SEMESTER III			
Core IX	**Computational Biology**		
Course Code: 21PZOC31	**Hrs/ Week: 6**	**Hrs/ Sem: 90**	**Credits: 4**

Objectives

- To understand the central principles and concepts of computational methods, tools and algorithms for biological data analysis and interpretation
- To impart interdisciplinary expertise in biological science, computer science and mathematics

Course Outcome

CO. No	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	understand descriptive and inferential statistical methods effectively	1,3	Un
CO-2	apply the methods of hypothesis testing, statistical inference and designing experiments	4	Ap
CO-3	analyse and interpret the biological data in a statistical perspective correctly and contextually	4	An
CO-4	infuse critical appraisal skills to assess the research data and produce original research	7	Cr
CO-5	carryout correlation and regression analysis and recognize theoretical distributions	6	An
CO-6	Formulate and test using appropriate statistical tools and softwares	4	Cr
CO-7	convert biological data into computational problem and execute quantitative analysis	5	Ap
CO-8	Demonstrate the mastery of concepts of skills for biological data management, analysis and graphical presentation	1,2	Ap

Unit I Biostatistics – Descriptive Statistics

Introduction – measures of central tendency - arithmetic mean, geometric mean, harmonic mean, median and mode – measures of dispersion – range, quartiles, mean deviation, variance, standard deviation, standard error and coefficient of variation – measures of skewness and kurtosis – stem and leaf diagram – boxplot.

Unit II Inferential Statistics

Theoretical probability distributions – binomial – Poisson – normal distribution – steps in hypothesis testing procedure – student's t – test and its applications in experimental biology – chi – square test – goodness of fit and contingency tables – ANOVA – assumptions – types – one-way and two-way – factorial design and randomized block design.

Unit III Correlation and Regression

Correlation – types – methods of determining correlation - graphical methods – mathematical methods – Computation and interpretation of Karl Pearson's correlation coefficient – coefficient of determination - Spearman's rank correlation coefficient – regression – types – regression lines and their properties – algebraic method of fitting linear regression equations and forecasting – relationship between correlation and regression coefficients.

Unit IV Computer Applications

MS Excel – spread sheet – statistical analysis of data - calculation of arithmetic mean – t test – ANOVA one-way classification – statistical packages – GenStat – statistical calculation – SPSS package – Principal Component Analysis (PCA).

Unit V Bioinformatics

Nucleic acid databases - DDBJ – protein sequence databases - NBRF – PIR and PSD - database similarity searches – Smith – Waterman algorithm – Needleman – Wunsch algorithm – scoring matrices-PAM and BLOSUM – multiple sequence alignment – sum of pair-wise method and progressive method – Phylogenetic trees – structure, construction and interpretation.

Books for Reference

1. Gurumani N. *An Introduction to Biostatistics*. Chennai: MJP Publishers, 2nd Edition, Triplicane, 2005.
2. Agarwal S.K. *Bioinformatics.* New Delhi: APH Publishing Corporation, 2008.
3. Gautham N. *Bioinformatics - Databases and Algorithms*. New Delhi: Narosa Publishing House Pvt Ltd., 2009.
4. Thiagarajan B. and Rajalakshmi Pa. *Computational Biology.* Chennai: MJP Publishers, 2009.
5. Rajathi A and Chandran P. *SPSS for you*. Chennai: MJP Publishers, 2010.
6. Claverie J M. and Notredame C. *Bioinformatics for Dummies.* 2nd edition, Hoboken: Wiley Publishing Inc, NJ07030-5774, 2007.
7. Pezzullo J.C. *Biostatistics for Dummies.* Hoboken: John Wiley & Sons Inc., NJ07030-5774, 2013.
8. Khan I and Khanum A. *Introductory Bioinformatics*. Hyderabad: Ukaaz Publications, 1st edition, 2004.

PRACTICALS

Course Code: 21PZOCR5

Hrs/ Week: 2 **Credit: 1**

1. Computation of mean, median, mode, variance, standard deviation, standard error and coefficient of variation for biological variables.
2. Display of data through stem and leaf diagram.
3. Test of significance using student's t – test.
4. Test of goodness of fit of data with the aid of chi – square test.
5. Analysis of variance of molluscan shells
6. Correlation coefficient between height and weight of students and length and width of leaves.
7. Fitting regression equations for two variables and prediction of values.
8. Statistical calculation (ANNOVA) using SPSS software package (version: 1.0.0.1406).
9. Multiple sequence alignment using Smith – Waterman algorithm
10. Construction of phylogenetic tree.

Books for Reference

1. Gurumani N. *An Introduction to Biostatistics*. Triplicane, Chennai: MJP Publishers, 2nd edition, 2005.
2. Rajadurai M. *Bioinformatics – A Practical Manual*. Chennai: PSB Book Enterprises, 2010.

SEMESTER – III			
Core X	**Aquaculture Practices and Farm Management**		
Course Code: 21PZOC32	**Hrs/Week:6**	**Hrs/Semester:90**	**Credits:4**

Objectives

- To develop a comprehensive knowledge and transferable professional skills for career in aquaculture industry
- To acquaint with technical and general knowledge for competent fisheries management

Course Outcome:

CO. No.	Upon completion of this course, students will be able to	PSO's addressed	CL
CO-1	design aquaculture systems	1	Cr
CO-2	develop practical skills for management of culture ponds	3	Ap
CO-3	apply techniques involved in breeding and culture of various organisms	1,2	Ap
CO-4	demonstrate competency in live feed culture and feed formulation	2,3	Un, Ev
CO-5	evaluate and manage aquaculture diseases, health and safety issues in aquaculture ventures	1,6	Un, Ev
CO-6	discuss important factors for performing a sustainable aquaculture	1,3	Un, Ap
CO-7	compare the principles of genetic improvement of fish stock	1	Un
CO-8	analyse aquaculture economics and marketing strategies	1,3	An, Ap

SEMESTER – III			
Core X	**Aquaculture Practices and Farm Management**		
Course Code: 21PZOC32	**Hrs/ Week:6**	**Hrs/Semester:90**	**Credits:4**

Unit I **Aquaculture Basics and Management**

Scope of aquaculture, Fishery resources of India and Tamil Nadu. Selection of site, construction of fish farm, soil chemistry, construction of different types of fish ponds. Management of culture ponds - fertilization, water quality management, predators and weed management.

Unit II **Seed Production and Culture Techniques**

Carp culture : Carp: Brooders care and management seed collection from natural sources, bundh breeding, hypophysation, fish seed transport, hatching and rearing techniques. Culture of edible oyster, pearl oyster and sea weed.

Unit III **Nutrition and Health Management**

Culture of fish feed organisms: diatoms, cladocerans, rotifers, artemia. Artificial feed formulation and management. Bacterial (gillrot & Furunculosis) viral (EUS White spot disease, Erythrocytic necrosis) fungal diseases (Saprolegniasis & Branchiomycosis) Nutritional deficiency diseases, ectoparasites, endoparasites, principles of fish health management, fish vaccines.

Unit IV **Integrated Aquaculture Management**

Water pollution, its effect on fisheries and methods of its abatement. Sewage – fed fish culture - sewage treatment. Integrated fish farming - animal husbandry cum fish culture, paddy cum fish culture, fish culture in cages and pens. Culture of air breathing fishes.

Unit V **Aquaculture Biotechnology and Economics**

Genetic improvement of stock - hybridization, polyploidy, production of monosex, sterile fish, transgenic fish, gynogenesis, androgenesis. Aquaculture economics, fish marketing, involvement of government organizations in marketing. Role of CMFRI, NIOT, CIBA & NABARD.

Books for Reference

1. Dubey. S.K. and Band and Ghosh. *Fish Biotechnology*. New Delhi: Wisdom Press. 2012.
2. Amita Saxena. *Fisheries Economics*. New Delhi: Daya Publishing House. 2011.
3. Schonder. S.L. *Hypophysation in Indian Major Carps*. Agra: Sathish Book Enterprises 1980.

4. Pandian. I.D. Abhinandan Kumar and Rajbhushan Prasad. *Aquaculture and Biotechnology*. New Delhi: A.K. Publ. 2009.
5. Agnihotri. S.B. *Aquaculture Management and Technology*. New Delhi: Swastik Publication. 2013
6. Felix. S. *Marine and Aquaculture Biotechnology*. Jodhpur, India: Agrobios. 2010.
7. Santhanam. R., Ramanathan, N. and G. Jegathesan. *Coastal Aquaculture in India.* Delhi: CBS Publishers 1st edn. 1990.
8. Shagufta. *Fish Health and Diseases*. New Delhi: APH Publishing Corpoartion. 2012.
9. Yougesh Kumar and Rajeev Tyagi. *Aquaculture Fisheries Biotechnology and Genetics*. Delhi: Mangalam Publishers & Distributors. 2013.
10. Chandra Sekar. Y.S. *Fish Nutrition in Aquaculture*. Delhi: Swasthik Publishers & Distributers. 2012.
11. Rajendra Kumar Rath. *Freshwater Aquaculture*. Jodhpur: Scientific Publishers. 2011.
12. Singh. V.B. *Fish Farming.* New Delhi: ALP Books. 2010.

PRACTICALS

Course Code : 21PZOCR5

Hrs/ Week: 2 **Credit: 1**

1. Estimation of dissolved ammonia in water samples
2. Estimation of alkalinity in water samples.
3. Analysis of fresh water plankton
4. Decapsulation technique and hatching of artemia cysts
5. Feed formulation exercise – preparation of compound feed - Demonstration
6. Identification of cultivable food fishes
7. Identification of aquatic weeds, predatory fishes and insects.
8. Induced breeding in fishes
9. Study of fish parasites and diseases.
10. Visit to aquaculture farm

Books for Reference

1. Methods in Hydrobiology Manual. *Centre for Advanced Studies in Marine Biology*, Published by Annamalai University, Parangipettai, Chidambaram. 2011.

2. Felix, N., Ahilan, B. and S. Athithan. *Fish Nutrition and Feed Technology Manual.* Thoothukudi: Fisheries College and Research Institute Tamilnadu Verteinary & Animal Science University. 2004.

3. FAO Fisheries Technical Paper. No. 361; *Manual on the Production and Use of Live food for Aquaculture.* Laboratory of Aquaculture and Artemia Reference Centre, University of Ghent, Belgium. 1996.

SEMESTER III			
Core XI - Developmental Zoology			
Course Code: 21PZOC33	**Hrs/Week: 5**	**Hrs/Sem: 75**	**Credits: 4**

Objectives :

- To understand the sequential changes in the development and organization of an embryo
- To acquire knowledge about the metamorphosis, regeneration and role of genes in development

Course Outcomes

CO. No	**upon completion of this course, students will be able to**	**PSO addressed**	**CL**
CO-1	define the process of gametogenesis and describe the structure of gametes	**1**	**Kn,**
CO-2	outline the events that lead up to and comprise the process of fertilization	**1, 2**	**Un**
CO-3	compare and contrast the patterns of cleavage in the various model organisms	**2**	**An**
CO-4	discuss the morphogenetic movements, cellular mechanisms and the functions of gastrulation	**2**	**Cr**
CO-5	explain tissue interactions and the development of organ systems in vertebrates	**3**	**Cr**
CO-6	analyse the role of genes in development, aging and senescence	**5**	**An**
CO-7	experiment with the role of hormones in amphibian and insect metamorphosis	**4, 6**	**Ap**
CO-8	determine the ability of regeneration in different groups of organisms	**4, 6**	**Ev**

Unit I **Gametogenesis and Fertilization**

Gametogenesis – spermatogenesis – oogenesis. Structure of gametes - sperm and egg of sea urchin and mammal – types of egg- Fertilization (biochemical, molecular aspects) in sea urchin and mammal- prevention of polyspermy. Parthenogenesis.

Unit II **Cleavage and Gastrulation**

Planes and patterns of cleavage – cleavage in sea urchin, drosophila, frog, bird and mammal. Mechanism of cleavage. Fate map of sea urchin and frog. Gastrulation – morphogenetic movements - gastrulation in sea urchin and frog.

Unit III **Organogenesis**

Derivatives of ectoderm, mesoderm and endoderm. Organogenesis in vertebrates - CNS, eye, heart, kidney, digestive tube and its derivatives-Development of extraembryonic membranes in chick. Placentation in mammals - types and physiology.

Unit IV **Role of Genes in Development**

Genomic equivalence – differential gene expression – amplified genes – selective gene transcription – control of gene expression. Programmed cell death in development – Aging and senescence.

Unit V **Metamorphosis and Regeneration**

Metamorphosis – definition - insect metamorphosis - moulting and metamorphic changes - hormonal control of insect metamorphosis. Amphibian metamorphosis – morphological, physiological, biochemical change and causation of metamorphosis. Regeneration – patterns – morphollaxis - epimorphosis and heteromorphosis – regeneration ability in different group of organisms - mechanism of limb regeneration in amphibian.

Books for Reference

1. Michael J.F. Barresi, Scott F. Gilbert. *Developmental Biology*. USA: OUP USA, 9th Edition. 2010
2. Wendell Smith, C.P., Williams,P.L. and Sylvia Tread Gold. *Basic Human Embryology*. Great Britain: ELBS Edition. Pitman Publishing Ltd., 1996.
3. Banerjee, S. *A Text Book of Developmental Biology*. New Delhi: Dominant Publishers and Distributors, 2015

4. Lewis Wolpert and Cheryll Tickle. *Principles of Development*. New Delhi: Oxford University Press, Fourth Edition . 2018
5. Verma, P.S, Agarwal, V.K. and B.S. Tyagi. *Chordate Embryology*. New Delhi: S.Chand & Company Ltd, 14th Edition. 2010.
6. Sanjib Chattopadhyay. *An Introduction to Developmental Biology*. Kolkata: Books and Allied (P) Ltd., First Edition. 2017.

PRACTICALS

Hrs / Week : 2 **Credit: 1**

Course Code: 21PZOCR6

1. Mounting of chick blastoderm.
2. Study of effect of thyroxin in amphibian metamorphosis
3. Study of regeneration in the tail of tadpoles
4. Culture of Drosophila
5. Observation of sperm, egg, T. S. of testis and T.S. of ovary of frog.
6. Observation of sperm, egg, T.S. of testis and T.S. of ovary of mammal.
7. Observation of developmental stages of frog - cleavage, blastula, gastrula external gill stage and tadpole stages
8. Observation of chick embryos – 24 hrs, 48 hrs, 72 hrs, 96 hrs.
9. Types of placenta in mammals (one eg. in each type).

Books for Reference.

1. Verma, P.S, Agarwal, V.K. and B.S. Tyagi. *Chordate Embryology*. New Delhi: S.Chand & Company Ltd, 14th Edition, 2010.
2. Verma P. S.*A Manual of Practical Zoology Chordates.* New Delhi : S. Chand and Company Ltd, First Edition, 2007.
3. Balinsky B.I. 1976. *An Introduction To Embryology*. Japan: B.W. Saunders Company, U.S.A and Toppan Company Ltd., Fifth Edition, 2012.

SEMESTER III			
Core XII	**Research Methodology and Biotechniques**		
Course Code : 21PZOC34	**Hrs / Week : 5**	**Hrs / Sem : 75**	**Credits : 4**

Objectives

- To make students familiar with various research methods that are obligatory to do quality research in future.
- To equip the students with the knowledge of scientific paper writing
- To prepare the students to utilize the biological techniques in their research

Course Outcome

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	demonstrate critical thinking and scientific approach in the design and implementation of an experiment.	7	Un, Ap
CO-2	develop skills to communicate scientific ideas in both written and oral formats	7	Ap
CO-3	apply a range of qualitative and quantitative research techniques to the scientific issues.	4	Ap
CO-4	identify a working comprehension of the technical and procedural aspects of laboratory testing, safety and ethical standards of practices	6	Ap
CO-5	list different methodologies to be adopted for conducting research in more appropriate manner.	6	An
CO-6	choose new scientific tools, concepts and theories to understand and solve scientific problems.	6	Ev
CO-7	develop a broad range of laboratory skills to perform experiments for employment prospects.	7	Cr
CO-8	design and conduct independent laboratory or field research that is consistent with the highest standards and practices of research	8	Cr

Unit I Research Designing

Introduction - literature collection – sources - Internet and e-journals - literature citation - experimental design - thesis formatting and typing - manuscript preparation, interpretation and report writing and Plagiarism.

Unit II Research Publication & Ethics

IPR: Patent, Copy right, H-index, I-10 index, Ethical Committee, Laboratory safety measures. Calculation of citation index in SCI/ Scopus/ Google scholar/ ICI.

Unit III Microscopy Types

Principle, construction and applications of Phase contrast – Polarization – Electron microscope – types (SEM, TEM) - fixation and staining techniques for EM (Positive and Negative staining, Metal shadowing and Freeze fracture), fluorescence – atomic force and magnetic force microscope – micrometry.

Unit IV Spectroscopic Techniques

Absorption and emission principles – construction and applications of spectrophotometer – UV - visible spectrophotometer, FTIR, spectrofluorimeter - flame photometer - atomic absorption and emission spectrophotometer, ESR and NMR.

Unit V Principles and Applications of Biotechniques

Centrifuge – types: ultra, cooling and density gradient centrifuge, column chromatography, electrophoresis: SDS-PAGE, isoelectric focusing, GM counter – sample preparation for radioactive counting – biochemical application of radioisotopes - autoradiography.

Books for Reference

1. Palanichamy S. and M. Shanmugavelu. *Research Methods in Biological Sciences*. Palani : Palani Paramount Publication.1997.
2. Gurumani. *Research Methodology for Biological Sciences*. Chennai: M.J.P. Publishers. 2011.

3. Veerakumari. L. *Bioinstrumentatio*n. Chennai: M.J.P Publishers. 2007.
4. Aparna Mathur. *Laboratory Instrumentation*. New Delhi: Black Prints. 2013.
5. Chinmoy Goswami, Abhijit Paintal and Rabindra Narain. *Hand Book of Bioinstrumentation.* Delhi: South Anarkali. 2011.
6. Debbie Holmes Peter Moody and Diana Dine. *Research Methods for the Biosciences.* U.K. Oxford University Press. 2006.
7. Rabindra Narain. *Practical Immunology*. New Delhi: Wisdom Press. 2012.

PRACTICALS

Course Code: 21PZOCR6

Hrs/ Week : 2 **Credit : 1**

1. Fractionation of fish liver by density gradient centrifugation
2. Measurement of cell size by micrometry
3. Phase contrast microscopic observation of living cells
4. Estimation of lipids (Bragdon method)
5. Absorption spectra of proteins/ pigments
6. Column chromatographic separation of plant pigments.
7. Checking plagiarism by URKUND (online Demo).
8. Use of different instruments in research methodology (Spotters)
    a. Electronmicroscope
    b. Chromatography – HPLC
    c. SDS-PAGE
    d. G.M Counter

Books for Reference

1. Gurumani. R*esearch Methodology for Biological Sciences*. Chennai: M.J.P. Publishers. 2011.
2. Veerakumari. L. *Bioinstrumentation.* Chennai: M.J.P. Publishers. 2007.

SEMESTER IV			
Core XIII	**Marine Biotechnology**		
Course Code: 21PZOC41	**Hrs/Week: 4**	**Hrs/Sem: 60**	**Credits: 4**

Objectives

- To impart knowledge of biotechnological applications of marine organisms among the students.
- To provide an excellent education emphasizing the important processes and impacts on the marine ecosystems and ways to control them.

Course Outcome

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	recall different zones of the sea	2	Un
CO-2	understand the physical and chemical properties of seawater and its impact on ocean life	5	Un
CO-3	identify and classify marine planktons based on their characteristics	3	An
CO-4	classify the flora and fauna of estuaries, mangroves and salt marshes and their adaptations	1	An
CO-5	analyse the role of microbes in recycling of nutrients	3	An
CO-6	explain the aspects of marine pollution and its impact on marine life	5	Un
CO-7	appraise the complexity and diversity of resources in the marine environment	4	Ev
CO-8	develop skills in a range of theoretical and practical applications on bioactive substances	6	Cr

Unit I Marine Habitat

Classification of marine habitat, plankton – classification and adaptations. Intertidal rocky, sandy and muddy shores – the features of fauna and adaptations. Marine microbes (bacteria, viruses and fungi).

Unit II Marine Ecosystems

Estuaries, mangroves, coral reef – ecology and types, species interaction and adaptations. Conservation of Gulf of Mannar Biosphere Reserve. Role of microbes in the sea: recycling of nutrients – nitrate, phosphate and sulphate.

Unit III Marine Pollution

Sources, effects and control measures of heavy metal, radioactive, oil and thermal pollutions. Biotechnology in marine pollution control.

Marine bioremediation - microplastics.

Unit IV Microbial Action in the Marine Environment

Biofouling – biofoulers – micro and macro foulers – impact of biofouling in maine environment and prevention. Biodeterioration: agents and protective methods.

Corrosion – mechanism and prevention.

Unit V Wealth of the Sea

Mineral wealth – petroleum, manganese nodules, beach placers, glauconite and garnet. Bioprospecting of marine resources - bioactive compounds from marine organisms (bacteria, fungi micro, macro algae and sponges). Sea-ranching of economically important marine organisms – crustaceans and molluscs.

Books for Reference

1. Bimla Singh. *Marine Biotechnology and Aquaculture Development*. Delhi: Vista International Publishing House. 2006.
2. Girish Chopra. *Coastal and Marine Geography*. Delhi: Common Wealth Publisher. 2012.
3. Gross G. *Oceanography: A view of the Earth*. New Jersey: Sixth edition. Prentice Hall Inc. 2008.
4. Mc Cormick J.M. and J.V. Thiruvathaakal. *Elements of Oceanography*. Philadelphia: W.B. Saunders Company. 1981.
5. Nybakken J.W. *Marine Biology – An Ecological Approach*. California: Addison Weslay Longman, Inc. 1997.
6. Olivia J. Fernando. *Sea water-Properties and Dynamics*. Thanjavur: Dhanesh Publications. 1999.
7. Frank E. Firth. *The encyclopedia of marine resources*. New York: Van Nostrand Reinhold Company.1969.
8. Veena. *Understanding Marine Biology*. New Delhi: Discovery Publishing House Pvt. Ltd. 2012.
9. Atlas R.M. and Bartha. M. *Microbial ecology- Fundamentals and Applications*. California: Benjamin- Cummings. 2003.
10. Vijaya Ramesh K. *Environmental Microbiology*. Chennai: MJP Publishers. 2004.
11. Moshrafuddin Ahamed and Basumatary S.K. *Applied Microbiology*. Chennai : MJP Publishers. 2006.
12. Tait R.V. and F.A. Dipper. *Elements of Marine Ecology*. Great Britain: British Library Cataloguing in Publication Data. 4th edition 1998.

PRACTICALS

Course Code: 21PZOCR7

Hours/ Week : 2 **Credits : 2**

1. Determination of acidity

2. Estimation of salinity

3. Determination of alkalinity

4. Estimation of total dissolved solids

5. Determination of nitrite

6. Estimation of phosphate

7. Collection and identification of marine plankton (any three phyto and zooplankton)

8. Identification and comments on the following

   i. Plankton net

   ii. Inter-tidal organisms

   a. Rocky shore: Sea anemone, Chiton
   b. Muddy shore: Uca, Cerithidia
   c. Sandy shore: Arenicola, Murex

   iii. Biofouling

   iv. Corrosion

9. Analysis of buckle canal sample (TDS/ Microbial load)

10. Visit to mangroves / estuaries / marine environment

Books for Reference

1. Strickland and Parsons. J.D.H. *A Practical Handbook of Seawater Analysis*, Canada: Bulletin 167, Fisheries Research Board of Canada. Second Edition 1972.

2. Kiewood Maff, D. *ICES* T*echniques in Marine Environmental Sciences*. Denmark: International Council for the Exploration of the Sea, 1987.

SEMESTER IV			
Core XIV	**Conservation Biology**		
Course Code: 21PZOC42	**Hrs/Week: 5**	**Hrs/Sem: 75**	**Credits: 4**

Objectives

- To create environmental awareness among students.
- To inculcate knowledge about the natural resources, biodiversity their conservation and efforts towards their sustainability.
- To generate concepts of prediction, prospecting, preservation and restoration of dwindling natural resources.

Course Outcome

CO. No.	**Upon completion of this course, students will be able to**	**PSO addressed**	**CL**
CO-1	infer the problems of unsustainable development	1	Un
CO-2	justify that human survival depends on developing practices that will achieve sustainable systems	3	Ev
CO-3	explore the biological, sociological and legislative perspectives for the management of flora and fauna to conserve wildlife.	5	An
CO-4	evaluate the importance of natural resources on conservation of biodiversity	3	Ev
CO-5	analyse the conservation management of various resources	3	An
CO-6	gain knowledge on values and threats of biodiversity	2	Ap
CO-7	learn the role of various organization in conservation of biodiversity	6	Un
CO-8	apply scientific principles and modern technologies to resolve problems in disaster management	8	Ap

Unit I Environment–Sustainable Development

Environmental ethics, issues - possible solutions - from unsustainable to sustainable development; Environmental Protection Act (1986) - Forest Conservation Act (1980), Wildlife (Protection) Act of Government of India (1972).

Unit II Conservation of Forest and Water Resources

Forest resources: Use and overexploitation – deforestation - timber extraction – mining - dams and forests – tribes. Conservation of forest.

Water resources: Use and over exploitation of ground water – surface water – conflicts over water – dams – benefits and problems - conservation of water.

Unit III Conservation of Land and Energy Resources

Land resources: Land as a resource – land degradation – soil erosion and desertification – conservation of soil.

Energy resources: Growing energy needs – renewable and non-renewable energy sources – use of alternate energy source.

Role of individual in conservation of natural resources.

Unit IV Biodiversity and Conservation

Biodiversity - values of biodiversity - threats to biodiversity – hot spots – biosphere reserve. *In-situ* conservation - *ex-situ* conservation - role of organizations in conservation **-** NBPGR, BSI, ZSI, WWF, IUCN - Ramsar Convention.

Unit V Disaster Management

Climate change – global warming

Causes, impact and management of earthquakes – cyclone – wildfires – landslide – flood – drought - disaster management system (DMIS).

Books for Reference

1. Dhulasi Brindha, V. *Environmental Studies*. New Delhi : Allied Publishers Pvt. Ltd. 2004.
2. Veer Bala Rastogi and M.S. Jayaraj. *Animal Ecology and Distribution of Animals*. Delhi: Kedarnath Ramnath, Meeruti.2009.
3. Agarwal, A.C. *Environmental Biology*, Bikaner : Agro Botanical. 1999.

4. Anjaneyalu, Y.B. *Introduction to Environmental Science*, Hyderabad: SPBS. Publications. 2004.
5. Kormondy Edward J. *Concepts of Ecology.* India: Prentice Hall Pvt. Ltd. 1994.
6. Odum, E.P. *Basic Ecology.* Saunder: CBS College Publishing. 1983.
7. Anubha Kaushik and C.P. Kaushik. *Environmental Science and Engineering*. NewDelhi: New Age International (P) Publishers. 2007.
8. Ravi Krishnan, A. *Environmental Science and Engineering*. Chennai: Sri Krishna Publications. 2010.
9. Saha, T.K. *Ecology and Environmental Biology*. Kolkatta: Books and Allied (P) Ltd. 2008.

PRACTICALS

Course Code: 21PZOCR8

Hrs/ Week: 2 **Credit: 1**

1. Estimation of population density using Quadrat method
2. Population density study – Mark and Recapture method
3. Chart – Rare, Threatened, Endangered and Extinct species
4. Mapping of National Parks in India with a note on important fauna
5. Mapping of Wild Life Sanctuaries in India with a note on important fauna
6. Renewable Energy Resources – Wind Energy
7. Case Study on Man Animal Conflict
8. Red Data Book
9. Shannon Wiener Index
10. Visit to an ecologically important place – National parks, Sanctuaries.

Books for Reference

1. Gareth Williams. *Techniques and Field work in Ecology*. Bell & Hyman Ltd. London. 1987.

2. Jaya Surya, Arumugam. N, Dulsy Fatima, Meyyan, R.P., Prasannakumar, S., Mani, A., Mariakuttikan, A., Narayanan, L.M., Nallasingam, K., Kumaresan, V. and A.M. Selvaraj. *Practical Zoology Vol-3*. Saras Publication, Nagercoil. 2013.

SEMESTER IV			
Core XV	**Commercial Zoology**		
Course Code: 21PZOC43	**Hrs/ Week: 5**	**Hrs/ Sem: 75**	**Credits: 4**

Objectives

- To facilitate self-employment and entrepreneurship in Apiculture and Sericulture.
- To motivate the students to take up careers related to agro-based, rural oriented cottage industry through imparting knowledge in apiary management, mulberry cultivation and silkworm rearing.

Course Outcome

CO. No	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	understand the behaviour of bees, prevent swarming and manage bee colonies	3	Un
CO-2	identify, choose suitable bees and maintain bee hive successfully	2	Ev
CO-3	inspect bee colony, identify diseases of bees, recognize their enemies and take necessary control measures	4	An, Ap
CO-4	apply their knowledge to implement the procedure to extract honey and other bee products	5	Ap
CO-5	demonstrate an understanding of mulberry cultivation, silkworm rearing and silk reeling	1	Un
CO-6	identify diseases, pests of mulberry, silkworm and adopt control measures	4	Ap, Cr
CO-7	utilize their knowledge in harvesting, marketing cocoons and reeling operations	5	Ap
CO-8	develop practical proficiency in apiculture and sericulture from the lab work as well as visit to the apiary and the sericulture unit.	6	Ap

Unit I **Beekeeping Technology**

Apiculture as a cottage industry - choice of species in apiculture- Indian bee, European bee. Beekeeping equipments - Langstroth hive and Newton's hive- appliances used in apiaries. Swarming – prevention and control. Queen rearing and introduction. Artificial feeding.

Unit II **Management of Bees & Honey Bee Products**

Diseases of bees - brood diseases, diseases of adult bees - nosema and septicemia, enemies and pests - greater wax moth, lesser wax moth, ants, wasps, mites - control measures. Extraction and uses of honey - bee wax - bee venom, pollen, propolis, royal jelly – Agmark index.

Unit III **Silkworm Rearing**

Mulberry silkworm development – silkworm rearing – rearing house – rearing appliances rearing operations. Shelf rearing – floor rearing – shoot rearing. Silkworm diseases – bacterial flacherie, muscardine, grasserie. Pest - Indian uzifly - symptoms and control measures.

Unit IV **Cocoon Mounting and Reeling**

Mounting - cocoons – harvesting and marketing of cocoon. Grading of silk and cost benefit ratio. Silk reeling – reeling operations, reeling appliances – cottage basin – filature units - by-products.

Unit V **Economics of Sericulture**

Sericulture industry – present status – prospects in India; Role of Governmental organizations and NGOs in the development of Sericulture industry – Schemes for Sericulture development – NABAARD, MSME, MUDRA.

Books for Reference

1. Krishnaswami S. *Improved Method of Rearing Young Age Silkworms*. Bangalore: Central Silk Board, 1990.
2. Hisao Aruga. *Principles of Sericulture*. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd. 1990.

3. Acharya J. *Sericulture and Development*. New Delhi: Indian Publishers Distributers Kamak Nagar, 1993.
4. Pierre Jean – Prost. *Apiculture*. New Delhi: Oxford & IBH Publishing Co. Pvt. LTD, 1994.
5. Raja Instus E. *Economics of Bee Keeping Industry*. Jaipur and New Delhi: Rawat Publications, 1994.
6. Mishra R.C. *Perspectives in Indian Apiculture*. Agro Botanica, 4E 176 J.N. Vyas Nagar, Bikaner, H.S. Offset Printers, Daryagunj, New Delhi: 1997-98.
7. Arthur G. and Carter J. *Beekeeping: A Guide to the Better Understanding of Bees, their Diseases and the Chemistry of Beekeeping*. New Delhi: Biotech books, 2004.
8. Everett Franklin Phillips. *Bee Keeping*. Jodhpur: Agrobios (India), Agro House, Chopasani Road, 2010.
9. Ganga G. and Sulochana Chetty J. *An Introduction to Sericulture*. New Delhi: Oxford & IBH Publishing Co Pvt. Ltd, 2019.

PRACTICALS

Course Code: 21PZOCR8

Hrs / Week : 2 **Credit: 1**

1. Identification of bee species and castes.
2. Mounting of mouth parts and legs of worker bee.
3. Adulteration in honey
4. Beekeeping equipments - Newton's hive, hive tool, smoker, uncapping knife, pollen box, honey extractor.
5. Identification of diseases and enemies of honey bees.
6. Development of silkworm.
7. Mounting of silk gland.
8. Rearing house and appliances.
9. Silkworm diseases and pests.

10. Filling forms for entrepreneurs

11. Visit to an apiary or sericulture unit.

Books for Reference

1. Tammanna N. Sonwalker. 1993. *Hand Book of Silk Technology*. Wiley Eastern Ltd. Chennai.
2. Alka Prakash. 2001. *Laboratory Manual of Entomology*. New Age International (P) Ltd, 4835/ 24, Ansari Road, Daryaganj, New Delhi – 110002.

SEMESTER IV			
Core Elective	**A. Ornamental Fish Culture**		
Course Code: 21PZOE41	**Hrs/ Week: 4**	**Hrs/ Sem: 60**	**Credits: 4**

Objectives

- To impart basic understanding for operating an ornamental fish farm and improve the quality of fisheries education, research and extension activities.

- To generate technically skilled manpower to work in ornamental fish farms, augment ornamental fisheries trade, export earnings and self employment.

Course Outcome

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	explain the construction, fabrication and accessories required for setting up an aquarium tank	1	Un
CO-2	apply the knowledge and skills in aquarium management	2	Ap
CO-3	evaluate the types and culture of live feed organisms and formulate the artificial feed	3	Ev
CO-4	demonstrate the mastery related with taxonomy and biology of ornamental fish	3	Ap
CO-5	identify the commercially important fresh water and marine ornamental fishes and their transport	8	Ap
CO-6	analyse the different breeding techniques employed for varieties of ornamental fish	2,3	An
CO-7	acquire competencies to become an entrepreneur in ornamental fish culture	3	Un
CO-8	develop entrepreneurial skills and make aware of National and International export process and income generation	2,7	Cr

Unit I Construction of Fishtanks

Design and Construction of fish tanks – setting up of tanks - accessories for aquarium - hood, light source, hand net, suction tube, scrapper tool, aerator, heater, gravels, filters and aquarium decor –aquarium plants and its importance.

Unit II Aquarium and Fish Health Management

Maintenance of water quality - temperature, water hardness, ammonia, pH, O_2, CO_2. Control of snail and algal growth. Fish diseases - protozoan, fungal, bacterial and parasitic diseases - symptoms, diagnosis, therapy and prevention.

Unit III Fish Nutrition

Different types of feed - artificial and live feed - culture of live feed organisms - infusorians - zooplankton - rotifers - copepods - cladocerans - spirulina - brine shrimp - chironomous - tubifex. Artificial feed: ingredients of feed formulation – Pearson square method of feed formulation - steps in the preparation of artificial feed – nutritional deficiency diseases.

Unit IV Biology and Breeding

Taxonomy and biology of egg layers - siamese fighting fish, gold fish, koi, rosy barb, neontetra, zebra cichlid and angel fish. Live bearers - molly, guppy, sword tail and platy. Breeding and spawning of egg layers and livebearers – parental care in ornamental fishes.

Unit V Marine ornamental Fishes and Transport

Commercially important marine ornamental fishes - butterfly fish, parrot fish, clown fish, marine angel fish. Transport of ornamental fishes – oxygen packing - use of sedatives - marketing strategies.

Books for Reference

1. Jameson. J.D. and R. Santhanam. *Manual of Ornamental Fishes and Farming Technologies* – Tuticorin: Fisheries College and Research Institute TANUVAS. 1996
2. Santhanakumar. R. and A.M. Selvaraj. *Manual of Fresh water Ornamental Fish Culture*, Tuticorin: Department of Fisheries Extension, Fisheries College and Research Institute, TANUVAS. 2007
3. Venkataramani V.K. and N. Jeyakumar. *Biodiversity and Stock Assessment of Marine Ornamental Fishes*. Tuticorin: Department of Fisheries Biology and Capture Fisheries,

Fisheries College and Research Institute, TANUVAS. 2004

4. Tharadevi, C.S. and K.V. Jayashree. *Home Aquarium*. Nagercoil: Saras Publications. 2009
5. Santhanam R., Sukumaran N. and P. Natarajan. *A Manual of Freshwater Aquculture*. NewDelhi: Oxford and IBH Publishing Co. Pvt. Ltd. 1990
6. Gupta, S.K. and P.C. Gupta. General and Applied Ichthyology. New Delhi: Chand and Company Ltd, 1st Edn. 2006
7. Dholakia, A.D. *Ornamental Fish Culture and Aquarium Management*. Delhi: Daya Publishing House, Trinagar. 2009.

SEMESTER IV			
Core Elective	**B. Vermitechnology**		
Course Code : 21PZOE42	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Objectives

- To impart a detailed knowledge on Vermitechnology and the benefits of eco-friendly organic farming
- To create expertise and avenues for self-employment

Course Outcome

CO. No.	**Upon completion of this course, students will be able to**	**PSO addressed**	**CL**
CO- 1	discuss basic techniques of vermiculture	1	Un
CO -2	recognise and identify different species of earthworms suitable for culture	2,3	Un
CO – 3	analyse the mechanisms of vermicomposting technology	6	An
CO – 4	perform recycling of wastes generated from various sources in an eco-friendly manner	5	Ap
CO – 5	explore new techniques and deepen their mastery in organic solid waste management	2	Cr
CO – 6	evaluate the methods of culture relevant to local area.	4	Ev
CO – 7	execute practical technology and entrepreneurship skills	8	Ap
CO – 8	examine the problems, constraints and opportunities for self-employment.	3	An

Unit I **Earthworms**

Taxonomic position – types of earthworms – indigenous and exotic species suitable for culture – ecological classification of earthworms – epigeic, aneic and endogeic forms – role of earthworms in the litter degradation and decomposition – worm casts.

Unit II **Vermiculture**

Need for vermiculture – wormery – breeding techniques – indoor and outdoor culture –- monoculture and polyculture – pests, parasites and pathogens affecting earthworms – problems in vermiculture and remedial solutions.

Unit III **Vermicomposting Technology**

Raw materials and requirements for vermicomposting – collection, segregation and processing of wastes – vermibed preparation – maintenance of vermibed. Vermicomposting methods – pit method - bin method – windrow method

Unit IV **Vermimanure and Vermiwash**

Harvesting of vermicompost- nutrient profile of vermicompost- physical, chemical and biological features of vermicompost - advantages of vermicompost over chemical fertilizers - vermiwash – preparation, composition and applications.

Unit V **Vermicomposting Potentials and Economics**

Packing and marketing of vermicompost – cost benefit analysis - importance of vermicompost in sustainable agri - horticultural practices – recycling of urban solid wastes – prospects of vermitechnology as a self-employment venture – financial supporting by governments and NGOs.

Books for Reference

1. Ismail S.A. *The Earthworm.* Goa: Second Revised Edition, Other India Press, Mapura 2005.

2. Seethalakshmy M and Shantha R. *Vermitechnology*. Nagercoil: 3rd edition, Saras Publications, 2012.
3. Edwards C.A, Arancon N.Q and Sherman R. *Vermiculture Technology; Earthworms, Organic Wastes and Environmental Management*. Florida: CRC Press, Boca, Raton 2011.
4. Renganathan L. S. *Vermibiotechnology from Soil Health to Human Health.* Jodhpur: First edition, Agrobios 2006.
5. Mary Violet Christy A. *Vermitechnology*. Chennai: M.J.P. Publishers 2020.
6. Prakash Malhotra. *Economic Zoology*. New Delhi: First edition. Adhyayan Publishers and Distributors 2008.
7. Gupta P. K. *Vermicomposting for Sustainable Agriculture*. Jodhpur: 2nd Revised Edition, Agrobios 2012.

SEMESTER III	
Self Study Course **Zoology for Competitive Examination**	
Course Code: 21PZOSS1	**Credit: +2**

Objectives

- To motivate the students appear for high level competitive exams
- To make students competent to face the examinations effectively.
- To provide in-depth knowledge on different fields of Zoology which are vital for any competitive examination.

Course Outcome

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	gain knowledge about the systematic position of the organisms.	1	Un
CO-2	able to identify the different species based on their salient features	6	An
CO-3	acquire in depth knowledge on biomolecules and relate the various physiological mechanisms prevailing in the organism	3	An
CO-4	analyse the genetic concepts and laws	4	An
CO-5	understand different theories and patterns of evolution	1	Un
CO-6	acquire in-depth knowledge about cellular components and cell cycle regulation and discuss the consequences of uncontrolled cell division	2, 7	Kn, Cr
CO-7	evaluate the techniques help in bioremediation and demonstrate gene therapy technique	7, 8	Ev
CO-8	understand the various types of pathogens, analyse their transmission and prevention of infectious diseases	5	An, Un

Unit I **Diversity of Life Forms**

Concepts of species and hierarchial taxa, biological nomenclature, classical and quantitative methods of taxonomy of animals. Unicellular, colonial and multicellular forms. Levels of organization of tissues, organs & systems. Classification of invertebrates up to classes and chordates up to order – diagnostic features and examples. Organisms of conservation concern – principles of conservation - rare, endangered species - conservation strategies.

Unit II **Biochemistry and Physiology**

Composition, structure and function of biomolecules - carbohydrates, lipids, proteins, nucleic acids and vitamins. Conformation of proteins - Ramachandran plot. Physiology of digestion and absorption, respiration, transport of oxygen, carbon-di-oxide; structure of kidney and nephron, urine formation in man; structure of heart, cardiac cycle; structure, composition and functions of blood of man; types of muscle, structure of neuron, nerve impulse conduction, physiology of vision and hearing in man. Structure and functions of pituitary, Islets of Langerhans and thyroid gland. Human reproductive systems – menstrual cycle.

Unit III **Genetics and Evolution**

Mendelian principles, modern concept of gene, split gene, genetic regulation, genetic code. Sex chromosomes and their evolution, sex determination in Drosophila and man. Recombination, linkage, multiple alleles, genetics of blood groups, pedigree analysis, hereditary diseases in man – Inborn errors of metabolism- mutations and mutagenesis, structural and numerical alterations of chromosomes. Theories of evolution- natural selection, role of mutation in evolution, evolutionary patterns, molecular drive, mimicry, variation, isolation and speciation, biological and cultural evolution of man.

Unit IV **Cell and Molecular Biology**

Structure of model membrane, Structure and function of cell and its organelles (nucleus, plasma membrane, mitochondria, Golgi bodies, endoplasmic reticulum, ribosomes and lysosomes), cell division and cell cycle (mitosis and meiosis), steps, control and

regulation of cell cycle, chromosome movement, chromosome type – polytene and lamp brush, organization of chromatin, heterochromatin. Protein synthesis, structure of DNA, RNA, replication of DNA. Nucleic acid topology, DNA motif, transcription, RNA processing, translation, protein folding and transport.

Unit V **Biotechnology and Microbiology**

DNA sequencing methods, RFLP, RAPD and AFLP techniques, transgenic animals. Bioremediation and phytoremediation. Biosensors, tissue culture, Genomics and its applications to health – gene therapy – recombinant vaccines. Major infectious and communicable diseases (malaria, filariasis, tuberculosis, cholera, AIDS and Covid-19) their vectors, pathogens and prevention.

Books for Reference

1. Jordan. K.C. & Verma. P.S. *Invertebrate Zoology*. New Delhi: S. Chand& Company Ltd. 2009.
2. Jordan E.L. and Verma. P.S. *Chordate Zoology*. New Delhi: S. Chand & Company Ltd, Ram Nagar. 1965.
3. Sinha, Adhikari, Ganguly, Bharati Gowswani. Biology of Animals – Volume I. Kolkatta: New Central Book Agency; 7th edition. 2012.
4. Sinha, Adhikari, Ganguly, Bharati Gowswani. Biology of Animals – Volume II. Kolkatta: New Central Book Agency; 7th edition. 2012.
5. Ambika Shanmugam. *Fundamentals of Biochemistry for Medical Students*. Madras: Navabharat Printers and Traders. 2012.
6. Satyanarayana. U and U. Chakrapani. *Biochemistry*. Haryana and Kolkatta: Elsevier and Allied. Fourth Edition 2014.
7. Shembulingam. K. and Prema Shembulingam. *Essentials of Medical Physiology*. New Delhi : Jaypee Brothers, Medical Publishers Ltd. 2005.
8. Verma. P.S and Agarwal. V.K. *Cell Biology, Genetics, Molecular Biology, Evolution & Ecology*. New Delhi: S. Chand & Company Ltd, Ram Nagar. 2013.
9. Kumaresan. V. *Biotechnology*. Nagercoil: Saras Publication. 2009.
10. Presscott Harley and Klein. *Microbiology*. New York: WCB Mc Graw Hill Co. 2005.