strategies-Cooperation and Conflict in Animal Societies. Universities Press, Hyderabad, India. ISBN(13) : 9788173711145
- Goodenough, J., McGuire, B. & Wallace, R.A. (1993) Perspectives on Animal Behavior. John Wiley & Sons, Inc., New York.
- Halliday, T.R. & Slater, P.J.B. (Eds.) (1983). Animal Behaviour Vol.2: Communication. Blackwell Scientific Publications, Oxford.
- Halliday, T.R. & Slater, P.J.B. (Eds.) (1983). Animal Behaviour Vol.3: Genes, Development and Learning. Blackwell Scientific Publications, Oxford.
- Hauser, M.D. (1996). The evolution of communication. MIT Press, Cambridge, Mass. USA. pp 760. ISBN 0-262-08250-0
- Krebs, J.R. & Davies, N.B. (1993). An Introduction to Behavioural Ecology (3rd Ed.). Blackwell Scientific Publications, pp 420. ISBN-10: 0632035463
- Manning, A. & Dawkins, M.S. (1998). An Introduction to Animal Behaviour. (5th Ed.) Cambridge: Cambridge University Press. ISBN 0521578914
- Slater, P. & Halliday, T. (Eds.). (1994): Behaviour and Evolution (1st Ed.) Cambridge University. Press. Pp 348.

MODEL QUESTION PAPER

19PZO32: ECOLOGY, ETHOLOGY AND BIODIVERSITY CONSERVATION

Time: 3 Hrs

Max. Marks: 75

I. Write short notes on ten of the following. Each question carries 2 marks.

1. Ecotone
2. Imprinting
3. Biotic potential
4. CITES, 1975
5. Habituation
6. Commensalism
7. Ecological equivalents
8. Indicator species
9. Brundtland Report, 1987
10. Pulse stability
11. Compression Hypothesis
12. Orientation
13. Territoriality
14. RAMRA, 1986
15. Cognitive learning

(10 × 2 = 20 Marks)

II. Answer six of the following. Each question carries 4 marks.

16. Explain the concept of fundamental and realized niche.
17. Comment on Gause's Principle and Lotka -Volterra model.
18. Describe the Ramsar Convention (1971) in India and Kerala.
19. Distinguish between keystone species and Umbrella species.

20. Explain *r* and *k* selection.
21. Describe classical conditioning and operant conditioning. Give examples.
22. Explain primary and secondary productivity.
23. Describe pheromones and chemical communication.
24. Explain the Kyoto Protocol and Framework Convention on Climate Change.
25. Explain ecological pyramids.

(6 × 4 = 24 Marks)

III. Answer three of the following. Each question carries 7 marks.

26. Briefly explain the “Project Tiger” and “Project Elephant” programmes.
27. Describe the evolution of communication in development of bird song.
28. Explain pathways of energy flow in an ecosystem.
29. Write an account on Biological rhythms.
30. Explain the biodiversity hot spots in India.

(3 × 7 = 21 Marks)

IV. Answer one of the following. The question carries 10 marks.

31. Elaborate an account on bird migration.
32. Write an essay on Ecological Succession with examples.

(1 × 10 = 10 Marks)

19PZO33: IMMUNOLOGY AND DEVELOPMENTAL BIOLOGY

Total hours: 100

Course outcomes

CO1: Understand the most essential fundamentals of immune system, immunogens and immunoglobulins.

CO2: Understand immunological concepts in other specialized fields that they will encounter in their higher studies.

CO3: Understand tissue transplantation and defects in immune mechanism.

CO4: Understand events in fertilization, early embryological developments, genetic control and gene action in development.

CO5: Explain the scope of IVF, embryo transfer, stem cell research, prospects of human cloning and ethical values involved.

IMMUNOLOGY

(40 hrs)

Module 1. Introduction to Immune System

(4 hrs)

1.1 Types of immunity, innate and acquired immunity; passive and active immunity; humoral and cell-mediated immunity (self -study).

1.2 Organs of immune system: Primary and Secondary lymphoid organs.

1.3 Brief account on immune cells: types and production.

Module 2. Immunogens (Antigens)

(6 hrs)

2.1 General properties and function, variability and diversity.

2.2 Factors affecting antigenicity.

2.3 Epitopes and Haptens.

2.4 Adjuvants and their role in enhancing immunogenicity.

Module 3. Immunoglobulins (antibodies)

(8hrs)

3.1 General Properties-Structure and functions (Self -study)

3.2 Different classes of immunoglobulin (IgA, IgD, IgE, IgG and IgM) (Self -study)

3.3 Genetic basis of antibody diversity: Immunoglobulin gene organization; Gene rearrangement and expression. Somatic recombination: V (D) J recombination and functional diversity

Somatic hyper mutation, Class switching.

3.4 Polyclonal & Monoclonal antibodies

3.5 Hybridoma technology — technique and applications

Module 4. Antigen-antibody interactions (10hrs)

- 4.1. Antigen presenting and processing- Class I,II, MHC molecules, role of antigen presenting cells
- 4.2. Strength of antigen-antibody interactions, Cross reactivity, precipitation reaction, Agglutination reaction. Alternatives to antigen-antibody reaction.
- 4.3. Immunodiagnosics-Radio immunoassay, ELISA, Western blotting, Immuno precipitation, Immunofluorescence.

Module 5. Complement System (5 hrs)

- 5.1 Complement systems-General features
- 5.2 Classical and alternate pathways, complement receptors, biological effects of complement.

Module 6. Transplantation (3 hrs)

- 6.1. Classification of grafts (Self -study)
- 6.2. Role of MHC in tissue transplantation; Mechanism of graft retention and rejection.
- 6.3. General immunosuppressive therapy:

Module 6. Defects in Immune Mechanisms (4 hrs)

- 6.1 .Defective innate immune mechanisms
- 6.2 Auto immune diseases

DEVELOPMENTAL BIOLOGY (60 hrs)

Module 1 Introduction to Embryology & Developmental Model Systems (16 hrs)

- 1.1. Definition, history, Scope of embryology and Practical applications (self -study)
- 1.2 Early development of *Drosophila*-Egg, cleavage, mid-blastula transition, gastrulation
- 1.3 Early development of *Caenorhabditis elegans*-Egg, cleavage and gastrulation.
- 1.4 Genetic control of development and embryonic axis formation.
 - 1.4.1 Gene action in development of *Drosophila*:- Maternal effect genes; Segmental genes (gap genes, pair-rule gene and segment polarity gene) and Homeotic genes. (Homeobox and homeo domains)
 - 1.4.2 Hox cluster genes in vertebrates.

Module 2. Fertilization (8 hrs)

- 2.1. Events in fertilization
- 2.2 Prevention of polyspermy
- 2.3 Significance of fertilization

Module 3. Medically assisted human reproductive technologies (12 hrs)

- 3.1 Conventional in vitro fertilization and embryo transfer (IVF-ET) - general protocol (Patient selection, manipulation of menstrual cycle, superovulation, oocyte retrieval, preparation of semen sample, IVF treatment, embryo transfer.
- 3.2 Gametic Intrafallopian Transfer (GIFT)
- 3.3 Zygotic Intrafallopian Transfer (ZIFT)
- 3.4 Tubal Embryo stage Transfer (TET)
- 3.5 Intra-cytoplasmic sperm injection (ICSI)
- 3.6 Intra Uterine Insemination (IUI)

Module 4. Embryonic Induction (10 hrs)

- 4.1 Types of embryonic induction — Primary, Secondary and Tertiary Induction (Experiments of Spemann and Mangold) (self- study)
- 4.2 Mechanism of axis formation in amphibians; Nieuwkoop centre.
- 4.3 The functions of organizer; the diffusible proteins of the organizer 1; the BMP inhibitors.

Module 5. Stem cells (4hrs)

- 5.1. Stem cells – properties, types, treatments, advantages and disadvantages of stem cells.

Module 6. Cloning experiments in animals & Ethical Implications (10 hrs)

- 6.1 Genomic equivalence; multiple potencies; differential gene expression.
- 6.2 Amphibian cloning, cloning mammals, human cloning-prospects and demerits, Ethical implications.

References

Developmental Biology

- Scott, F. Gilbert; (2000) *Developmental biology*, Sinauer Associates, Inc., Publishers, Massachusetts.
- V.R. Walvekar, M.J.Jassawalla, P.H.Anjaria and R.J. Wani, *Reproductive Endocrinology- A Clinical approach*
- K. Vasudeva Rao, *Developmental Biology - a modern synthesis*.
- R.M. Twyman, *Developmental Biology*
- Lewis Wolpert, et al., (2000) *Principles of Development*, -Oxford-University Press. • Balinsky, B.I, *An Introduction to Embryology*
- D.J.Bejley, J.A. Firth, J.R.F.Houtt, *Human Reproduction and Developmental Biology*

Immunology

- Roitt, L, Brostoff, J and Male, D., *Immunology*
- Ashim K Chakravarthy, *Immunology*
- M.K. Majumdar, *Microbiology and immunology*
- Kudy (2000) *Immunology*. W.H. Freeman and Company.
- Lydyard, P.M., Whelan, A., and M.W.Fanger (2002). *Instant Notes in Immunology*, Viva Books Private Limited.
- Janeway, Travençolo, (1996) *Immunobiology*. Current Biology Ltd., Middle Sex House 34-42 Cleveland Street, London.

MODEL QUESTION PAPER

19PZO33: Immunology and Developmental Biology

Time: 3 Hrs

Max. Marks: 75

I. Write short notes on ten of the following. Each question carries 2marks.

1. Adjuvants
2. ZIFT
3. Epitopes and Haptens
4. Rheumatoid arthritis
5. Developmental Organizer
6. Hox cluster genes
7. Superantigens
8. Dendritic cells
9. DiGeorge's syndrome
10. Class switching
11. Super ovulation
12. Nieuwkoop centre
13. Genomic equivalence
14. Stem cells
15. Allograft and Autograft

(10x2 = 20 Marks)

II. Answer six of the following. Each question carries 4 marks.

16. Comment on the various Antigen- Antibody reactions.
17. Comment on complements and their involvement in the defense mechanism.
18. Write notes on the theories of antibody formation.
19. Comment on the ethical implications of cloning and embryo transfer.
20. Differentiate between ICSI and IUI.
21. Write notes on embryonic stem cells and its applications.
22. Comment on Somatic hyper mutation.
23. Write notes on monoclonal antibodies and their applications.
24. Write notes on primary and secondary immune responses.
25. Give a brief account on Auto immune diseases.

(6x4 = 24 Marks)

III. Answer any three of the following. Each question carries 7 marks.

26. Explain the genetic basis of antibody diversity.
27. Briefly explain the Hybridoma technology and its applications.
28. Give an account on the in vitro fertilization and embryo transfer along with the different types of medically assisted human reproductive technologies.
29. Describe the different types of embryonic induction.
30. Describe the mechanism of axis formation in amphibians.

(3x7 = 21Marks)

IV. Answer ONE of the following. The question carries 10 marks.

31. Explain in detail the mechanism of gene action in *Drosophila* development.
32. Give a detailed account of the complement components, their activation pathways and regulation.

(1x10 = 10 Marks)

PRACTICAL III

19PZO34: MICROBIOLOGY, BIOTECHNOLOGY, ECOLOGY, IMMUNOLOGY & DEVELOPMENTAL BIOLOGY

MICROBIOLOGY & BIOTECHNOLOGY

1. Techniques for Isolation of bacteria - serial dilution, pour plate, spread plate techniques.
2. Study of bacterial flora of environment – Laboratories, soil, water, fermented foods and spoiled foods, commercial samples of water and drinks etc
3. Motility Testing - hanging drop method.
4. Gram staining.
5. Determination of quality of milk - methylene blue reductase test.
6. Biochemical tests - catalase test, kovac's oxidase test, gas production etc.
7. Isolation of DNA from plant/animal tissue.
8. Plasmid isolation.

IMMUNOLOGY

1. Antigen-antibody interaction in vitro and identification of blood groups.
2. Blood film preparation and identification of cells.
3. Detection of pregnancy using kits.
4. Immunodiffusion and Immunoelectrophoresis

DEVELOPMENTAL BIOLOGY

1. Induced ovulation
2. Preparation of temporary whole mounts of chick blastoderm
3. Vital staining of chick blastoderm and tracing the development of stained parts (window method)
4. Effect of drugs on heart beat of chick embryo.
5. Study of different types of eggs: insect egg, frogs egg, hen's egg, mammalian egg-using models/charts
6. Morphological and histological studies of different placental types of mammals (3 numbers)
7. Identification of cross sections of chick embryo through heart, eye and ear.
8. **Study of life cycle of *Drosophila melanogaster*.**

ECOLOGY

1. Estimation of pyramid of numbers and biomass in a small ecosystem.
2. Estimation of Primary productivity using dark and light bottles.
3. Description of ecological adaptations of any 10 organisms.
4. Habituation" in *Pila* / alarm response in ants or fishes / maize learning in rats.
5. Study of biodiversity indices:
 - a. Population
 - b. Density and relative density
 - c. Frequency and relative frequency

- d. Abundance and distribution
- e. Modified similarity Index
- f. Shannon- Wiener Index
- 6. Composition assessment of the Taxonomic diversity biodiversity in a habitat (grass land, Wet land, etc.)
- 7. Assessment of Invertebrate and Vertebrate diversity in your locality (e.g. campus).
- 8. *Insect diversity in soil.***
- 9. Quantitative estimation of plankton
- 10. *Principles of GIS, GPS and RS technology.***
- 11. *Interpretation (visual and automated) of remote sensing information for landscape differentiation***
- 12. Poster Presentation on a relevant topic (e.g. International conventions and treaties, species interactions, biodiversity loss, etc.)

SEMESTER - IV

SPECIAL COURSE: FISH BIOLOGY AND FISHERY SCIENCE

19PZO41: ICHTHYOLOGY

Total hours: 100

Course Outcome

CO1: Describe the distribution of fishes in different habitat, and their adaptation to special conditions.

CO2: Understand morphology, bionomics and biology of fishes.

CO3: Understand the mechanism of locomotion, endocrine gland functions and sense organs in fishes

CO4: Describe the techniques of hybridisation, chromosome manipulation and sex determination.

Module 1. Classification and distribution of fishes (12hrs)

1.1. Scope and history of Ichthyology (self- study)

1.2. Geographical distribution of fishes in marine and freshwater habitats

1.3. Distribution of fishes in marine and freshwater, habitats in India and Kerala

1.4. Distribution of brackish water fishes of India and Kerala

1.4. Classification of fishes, up to family- distinguishing characters with examples 1.5. Bar-coding in fish taxonomy

Module 2. Adaptation of fishes to special conditions (8 hrs)

2.1. Deep sea fishes

2.2. Cave dwelling fishes

2.3. Hill stream fishes

2.4. Air breathing fishes

2.5. Venomous fishes , Ornamental fishes

2.6. Larvicidal fishes and biological control

Module 3. Functional morphology and bionomics fishes (15 hrs)

3.1. Gross external anatomy of fishes

3.2. Body form diversity

3.3. Fins-types structure, function and modifications

3.4. Skin-structure and function

3.4.1. Scalation - types of scale, structure, development and modifications

3.4.2. Coloration —types of chromatophores, biological significance.

Module 4. Food, feeding, digestion and growth in fishes (10 hrs)

4.1 Basic anatomy of digestive system of a cartilaginous and a bony fish

4.2 Food and feed in habits-natural food, feeding habit and adaptations; feeding in relation to season; growth, sex and breeding; gastro-somatic index

4.3 Digestion absorption and. utilization of food

4.4 Growth in fishes- length and growth relationship, growth curve and growth studies using scales and condition- factor

Module 5. Excretion and osmoregulation (7 hrs)

5.1. Brief account of structure and function of kidney.

5.2. Hormonal control of excretion and Osmoregulation

5.3 Osmoregulation in freshwater, brackish water and marine fishes

Module 6. Locomotion (8 hrs)

6.1. Types of locomotion-swimming non swimming

6.2. Body form and locomotion

6.3. Fins and locomotion

6.4. Swim bladder and buoyancy-origin and function

6.5. Weberian ossicles and its significance

- Module 7. Sense organ in fishes** (10 hrs)
 7.1. Lateral line sense organs, Ampullae of Lorenzini,
 7.2. Chemo, mechano, thermo, and electro receptors
 7.3. Structure of eye and visual pigments
- Module 8. Endocrine glands in fishes** (10 hrs)
 8.1 Structure and function of — Pituitary gland, ultimobranchial gland, Caudal neuro-secretory cells, urophysis, corpuscles of stannous, Inter renal tissue and chromaffin tissue, islets of Langerhans, thyroid gland, gonad and pineal organ
- Module 9. Reproduction in fishes** (10 hrs)
 9.1. Sexuality-hermaphroditism, unisexuality and bisexuality
 9.2. Gonads- phases of maturity, length at first maturity, gonado-somatic index, fecundity
 9.3. Reproductive behavior-sexual dimorphism, courtship; parental care, nest building
- Module 10. Fish genetics** (10 hrs)
 10.1. Sex determination in fishes
 10.2. Recent trends and techniques of hybridization
 10.3. Chromosome manipulation in fishes
 10.4. Transgenesis in fishes

**MODEL QUESTION PAPER
 19PZO41: ICHTHYOLOGY**

Time: 3 hrs

Max.Marks: 75

I. Answer any TEN of the following questions. Each question carries two marks.

1. Name any two venomous fishes.
2. What do you mean by Gastrosomatic index.
3. What are neurosecretory cells/
4. Give the functions of the ultimobranchial gland.
5. Name any two larvicidal fishes.
6. State the functions of Ampulla of Lorenzini.
7. Define cycloid scales.
8. Write on Perciformes.
9. List out the different types of chromatophores.
10. How will you identify the sex in fishes?
11. Define osmoregulation.
12. Illustrate Weberian ossicles and explain briefly.
13. Write down the functions of visual pigments.
14. Write a note on fish barcoding.
15. Give the scientific name of any two fresh water fishes of India.

(10 x2 =20)

II. Answer any SIX of the following . Each question carries four marks.

16. Discuss the adaptations of deep sea fishes.
17. Briefly explain any two marine fishes.
18. Brief on the adaptations of hill stream fishes.
19. Comment on the growth studies of fishes using scales.
20. Write a note on the hybridization of fishes.
21. List out the different body forms of fishes and give examples.
22. Comment on the feeding habits of fishes.
23. Bring out the significance of chromatophores.
24. Write a note on the chromaffin tissue.
25. Brief the mechanism of digestion in carnivorous fishes.

(6x4 =24)

III. Answer any THREE of the following. Each question carries seven marks.

26. List the different types of fins and mention their functions. Give illustrations wherever possible.
27. Highlight the nest building and parental care in fishes.
28. Explain the different types of swimming movements.
29. Elaborate on the chromosome manipulation techniques in fishes.
30. Give an account on the structure and function of the kidney.

(3X7=21)

IV. Answer any ONE of the following. The question carries 10 marks.

31. Write an essay on larvicidal fishes and its biological control.
32. Expound the structure and functions of swim bladder.

(1x10=10)

19PZO42: FISHERIES AND AQUACULTURE

Course outcome:

- CO1: To make the student aware of the vast potentials involved in ornamental fish farming and trading
CO2: To familiarize with the fisheries sector its development potential in India and abroad.
CO3: To have an in-depth understanding of fish harvest and post-harvest technology
CO4: To have an exhaustive understanding of aquaculture practices and its management.
CO5: To have an entrepreneurial expertise in pisci culture, aqua farm management, aqua feed production, fisheries export and value added fish products.

FISHERIES

Module 1. Fishery Science

(15 hrs)

- 1.1 Importance of Fishery science-Inland fisheries, Marine fisheries, capture fisheries and culture fisheries
- 1.2. Inland capture fisheries- Riverine fisheries, reservoir fisheries, cold water fisheries and estuarine fisheries. Importance of Mangroves in fisheries.
- 1.3. Marine capture fisheries in India- Offshore and deep sea fisheries- fin fish fishery, shell fish fishery (crustacean and Molluscan)

Module 2. Methods of fishing

(7 hrs)

- 2.1 Indigenous fishing crafts of India: sea fishing. crafts- Catamaran, Musula boat, caravel boats, Dinghi, Dugout canoes, plank built canoes, out trigger canoes(self- study)
- 2.2 Inland fishing crafts: Dug out and plank built boats (self -study)
- 2.3 Mechanized Indian fishing crafts- fishing vessel characteristics
- 2.4 Indigenous fishing gears in India: Traditional and conventional; sea fishing gears and inland fishing gears
- 2.5. Application of Remote Sensing and GIS in fisheries.

Module 3. Harvest and Post -harvest Technology

(20 hrs)

- 3.1 Harvesting- precautions observed during harvesting, sorting, and grading the catch
- 3.2 Nutritive value of fish and biochemical composition of fish flesh
- 3.3 Fish spoil age and preservation
- 3.4 Fish preservation and processing- Icing and freezing, canning, salting, Drying, curing, smoking etc
- 3.5 Fish products and byproducts- Liver oil, meal, manure, glue, isinglass, Leather, chitosan, fish maws, fish protein concentrate, fish fins
- 3.6 Fish food poisoning

Module 4. Fish Export and Extension

(5 hrs)

- 4.1 Transportation and marketing: Overseas market for diversified products and principal world market for diversified sea food products
- 4.2 Fisheries extension: concept and present status in India and abroad, special reference Kerala
- 4.2 The status of Indian fishery co-operative movement and Fish farmers development agencies.

AQUACULTURE

Module 5. Aquaculture

(10 hrs)

5.1 Scope and objectives of aquaculture; status in India

5.2 Culture systems – Criteria for space and site selection, Culture systems-, Pokali culture, Pond, Bheries, salt pans, tanks, race way, cage, pens etc.

5.3 Hatcheries- different types.

5.4 Design and construction of aqua farms, aquaculture engineering- aquahouses,

Module 6. Breeding and seed production

(10 hrs)

6.1 Bionomics of cultivable species of fish and shellfish (Mulletts, milk fish, pearl spot, carps, Seabass, Cobia, *Penaeus* spp., *Macrobrachium*-sp.)

6.2 Breeding and seed production of fishes with special reference to Indian major carps - wet and dry bunch technique for breeding

6.3 Induced breeding

6.3.1 Induced breeding in Fish - Principle, techniques and advantages of hypophysation, selective breeding and 'seed production

6.3.2 Induced breeding in Prawn and Shrimp- Techniques involved in shrimp breeding and seed production eye stalk ablation etc.

6.3.3. Breeding and larval rearing of Crabs.

6.4 Transport of live fishes-.fingerlings and breeders

6.5 Cryopreservation of gametes and embryos

6.6 Common fish diseases - viral, fungal, bacterial and parasitic infections

Module 7. Nutrition in culture fishes

(3 hrs)

7.1 Nutritional requirement of a culture fish

7.2 Feed-Live and formulated.

7.3 Procedure of Feed formulation

7.4 Alternative protein sources in aquaculture diets, role of probiotics in nutrition

Module 8. Methods of fresh water and brackish water fish culture

(10 hrs)

8.1 Monoculture - Indian major carps (Catla, Rohu, Mrigal), exotic carps, Tilapia

8.2 Composite culture

8.3 Culture of air breathing fishes - ecology of swamps & use in culturing air breathing fishes

8.4 Ornamental fish culture- exotic and indigenous species

8.5 Aquarium set up and maintenance; Aquarium plants and aquarium accessories

8.6 Frog culture

Module 9. Crustacean Farming

(7 hrs)

9.1 Shrimp culture: traditional and scientific brackish water culture practices in India with special reference to Kerala.

9.2 Prawn Culture

9.3 Lobster culture

9.4 Crab culture

Module 10. Mariculture in India

(5 hrs)

10.1 Sea farming and sea ranching

10.2. Pearl culture and culture of edible molluscs

10.3 Turtle farming

10.4. Sea weed cultivation

Module 10. Integrated fish culture

(5 hrs)

10.1 Paddy cum fish culture

10.2 Fish-livestock farming- manurial value of livestock wastes and their role in recycling for raising fish production

10.3 Sewage fed fish culture.

10.4. Aquaponics

Module 11. Sustainable aquaculture

(3hrs)

11.1 Aquacultural wastes and future developments in waste minimization, environmental consequences of hypernitrification.

11.2 Fish vaccines-strategy and use in aquaculture.

11.3. Probiotics and immunostimulant in aquaculture.

FIELD WORK

1. Visit to freshwater and brackish water fish farms.

2. Collection of water & soil samples of fish ponds for analyzing hydrographical parameters.

STUDY TOUR

Visit to fisheries institutes and fishing harbours to study the following:

1. Freshwater and brackish water aqua culture.

2. Fishing operations

3. Fish preservation and processing

4. Boat building and net making

5. Fisheries research, survey, education and extension

MODEL QUESTION PAPER 19PZO42: Fisheries and Aquaculture

Time: 3hrs

Total Marks:75

I. Write short notes on TEN of the following. Each question carries 2 marks

1. Comment on catamaran.
2. Explain Mariculture
3. Briefly describe Isinglass
4. Comment on trawl net.
5. Explain exclusive economic zone.
6. Comment on *Fenneropenaeusindicus*.
7. Differentiate between monoculture and polyculture.
8. Describe Mullet.
9. Comment on cryopreservation.
10. Explain sea ranching.
11. What are continental shelves?
12. Comment on CIBA.
13. Comment on salting.
14. Comment on Mrigal.
15. Explain boat seine and its applications.

(10×2=20 marks)

II. Answer SIX of the following. Each question carries 4 marks.

16. Define cage culture
17. Explain various methods involved in the transport of fingerlings.
18. Explain the importance of seaweeds.
19. Briefly explain crustacean fishery
20. Advantages of smoking in preservation
21. Explain the culture of air-breathing fishes
22. Write an account on fisheries extension.
23. Explain recent trends in hybridization techniques of fishes.
24. Comment on sex determination in fishes.
25. What are the importance of larvicidal fishes?

(6X4=24 marks)

III. Answer THREE of the following. Each question carries 7 marks.

26. Comment on the importance of hatcheries in aquaculture.
27. Write an account on reservoir fisheries.
28. Comment on sewage fed fish culture.
29. Comment on the breeding techniques of major Indian Carps.
30. Discuss various fish vaccines-strategy and their use in aquaculture.

(3×7=21 marks)

IV. Answer ONE of the following. Each question carries 10 marks.

31. Explain the principles, techniques and advantages of induced breeding of fishes and prawns.
32. Explain in detail the integrated fish culture.

(1×10=10 marks)

PRACTICAL I

19PZO43: ICHTHYOLOGY

Taxonomy

1. Identification and classification of 10 local fishes (Marine/freshwater) up to species level
2. Identification and classification of 5 prawns up to species level

Dissections and Mounting

3. 5th Cranial nerve of a teleost fish.
4. Accessory respiratory Organs in fish (any 2)
5. Fish Brain (Mounting)
6. Scales-Placoid, cycloid; ctenoid.
7. Digestive system of a fish (cartilaginous or bony fish)
8. Urinogenital system of a teleostean fish
9. Pituitary gland
10. Mounting of Otolith.

Fish Physiology

11. Qualitative and 'quantitative analysis of gut content in a herbivorous and carnivorous fish
12. Determination of gastro somatic index
13. Smear preparation of fish blood to study the morphology of different cellular elements
14. Differential count of fish WBC Fish genetics
15. Sex determination –morphological (any3)
16. Hybridization techniques in fishes
17. Karyotyping in fishes
18. *Osmoregulation- in different abiotic conditions*

PRACTICAL II

19PZO44: FISHERIES AND AQUACULTURE, FISH POND ECOLOGY

Fish Pond Ecology

1. Determination of nutrients in the water samples from freshwater and brackish water ponds (Phosphate, sulphate, and nitrate)
2. Determination of free calcium carbonate in the soil sample from freshwater and brackish water ponds
3. Determination of LC 50 for fish exposed to a given pollutant

Fish Pathology

4. Identification of common external fish parasites (At least 5 numbers)
5. Estimation of spoilage in fish by pH method
6. Determination of bacterial plate count for fish skin, flesh and gut Breeding Techniques
7. Mounting of pituitary gland
8. Preparation of pituitary gland extract

9. Demonstration of hypophysation technique
10. Demonstration of artificial insemination
11. Demonstration of sperm motility in a fish
12. Preparation of a formulated fish feed Fish byproducts
13. Identification and study of fish byproducts
14. Preparation of anyone fish byproduct
15. **Estimation of ovarian egg counts**
16. Analysis of proximate composition of fish

Fishing crafts and gear

17. Identification and study of different types of fishing crafts (Minimum 5 numbers)
- 18 Identification and study of different types of fishing gears (Minimum 5 numbers)

Aquarium setting and management

19. Setting up of an aquarium
20. Study of aquarium accessories
21. **Collection and identification of aquatic weeds and aquatic insects** (Minimum 5 numbers)

Fisheries Extension

22. **Visit to a coastal/ mariculture farm and harbour and study the socio-economic status of the fisherman community.**

References

- Ali, M. 1-80) Environmental-Physiology of fishes advanced Study Institute series. Series A: Life sciences, vol. 35, Plenum Press, New York.
- Bal, D.V. and Rao, K.V.(1989). Marine Fisheries. Tata Mac Graw Hill Publishing Co., Delhi.
- Biswas, K.P. (1996).A text book of fish, fisheries and technology. Narendra Publishing House, Delhi.
- Balakrishnan, N. and Thampy D.M. (1990) A text book of marine ecology. Macmillan ce., India
- Barnes, R.S..K- and Mann, K.H.(1980). Fundamentals of aquatic ecosystems. Blackwell Scientific Publications, Oxford and London.
- Beavan, R.(1990). Freshwater fishes of India Low price Publications, Delhi.
- Biswas (1993). Manual of methods in fish biology. South Asian Publishers Ltd., Delhi.
- Boyd, C.E.(1979). Biology of fishes. Saunders Publ. Philadelphia
- Boyd, C.E. (1982). Water quality management for pond fish culture: developments in aquaculture and fisheries sciences, Elsevier, Amsterdam.
- Bye, V. J. and Ponniah, A.G. (1983). Application of genetics in aquaculture. CMFRI special publication, NO.13, CMFRI, Cochin.
- Charles, T. Cutting (1996). Fish processing and preservation. Agro Botanical Publishers, Bikaner. Claude E Boyd,(1984). Water quality management in aquaculture, CMFRI special Publication, No.22
- Cushing, D.H. 1980 Marine ecology and fisheries. Cambridge University Press
- Das, P. and Jhingran,A.G .(1989). Fish genetics in India. Today and tommrrow's Printers and publishers, New Delhi
- Datta Munshi, J.J. and H.M. Dutta(1995). Fish morphology: Horizon of new research. Oxford and IBH Publishing Co.,Pvt. Ltd.
- Gahlawat, S.K. and R.K. Gupta(2007). Manual of experimental Ichthyology, Day a Publishing House, New Delhi.
- Gerhard Brunner,(1973). Aquarium plants, TFH.Publications, Inc. Ltd., Hong Kong
- Gupta, S.K. and P.O . Gupta (2006). General and applied Ichthyology, S. Chand and Co. New Delhi
- Halver J .E. (1977). Fish nutrition. Academic press, London.
- Harvey, BJ and Hoar W.S. (1979) .Theory and practice of induced breeding in fish international Development Research Centre, Ottawa.
- Hoar, W.S. and Randall, DJ.(1969-1988). Fish Physiology. Vols.I-X. Academic press, New York.
- Jayaram, K.C.(1981). The freshwater fishes of India, Pakistan, Bangladesh, Burma and SriLanka- a hand book. Zoological survey of India, Calcutta.
- Jhingran, V.G.(1991). Fish and fisheries of India. Hindustan Publishing Corporation(India) ,New Delhi.

- John, S. Lucas and Paul C. Southgate(2000) Farming aquatic animals and Plants. Fishing News Books, Blackwell publishing co.,
- Jorgen Hansen,(1979). Making your own aquarium, Bell and Hyman Ltd. London
- Lagler, K.F.,Bardach, J.E., Miller, R.R. and D.R. May Passino(2003). Ichthyology. John Wiley and sons (Asia) Pvt. Ltd., Singapore.