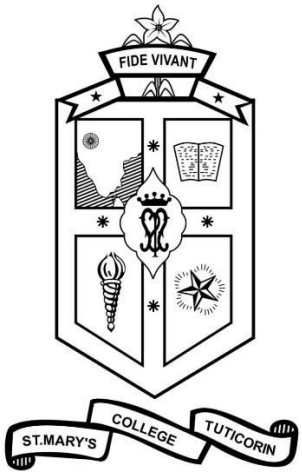
ST. MARY'S COLLEGE (AUTONOMOUS)

Re-accredited with A+ Grade by NAAC

Thoothukudi – 628001, Tamil Nadu

(Affiliated to Manonmaniam Sundaranar University)



Syllabus

M.Sc. Zoology

School of Biological Sciences

Outcome Based Curriculum

(w.e.f. 2021)

Preamble

Master of Science in Zoology is a post graduation course of St. Mary's College. The students pursuing this course would have to develop in-depth understanding of various aspects. The working principles, design, guidelines and experimental skills associated with different fields of Zoology. In pace with the recent trends and developments in Zoology the course content is being modified. There is also scope for self- employment. The practicals will improve all skills of students in microscopy and different laboratory techniques. This curriculum of the zoologists, for the zoologists and by the zoologists developed with the united efforts will take our ever progressive subject to greater heights in the years to come.

Vision: To prepare young women face the challenges of life through education, an ideal weapon for empowerment.

Mission: To impart knowledge and skills in zoology through specialization in recently emerging technologies and thereby to produce quality graduates capable of contributing to the development of knowledge based society.

Programme Outcome:

PO.No.	At the end of the M.Sc. Programme, the students will be able to
PO-1	obtain in-depth and detailed functional knowledge of the fundamental theoretical concepts and experimental methods in Science
PO-2	understand their subject areas more clearly and develop skills to critically reflect upon the theory they learn.
PO-3	adopt the scientific methods and hypothesis testing in designing and execution of experiments.
PO-4	think critically, work independently and focus in research oriented activities.
PO-5	inculcate an ability to engage in life-long learning to improve professional competency.
PO-6	extend and understand the impact of science on society.
PO-7	apply their professional ability for entrepreneurship and self-employment.
PO-8	understand and commit to professional ethics and social responsibility.

PG Zoology

Course Structure (w.e.f 2021)

Semester – I

Subject	Course Code	Course Title	Contact Hours / Week	Credits	Max. Marks		
					CIA	ESE	Total
Core I	21PZOC11	Cell and Molecular Biology	6	4	40	60	100
Core II	21PZOC12	Genetics and Evolution	6	4	40	60	100
Core III	21PZOC13	Biochemistry	5	4	40	60	100
Core IV	21PZOC14	Applied Entomology	5	4	40	60	100
Core Practical I	21PZOCR1	21PZOC11, 21PZOC12	4	2	40	60	100
Core Practical II	21PZOCR2	21PZOC13, 21PZOC14	4	2	40	60	100
			30	**20**			

Semester – II

Subject	Course Code	Course Title	Contact Hours / Week	Credits	Max. Marks		
					CIA	ESE	Total
Core V	21PZOC21	Animal Physiology	5	4	40	60	100
Core VI	21PZOC22	Immunology	5	4	40	60	100
Core VII	21PZOC23	Applied Biotechnology	5	4	40	60	100
Core VIII	21PZOC24	Microbiology	4	4	40	60	100
Field Work	21PZFW21		3	3	40	60	100
Core Practical III	21PZOCR3	21PZOC21, 21PZOC22	4	2	40	60	100
Core Practical IV	21PZOCR4	21PZOC23, 21PZOC24	4	2			
			30	**23+2**			

Semester – III

Subject	Course Code	Course Title	Contact Hours / Week	Credits	Max. Marks		
					CIA	ESE	Total
Core IX	21PZOC31	Computational Biology	6	4	40	60	100
Core X	21PZOC32	Aquaculture Practices and Farm Management	6	4	40	60	100
Core XI	21PZOC33	Developmental Zoology	5	4	40	60	100
Core XII	21PZOC34	Research Methodology and Biotechniques	5	4	40	60	100
Core Practical V	21PZOCR5	21PZOC31, 21PZOC32	4	2	40	60	100
Core Practical VI	21PZOCR6	21PZOC33, 21PZOC34	4	2	40	60	100
Self Study Course / MOOC	21PZOSS1/ 21PZOM31	Zoology for Competitive Examination		+2		100	100
			30	**20+2**			

Semester – IV

Subject	Course Code	Course Title	Contact Hours / Week	Credits	Max. Marks		
					CIA	ESE	Total
Core XIII	21PZOC41	Marine Biotechnology	4	4	40	60	100
Core XIV	21PZOC42	Conservation Biology	5	4	40	60	100
Core XV	21PZOC43	Commercial Zoology	5	4	40	60	100
Core Practical VII	21PZOCR7	21PZOC41	2	2	40	60	100
Core Practical VIII	21PZOCR8	21PZOC42, 21PZOC43	4	3	40	60	100
Core Elective	21PZOE41 21PZOE42	A. Ornamental Fish Culture B. Vermitechnology	4	4	40	60	100
Project	21PZOP41		6	6		100	100
			30	**27**			

Semester	Hours / Week	Credits	Extra Credits	Total Marks
I	30	20	-	500
II	30	23	2	600
III	30	20	2	600
IV	30	27	-	500
Total	**120**	**90**	**4**	**2200**

Programme Specific Outcome

PSO No.	Students of M.Sc., Zoology will be able to
PSO-1	comprehend and synthesis advance knowledge in specific areas of Zoology
PSO-2	demonstrate an in-depth understanding and the ability to apply information from different areas of Biology.
PSO-3	examine and evaluate knowledge across a broad range of courses, acquire a set of transferable skills for employment.
PSO-4	appreciate and use science as a way of problem solving, formulate hypotheses, design experiments and draw logical conclusions.
PSO-5	expound the relevance of the biological science to the real-world issues of bioethical, biological and social basis for human welfare and environment.
PSO-6	achieve practical proficiency in experimental techniques and methods of analysis.
PSO-7	design and develop projects with scientific report, oral / poster presentation and extend the findings to the society
PSO-8	select and apply experimental procedures to the spectrum of fields in Biology

SEMESTER I			
Core I	**Cell and Molecular Biology**		
Course Code: 21PZOC11	**Hrs/ Week : 6**	**Hrs/ Sem: 90**	**Credits: 4**

Objectives

- To develop basic knowledge and skills in cell and molecular biology and become aware of the complexity and harmony of the cell
- To gain the comprehensive knowledge on the molecular structure of cells, organelles including membrane structure and its dynamics

Course outcome

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	acquire knowledge on the structure and function of biological membrane including the roles of gradients in energy transduction	1	Un
CO-2	compare the different types of transporters and its functions	2	An
CO-3	relate the mechanisms of cell to cell signaling, including intercellular signaling and second messenger	1	An
CO-4	understand the structure and function of proteins including the roles of amino acids in protein folding and protein-protein interactions.	1	Un
CO-5	identify the regulation of gene at the transcriptional and post transcriptional level	3	Ap
CO-6	illustrate the structural organization of gene and the control of gene expression	5	Un
CO-7	explain the cell cycle and its regulation, including the mechanism of mitosis and meiosis	6, 7	Ev
CO-8	demonstrate the characteristics, causes and onset of cancer, metastasis, proto oncogenes, tumor suppressor genes and apoptosis	6, 8	Un

Unit I **Cell and Transport Across Cell Membranes**

Molecular organization of cell membrane – molecular models (Unit membrane, Trilaminar and Fluid mosaic) – intercellular junctions - types of transport - diffusion –membrane transport proteins – uniporter catalysed transport – membrane electrical potential. Active transport by ATP powered pumps. Co - transport by symporters and antiporters.

Unit II **Cell Receptors and Cell Signaling**

Cell signaling – principle of cell signaling - signaling mechanisms - signal receptors - intercellular signaling - cell surface receptors – types - G protein coupled receptors - second messengers (cAMP, IP_3,DAG, cGMP, & Ca^{2+}) - signaling from plasma membrane to nucleus.

Unit III **Chromosome and Genes**

Chromosome structure, Organization of genes in chromosomes – introns and exons – simple, complex and split genes – forms of DNA-A,B,Z - molecular basis of mutation – transition - transversion – frame shift – induction of mutation – repair systems to counteract DNA damage and mutation – post-transcriptional modification.

Unit IV **Cell Organelles, Protein Synthesis and Processing**

Ultrastructure of ribosome – endoplasmic reticulum – Golgi complex, mitochondria. Protein synthesis - translational proof reading. Post translational modification - disulfide bond formation, correct folding, assembly into multimeric proteins and protein glycosylation - O-linked and N-linked glycolysation in endoplasmic reticulum.

Unit V **Cell Division**

Cell division and cell cycle: Mitosis and meiosis, their regulation, cell cycle - control - apoptosis and its regulations - characteristics of cancer cells – causes and onset of cancer – metastasis – proto oncogenes - tumour suppressor genes.

Books for Reference

1. De Robertis, E.D.P. and Robertis E.M.F. Cell *and Molecular Biology 9th International Edition,* Mumbai: K.M. Varghese Company, 1988.
2. David M. Prescott Cells – *Principles of Molecular Structure and Function*. USA: Jones and Bartlett Publishers.1988.
3. Lodish, H., Baltimore D. and Darnell J. *Molecular Cell Biology*. USA : Scientific American Book, Inc.
4. Ajoy Paul. *Text Book of Cell and Molecular Biology*. Kolkata: Books and Allied (P) Ltd.

Third Edition. 2011.

5. Bhamrah, H.S. *Molecular Cell biology*. New Delhi: Publications Pvt Ltd. 1995
6. David Freifelder. *Essentials of Molecular Biology*. New Delhi: Narosa Publishing House. 1995.
7. Sivarama Sastry, K., Padmanaban G. and Subramanyam. C. *Text Book of Molecular Biology*. New Delhi : Mac Millan India Limited. 1994
8. Gerald Karp. *Cell Biology*. Mc Graw Hill. Second Edition. 1984.
9. Prakash S. Lohar. *Cell and Molecular Biology*. Chennai: MJP Publishers. 2007
10. Gupta M.L and Jangir, M.L. *Cell Biology Fundamentals and Application*. Jodhpur: Saraswati Purchit for Student Edition. 2001
11. Rastogi S.C. *Molecular Biology*. New Delhi : CBS Publishers and Distributors Pvt. Ltd., 2006.

PRACTICALS

Course Code: 21PZOCR1

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

1. Preparation and observation of squamous epithelial cells.
2. Preparation and observation of human blood smear.
3. Preparation and observation of cockroach haemolymph smear.
4. Meiotic cell division in grasshopper testis.
5. Giant chromosome in chironomous larva.
6. Observation of blood smear of frog.
7. Genomic DNA isolation
8. Observation of sarcomere, columnar epithelial cells and ciliated epithelial cells.
9. Observation of different types of tissues : bone, hyaline cartilage, liver, kidney and nervous tissue.

Books for Reference

1. Nagesh Rao K.M.S. *Histology.* New Delhi: CBS Publishers and Distributors. 2007.
2. Shah and Chinoy, N.J. *Essential Techniques in Cell Biology*. Ahmedabad: Anada Book Depot. Educational Publishers. 2007
3. Goswaml, H.K. *Practical Cytology*, *Applied Genetics and Biostatistics*. Bombay: Himalaya Publishing House.1986.

SEMESTER I			
Core II	**Genetics and Evolution**		
Course Code: 21PZOC12	**Hrs/ Week: 6**	**Hrs/ Sem: 90**	**Credits: 4**

Objectives:

- To highlight the importance of genetics and evolutionary significance to the society
- To learn about the genetic recombination of chromosomes, microbial genetics, evolutionary concepts and future evolution of man.

Course outcome

CO. No	Upon completion of this course, students will be able to	PSO addressed	CL
CO- 1	examine the chromosomes and genetic recombination and interpret linkage and mapping data	1	Un
CO-2	discuss the theories of crossing over and construction of chromosome map	1	Un
CO-3	infer genetic recombination mechanisms in bacteria and assess the genetic and clinical significance of transposons	2	Un, Ev
CO-4	analyse changes in gene and genotypic changes and evaluate its consequences in populations	6	An, Ev
CO-5	discriminate various human genetic disorders and genetic variations in drug metabolism	4	An
CO-6	provide detailed explanations of neo – Lamarkism, neo – Darwinism, stabilizing and experimental evolution	1 , 6	Un, Cr
CO-7	examine, summarize and integrate central ideas underpinning evolutionary patterns and processes from the molecular to the macro scale	2	Un, Ap, Cr
CO-8	Critically analyse, issues such as speciation mechanisms relating to the formation of species.	2	Un, An

Unit I Chromosomes and Genetic Recombination

Introduction – human karyotype analysis– linkage – comparison of complete and incomplete linkage – Morgan's experiments - theories and molecular mechanism of crossing over – construction of chromosome map – three point test cross (Drosophila), tetrad analysis (Neurospora) - chromosome banding and chromosome painting techniques.

Unit II Microbial Genetics

Recombination in bacteria – conjugation – transformation – transduction – sexduction – transposons – families of transposable elements in bacteria. Yeast Ty elements – Drosophila transposons – modes of transposition – genetic, medical and evolutionary significance.

Unit III Population Genetics and Human Genetics

Gene pool concept – gene and genotype frequencies – Hardy – Weinberg equilibrium – algebraic proof - estimation of equilibrium gene frequencies for complete dominance, co-dominance and multiple alleles. Neurodegenerative diseases – Alzheimer's – Huntington's disease – genes in pedigree - dermatoglyphics – diagnostic features – pharmacogenetics – drug metabolism – genetic variation in the effect of drugs – genetic counselling.

Unit IV Evolutionary Concepts

Neo – Lamarkism, Neo- Darwinism - stabilizing, directional and diversifying selection, experimental evidences - modern concepts of recapitulation theory; genetic and non-genetic variations - origin and evolutionary significance.

Unit V Speciation

Species - modes of speciation – sexual selection and co – evolution - Genetic drift - evolutionary significance - isolating mechanisms and their significance – Simpson's adaptive grid concept – micro, macro, and mega evolution – evolution of man – cultural evolution – future evolution.

Books for Reference

1. Strickberger M.W. *Genetics*. 3rd edition, New York: Maxwell Macmillan International Edition 1985.
2. Gardner, Simmons and Snustad. *Principles of Genetics*, 6th edition New York: Prentice Hall. Inc.1991.
3. Klug W.S. and M.R. Cummings. *Concepts of Genetics*. 6th edition New York: Prentice Hall. Inc. 2000.
4. Emmanuel C, Ignacimuthu S. and S. Vincent. *Applied Genetics – Recent Trends and Techniques.* Chennai: JP Publishers 2009.
5. Amita Sarkar. *A Text Book of Human Genetics.* New Delhi: Wisdom Press 2011.
6. Kreb J.E. Goldstein. S. and T. Kilpatrick. *Genes*10th edition. USA: Jones Bartlett Publishers 2011.
7. Ujjwala Deshmukh. *Cytogenetics and Evolution*. New Delhi: Dominant Publishers and Distributors 2005.
8. Gurbacham S. and Miglani. *Essentials of Molecular Genetics*. New Delhi: Narosa Publishing House 2015.
9. Ledyard Stebbins. *Processes of Organic Evolution*. New Delhi: Prentice Hall of India 1970.
10. Ernst Mayr. *Populations, Species and Evolution. An Abridgment of Animal Species and Evolution*. Cambridge: Harvard University Press 1970.
11. Dobzshansky, Francis J. Ayala, G. and W. Ledyard Stebbins James. *Valentine Evolution*. Delhi: Surjeet Publications 1973.

PRACTICALS

Hours/ Week: 2 **Course Code: 21PZOCR1** **Credit: 1**

1. Construction of genetic map for a given three point test cross.
2. Preparation of culture medium of Drosophila
3. Tracing the stages in the life cycle of Drosophila.
4. Observation of common mutants of Drosophila
5. Survey of simple Mendelian traits and ABO blood group in the class population and estimation of gene and genotype frequencies based on Hardy – Weinberg law.
6. Demonstration of role of random genetic drift in small populations using simulation (beads)
7. Analysis of dermatoglyphic data (finger print) of the class population.
8. Construction of pedigree
9. Bacterial conjugation (chart).
10. Industrial melanism - Peppered moth

Books for Reference

1. Michael Breitenback. *Experimental Genetics I– Biophysics*. *shg. ac /at/ home.htm* 1997.

2. William. D. Stansfield. Schaum's Outline Series. *Theory and Problems of Genetics. Second Edition.* USA: Mc Graw Hill Book Company 1977.

SEMESTER I			
Core III	**Biochemistry**		
Course Code: 21PZOC13	**Hrs/Week: 5**	**Hrs/ Sem: 75**	**Credits: 4**

Objectives:

- To develop and enhance an optimum academic environment to prepare professional graduates in the field of biochemistry**.**
- To give a broad based knowledge on how biological molecules give rise to the processes that occur within living cell which in turn relates greatly to the whole organism.

Course Outcome:

CO. No	**Upon completion of this course, students will be able to**	**PSO addressed**	**CL**
CO- 1	classify and explain structure and functions of biomolecules	1	Un
CO-2	relate between biology and chemistry	2, 4	Un
CO-3	compare the specificity of enzymes (biochemical catalysts) and the chemistry involved in enzyme action.	3	An
CO-4	recognise the metabolic pathways of protein, amino acids, carbohydrates, fats and nucleic acids	1	Ev
CO-5	relate to real life situations and applications in research and industry	4	Un
CO-6	have firm foundations in fundamental applications of biomolecules	7	Un
CO-7	solve the problems in biochemistry	5, 8	Ap
CO-8	design, carryout, record and analyse the results of chemical experiments	6	Cr

Unit I Atoms and Molecules

Structure of an atom, chemical bonds (ionic, covalent and hydrogen). Structure and properties of water. Vanderwaals interaction, role of water in life. pH and buffers - weak acids and alkalies, Henderson and Hasselbalch's equation - Biological buffer system

Unit II Carbohydrates

Classification – structure – properties and functions of carbohydrates. Metabolism: glycolysis – TCA cycle – energy budget of glucose oxidation -– glycogenolysis – glycogenesis – gluconeogenesis – HMP shunt pathway .

Unit III Protein

Classification – structure – properties and functions of amino acids – classification – properties and functions of proteins – metabolism of proteins – metabolism of tryptophan – phenylalanine – tyrosine- Inborn errors of metabolism (Phenylketonuria and Hartnup's disease).

Unit IV Lipid

Classification – Biological importance of simple lipids (triglycerides and wax), compound lipids (phospholipids and glycolipids) and derived lipids (saturated, unsaturated and cholesterol) – β oxidation, ketogenesis – biosynthesis of fatty acids – disorders of fat metabolism (hypercholestrolemia, hyperlipoproteinemia and atherosclerosis). Role of liver in fat metabolism.

Unit V Enzymes and Nucleic acids

Nomenclature – classification – properties – functions and mechanism of enzyme action and its regulation – coenzyme, isoenzyme. Nucleic acids - chemistry of nucleic acids, structure, biosynthesis and degradation, purine and pyrimidine nucleotides and disorders of their metabolism (Gout, Severe combined immunodeficiency, Orotaciduria and Thymidine phosphorylase deficiency).

Books for Reference

1. Ambika Shanmugam, *Fundamentals of Biochemistry for Medical Student*s, Madras: Navabharat Printers and Traders, 2012.
2. Pankaj Naik, *Biochemistry for Medical Students* NewDelhi: 4th edition, Health Science Publishers, 2016.
3. Jain J.L, Sunjay Jain, Nitin Jain, *Fundamentals of Biochemistry*, New Delhi: S. Chand& Company, 2007.
4. Styer L.W.H, *Biochemistry*, San Francisco: Freeman & Company, 1995.
5. Murray R.K., Gaaner D.K, Mayer P.A and V.W. Rodwell. *Harper's Biochemistry*, Tokyo: 24th edition. Prentice Hall of Japan, Inc, 1996.
6. Rastogi S.C, *Biochemistry*, New Delhi: Second Edition. Tata Mc Graw Hill Publishing Company Ltd., 2003.
7. Satyanarayana U and U. Chakrapani. *Biochemistry,* Haryana and Kolkata : Fourth Edition. Elsevier & Allied. 2014.
8. Edward Staunton West, Wilbert R. Todd, Howard S. Mason, John T. Van. Bruggen, *Biochemistry*, New Delhi: Fourth edition. Oxford and IBH Publishing Co. 1966.
9. Bernard L. Oser, *Hawk's Physiological Chemistry*, New Delhi: 14th edition. Tata Mc Graw Hill Publishing Company Ltd.1965.
10. Chatterjee M.N, *A Textbook of Biochemistry*. New Delhi: Jaypee Brothers, Medical Publishers Pvt Ltd. 2010.
11. Lehninger, A. *Principles of Biochemistry*, New Delhi: CBS Publishers & Distributers, 1993.

PRACTICALS

Course Code: 21PZOCR2

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

1. Effect of pH on salivary amylase activity.
2. Effect of substrate concentration on salivary amylase activity.
3. Salivary amylase activity in relation to enzyme concentration.
4. Preparation of standard graph for carbohydrate
5. Preparation of standard graph for protein
6. Quantitative estimation of muscle protein
7. Determination of iodine number of an edible oil

8. Separation of lipids by TLC - Demonstration only
9. Separation of amino acids by paper chromatography / Ninhydrin method
10. Preparation of buffers : acetic acid and acetate buffers
11. Phenylketonuria (chart)

Books for Reference

1. Jayaraman J. *Laboratory Manual in Biochemistry*, New Delhi: New Age International (P) Ltd. Publishers, 2000.
2. Kanai L. Mukherjee & Swarajit Ghosh, *Medical Laboratory Technology* New Delhi: 2nd Edition, Tata Mc Graw Hill Education (P) Ltd., 2012.
3. Deepti Saini and Deepak K. Sain. *Hand Book of Practical Biochemistry.* New Delhi: PEE PEE Publishers & Distributers (P) Ltd., 2008.

SEMESTER I			
Core IV	**Applied Entomology**		
Course Code: 21PZOC14	**Hrs/ Week : 5**	**Hrs/ Sem: 75**	**Credits: 4**

Objective:

- To explore the richness and significance of insects.
- To impart knowledge on the beneficial and harmful effects of insects and to familiarize them with effective control measures

Course outcome

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	know about the diversity of insects, classify and state their major different orders	1	Un
CO-2	develop skills for collecting, mounting and preserving insects	1, 6	Cr
CO-3	acquire knowledge on beneficial insects, helpful insects and insects of medicinal and aesthetic value	1	Un
CO-4	analyze the main pest species of crops based on the symptoms of the attack and morphological traits	2	An
CO-5	explain the life cycle of main pest species on crops and insect vectors	2, 1	Un
CO-6	identify, collect and manage different insects of importance to household, man and animals.	4, 6	Ap
CO-7	apply appropriate indirect and direct measures to prevent or reduce pest attack	5, 7	Ap
CO-8	plan and implement crop protection according to the IPM principles	4, 8	Ev, Cr

Unit I Insect Taxonomy

Introduction – principles of classification – Imm's classification down to orders with their diagnostic characters of any ten significant orders – methods of collection, killing and preservation of insects.

Unit II Beneficial Insects

Productive insects – economic value of products of honey bee, silk worm and lac insect - helpful insects – insect pollinators, scavengers - insects as protein sources of human and animal feeds, medicinal uses of insects, weed killers, Forensic Entomology.

Unit III Harmful Insects

Insect pests - general characters, damage, symptoms, bionomics and control measures of any three important pests of paddy (paddy stem borer, rice gall midge, rice swarming caterpillar), sugarcane (sugarcane stemborer, sugarcane leaf hopper, cane white fly) and coconut (leaf caterpillar, red palm weevil, rhinoceros beetle) – pests of stored products – Internal feeders (rice weevil, cigarette beetle) – External Feeder (Red Flour beetle, Indian meal moth).

Unit IV Medical Entomology

Insects in relation to public health –Direct effect: annoyance, dermatosis, myiasis, envenomization, allergic reaction and entomophobia. Indirect effects: host pathogen interactions: common insects of medical importance - life cycle and control measures – mosquitoes (Anopheles and Aedes), housefly, human louse - vector borne disease: dengue, malaria, chikungunya, filariasis and sleeping sickness.

Unit V Pest Management

Methods of pest control - natural, cultural, mechanical, legal, biological and chemical (organic and inorganic compounds – synthetic pyrethroids). Recent trends in pest control: Biointensive integrated pest management, hormones, pheromones, anti-feedants, sterile

insect technique - insect viruses - modern trends in pest control - integrated pest management (IPM).

Books for Reference

1. Fenemore, P.G. and B. Prakash. *Applied Entomology.* New Delhi: Wiley Eastern Ltd.1997.
2. Tembhare. D.B. *Modern Entomology.* New Delhi: Himalaya Publishing House. 2017.
3. Nalina Sundari, M.S. and R. Shanthi. *Entomology.* Chennai: MJP Publishers. 2006.
4. Abishek Shukla. *Economic Entomology*. New Delhi: Daya Publishing House. 2009.
5. Sandhya Agrawal. *Applied Entomology*. Jaipur, India: Oxford Book Company. 2009.
6. Ravindran K.R. *A Text Book of Economic Zoology*. New Delhi: Wisdom Press. 2013.
7. Sathe, T.V., Satha, A.T. and Jagtap. *Mahendra. Mosquito Borne Diseases*. New Delhi: Mangalam Publishers & Distributers. 2011.
8. Saxena, R. C. and R.C. Srivastava. *Entomology.* Udaipur: Agrotech Publishing Academy, 2007.
9. David, B.V and T.N. Ananthakrishnan. *General and Applied Entomology.* Bangalore: Mc Graw Hill Education, 2004.
10. Vasanthraj David B. and V.V. Ramamurthy. New Delhi: Elements of Economic Entomology. Brillion Publication. 2016.

PRACTICALS

Course Code: 21PZOCR2

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

1. Identification and classification of common insects – butterfly, grasshopper, stick insect, leaf insect, beetle.
2. Mounting– Honey bee (mouthparts, sting and pollen basket), Mosquito (mouthparts)
3. Submission of insect box with minimum 10 insects.

   Spotters (Museum specimen/ Slide) :
4. Beneficial insect - Honey bee colony and their product (honey)
5. Beneficial insect - Silk moth – life stages, silk
6. Any three insect pests and their damages – one pest on each crop paddy, coconut, sugarcane.
7. Life history of the insect vector – House fly
8. Life history of the insect vector – Mosquito

9. Any two household insects – bed bug, silverfish
10. Any two ectoparasites – human head louse, flea

Books for Reference

1. Vasantharaj David B. *Elements of Economic Entomology*. Chennai: Popular Book Depot. 2001.
2. Nayar, K.K., Vasantharaj David, B, and T.N. Ananthakrishnan. *General and Applied Entomology.* New Delhi: Tata Mc Graw Hill Publishing Company Ltd. 2004.
3. Fenemore, P.G. and Alka Prakash. *Applied Entomology*. New Delhi: New Age International Publishers. 2006.

SEMESTER II			
Core V	**Animal Physiology**		
Course Code: 21PZOC21	**Hrs/ Week: 5**	**Hrs/Sem: 75**	**Credits: 4**

Objectives:

- To provide students with an outstanding educational experience that prepares them for different careers, innovative and cutting edge research, and academia.
- To equip the students in the discipline of Physiology, by imparting knowledge and understanding of structure and function of human biological systems.
- To foster the development of professional skills through well designed curriculum; based on experiments, training and research.

Course outcomes

CO. No	Upon completion of this course, students will be able to	PSOs addressed	CL
CO- 1	compare digestive and circulatory system and infer regulation of blood pressure and heart beat	1, 2	Un, An
CO-2	understanding mechanisms of respiration and point out physiological adaptations to special conditions	1, 2	Un, An
CO-3	indicate the relationship between different environments and excretory organs and osmo ionic regulation	5	Ap, An
CO-4	appraise neuromuscular mechanisms and relate the physical and chemical phenomena	2 , 6	Un, Ev
CO-5	associate the endocrine glands with physiological actions and develop healthy life style	2, 4	Un, Cr
CO-6	perceive the steps involved in transmission of nerve impulses	5	Ev
CO-7	relate the structure and physiology of muscular system	7	Un
CO-8	elaborate the integration and interactions of hormones	8	Cr

Unit I **Digestive and Circulatory Systems**

Digestive system - gastrointestinal secretary functions and the glands - role of GI hormones. Structure of mammalian heart-cardiac cycle - cardiac output- control of heart beat - blood pressure and its regulation – related diseases (hypertension, hypotension, stroke).

Unit II **Respiratory System**

Human respiration**:** Anatomy and Physiology of the respiratory tract - transport of oxygen and carbon dioxide - regulation of respiration - artificial respiration - physiological response to oxygen deficient stress (diving, high altitude) and exercise.

Unit III **Neuromuscular System**

Nervous system: neurons – structure and types - nerve impulse propagation – concept of synapse - transmission of electrical and chemical synapse - reflex arc - – reflex action.

Muscular system: Structural basis of contraction - sliding filament theory – mechanism and energetics of muscle contraction.

Unit IV **Excretory System**

Human kidney: nephron – mechanism of urine formation – regulation of ionic and osmoregulation in invertebrates – Protozoa, crustaceans and insects, Chordates – fishes, birds and mammals.

Unit V **Endocrinology**

Basic mechanisms of hormone action - endocrine glands in mammal – pituitary, thyroid, adrenal and islets of Langerhans - hormones and functions - hormonal disorders - role of hormones in menstrual and estrous cycle - pregnancy – parturition – lactation - hormones and neoplastic growth.

Books for Reference

1. Hoar. *General and Comparative Physiology*. New Delhi. Prentice. Hall of India Pvt Ltd, 1975.
2. Sembulingmam K, and Prema Sembulingam. *Essentials of Medical Physiology.* New Delhi: Jay Pee Brothers, 2006.

3. Kunt Schmidt-Nielsen K. *Animal Physiology, Adaptation and Environment*. Cambridge University Press. 1985.

4. Ladd Prosser C. *Comparative Animal Physiology*, Agra: Third edition. Satish Book Enterprise Book Sellers and Publishers, 1984.

5. Malcolm S. Gordon. *Animal Physiology Principles and Adaptations*. London: Third Edition. Collier Mac Millan International Edition. Collier Mac Millan Publishers. 1984.

6. Nagabhushanam, R and M.S. Kodarkar. *Textbook of Animal Physiology,* New Delhi: Oxford and IBH Publishing Co., 1978.

7. Bentley P.J. *Comparative Vertebrate Endocrinology*, Delhi: First Edition Chand& Company Ltd, 1980.

8. Constance R. Martin. *Endocrine Physiology*, New York: First Edition. Oxford University Press, 1985.

9. Prakash S. Lohar. *Endocrinology – Hormones and Human Health*, Chennai: MJP Publishers, 2005.

10. Sawant S.C. *A Textbook of Human Physiology* New Delhi: Wisdom Press, 2015.

PRACTICALS

Course Code: 21PZOCR3

Hrs/ Week 2 **Credit : 1**

1. Estimation of haemoglobin
2. Determination of erythrocyte sedimentation rate (ESR)
3. Detection of haemin crystals of blood
4. Salt loss/ salt gain in a fish
5. Effect of temperature on oxygen consumption of fish
6. Urine analysis for sugar, albumin, urea and creatinine
7. Urine analysis for sediments
8. Assay of acid/ alkaline phosphatase enzyme
9. Chart/ slide/ photograph

a. Endocrine glands in man - Transverse section of pituitary, thyroid, pancreas and adrenal

b. Conditional reflex

c. Pregnancy test – demonstration

Books for Reference

1. Rastogi S.C. *Experimental Physiology*, New Delhi: Wiley Eastern Limited, 1982.
2. Nigam S.C. and Omkar. *Experimental Animal Physiology and Biochemistry,* New Delhi: New Age International (P) Limited, 2006.

SEMESTER II			
Core VI	**Immunology**		
Course Code: 21PZOC22	**Hrs / Week : 5**	**Hrs / Sem: 75**	**Credits : 4**

Objectives:

- To understand the fundamentals of immunology and key principles of immune system.
- To impart knowledge on the structure and functioning of immune system and how it relates to health and disease.

Course Outcome:

CO. No	Upon completion of this course, students will be able to	PSO addressed	C L
CO-1	analyse the genetic basis of antibody diversity, organization and arrangement of immunoglobulin genes	1	An
CO-2	understand the principle of the routine serologic procedures performed in the clinical laboratory.	1, 2	Un
CO-3	describe the structure and function of MHC molecules and the immunologic responses involved in preventing and combating infections	1	Un
CO-4	describe the basic mechanisms, distinctions and functional interplay of innate and adaptive immunity	1, 4	Un
CO- 5	describe immunological response and how it is triggered and regulated	1	Un
CO -6	transfer knowledge of Immunology into clinical decision – making	5	Ev
CO-7	elaborate the role and advances being made in transplantation with artificial organs and the aberrations of the immune system such as infections and autoimmunity	1, 6	Cr
CO- 8	discuss the modern laboratory techniques applicable in the diagnosis and monitoring of diseases involving the immune system.	6	Cr

Unit I Immunoglobulin Genes - Organisation and Expression

Scope - structure of Immunoglobulin (IgG) - Genetic model for Immunoglobulin structure - germ line and somatic variation – Dryer and Bennett two gene model organization of Immunoglobulin (Ig) genes. Gene rearrangements in variable region - mechanism of variable region DNA rearrangements - generation of diversity – class switching.

Unit II Antigen - Antibody Responses

Antigen - Antibody reactions: Salient features of antigen antibody reaction. Detection of antigen antibody reaction - precipitation - single radial immunodiffusion – double immunodiffusion – immunoelectrophoresis – rocket immune electrophoresis - immunofluorescence. Agglutination: haemagglutination - bacterial agglutination- passive agglutination - agglutination inhibition test - ELISA.

Unit III Immunobiology

Hypersensitivity: Types – Type I Anaphylaxis – Type II Antibody dependent cytotoxicity – Type III Immune complex mediated disease – Type IV Delayed type hypersensitivity and Type V Stimulatory hypersensitivity - factors causing hypersensitivity - Major Histocompatibility Complex - MHC products – structure, distribution and functions - clinical importance of HLA - HLA typing - HLA paternity testing - HLA and diseases.

Unit IV Infection and Immunity & Defects in immunity

Immune response to pandemic virus infections - role of innate immunity in controlling viral infection – adaptive immune responses to viral infection - examples of pandemic virus infections (Influenza virus and corona virus). Autoimmunity – causes of autoimmune diseases - organ specific and systemic autoimmune diseases – diagnosis and treatment.

Unit V Clinical Immunology

Tumour immunology – tumour antigens - natural immunity to tumours – T cell mediated immunity to tumours - therapeutic approaches to cancer - immune surveillance. Transplantation immunology - types of grafts - mechanism of graft rejection - graft versus host reaction – immune suppression - prevention of graft rejection. Vaccine – types – live attenuated vaccine and inactivated killed vaccines – Vaccination schedule.

Books for Reference

1. Catherine Sheehan. *Clinical Immunology*. *Principles and Laboratory Diagnosis*. Philadelphia: Wolterskluwer Company1997.
2. David Male, Brian Champian and Annie Cooke. *Advanced Immunology*. Philadelphia: J.B. Lippincott Company, Gower Medical Publishing 1987
3. Emil R. Unanue and Baruj Benacerraf. *Text Book of Immunology*. *II Edition.* London: Williams and Wilkins 1984.
4. Ivan M. Roitt. *Essential Immunology*. Oxford: Blackwell Scientific Publications 1994.
5. Joshi K.R and Osamo N.O. *Immunology*. India: Agro Botanical Publishers 1994.
6. Mary S. Leftfel, Albert D. Donnenberg and Noel R. Rose. *Hand Book of Human Immunology.* New York: CPC Press 1997.
7. Vamen Rao C. *Immunology*. New Delhi: Narosa Publishing House 2011.
8. Rastogi, S.C. *Essentials of Immunology*. New Delhi: CBS Publishers and Distributors 2002.
9. Talwar G.P. and Gupta S.K. *A Hand Book of Practical and Clinical Immunology.* Delhi: CBS Publishers and Distributors 1993.
10. Yadav P.R. *Immunology.* New Delhi: Discovery Publishing House 2004.
11. Surendra Naha. *Fundamentals of Immunology*. New Delhi: Dominant Publishers Pvt. Ltd 2012.
12. Sudha Gangal and Shubhangi Sontakke. *Textbook of Basic and Clinical Immunology*. Hyderabad: Universities Press (India) Pvt. Ltd 2016.

PRACTICALS

Hrs/Week - 2 **Course Code: 21PZOCR3** **Credit - 1**

1. Radial Immunodiffusion.
2. Double Immunodiffusion.
3. Haemagglutination.
4. Direct Agglutination - ABO blood grouping.
5. Rh - Typing.
6. Immunoelectrophoresis.
7. ELISA - Demonstration.
8. Isolation of lymphocytes and enumeration.
9. HLA typing.
10. Lymphoid organs in rat (spotter)

Books for Reference

1. Rabindra Narain, *Practical Immunology*. New Delhi: Wisdom Press, 2012.

2. Talwar G and S. K. Gupta. *A Handbook of Practical and Clinical Immunology.* Vol. 1 Second Edition. Delhi: CBS Publishers & Distributers 1992.

SEMESTER II			
Core VII	**Applied Biotechnology**		
Course Code : 21PZOC23	**Hrs / Week : 5**	**Hrs / Sem : 75**	**Credits : 4**

Objective:

To motivate the students to develop scientific attitudes towards emerging technologies

To discover the potential sources of biotechnology and their applications in various fields

To serve as a platform for students to explore their professional skills

Course Outcome

CO. No.	**Upon completion of this course, students will be able to**	**PSO addressed**	**CL**
CO-1	perform biotechnological manipulation of microbes for production of industrially important products	1	Un
CO-2	get more insight on the application of biotechnology in treatment of diseases	3	Un
CO-3	apply biotechnology for production of pharmaceutical products .	7	Ap
CO-1	use biotechnology to monitor environmental pollution	3	Ap
CO-5	apply their knowledge to alleviate the effects of various environmental pollutants using biotechnology.	8	Ap
CO-6	create transgenic animals	3	Ap
CO-7	evaluate the ethical issues related with genetically modified organism	2	Ev
CO-8	imbibe the practical and theoretical knowledge of nanomaterials essential for pursuing higher studies.	6	Un

Unit I Microbial Biotechnology:

Isolation and improvement of microbial strains – microbial production of food – beverages - single cell proteins - methods of enzyme production - production of penicillin - bioethanol – biogas.

Unit II Biotechnology and Health Care

Gene therapy: Ex vivo - gene therapy for adenosine deaminase deficiency, in vivo gene therapy - cancer and AIDS. Pharmaceutical products: Insulin, human growth hormone. Recombinant vaccines: Hepatitis B - influenza virus. Monoclonal antibodies - production and applications.

Unit III Environmental Biotechnology

Biotechnological methods for management of pollution - atmospheric CO_2, metal pollution - biotechnological methods for measurement of pollution - Bioassays – animal test systems - molecular biology – biosensors for environmental monitoring – bioremediation.

Unit IV Genetic Engineering

Construction of animal viral vectors for animal transformations - methods of developing transgenic animals: mice - fish – genetically engineered microbes (GEMOs) - applications of genetic engineering - ethics of genetic modification of animals.

Unit V Nanotechnology

Nanomaterials, synthesis of nanoparticles: RF plasma, chemical methods, thermolysis, biological methods - biofabrication, nanobiosensor, nanofluids, nanocrystals - synthesis of nanodrugs - nanomedicine.

Books for Reference

1. Dubey R.C. *A Text Book of Biotechnology*, 4th edition. New Delhi: S. Chand& Company Ltd. 2006.
2. Singh B.D. *Biotechnology.* Revised edition. New Delhi: Kalyani Publishers. 2005.
3. Kumaresan V. *Biotechnology*. Nagerkoil: Saras Publication. 2009.
4. Rema L.P. *Applied Biotechnology*. Chennai: MJP Publishers, 2007.
5. Satyanarayana U. *Biotechnology.* Kolkatta: Books and Allied (P) Ltd. 2006.

6. Robert Preidt, Laura Costlow and Peter. *Introductory Nanotechnology*. New Delhi: Dominant Publishers and Distributors. 2007.
7. Suhas Bhattacharya. *Introduction to Nanotechnology*. New Delhi: Wisdom Press. 2013.

Practical

Course Code 21PZOCR4

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

1. Isolation of plasmid DNA
2. Restriction digestion
3. Immobilization of enzymes by sodium alginate method
4. Bioadsorption or phytoremediation of an organic substrate.
5. PCR amplification.
6. SDS-PAGE
7. Mushroom culture
8. Charts and models pertaining to theory for spotters

   pBR322, monoclonal antibodies, transgenesis, organ culture, somatic cell fusion,

   Southern blotting, *Agaricus bisporus,* ultra sonication, laminar flow chamber.
9. Report of visit to biotechnology lab

Books for Reference:

1. Asish Verma, Surajit Das, Anchal Singh. *Laboratory Manual for Biotechnology*. New Delhi: S. Chand and Company. 2008.
2. Harisha S. *Biotechnology Procedures and Experiments Hand Book*. New Delhi: Infenity Science Press. 2007.
3. Joseph Sambrook and David S. Russel. *Molecular cloning - A laboratory manual.* New York, Cold Spring Harbor: Cold Spring Harbor Laboratory Press. 2001.

SEMESTER II			
Core VIII	**Microbiology**		
Course Code: 21PZOC24	**Hrs/ Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Objective

- To prepare graduate students with thorough knowledge and understanding of the core concepts in the field of Microbiology.
- To equip the students with knowledge about taxonomy, organization, multiplication and infection of microbes and to develop expertise in microbiological techniques.

Course Outcome :

CO. NO	**Upon completion of this course, the students will be able to**	**PSO addressed**	**CL**
CO- 1	classify microorganisms focusing on the modern trends of Taxonomy	1	Un
CO- 2	prepare media to be utilized in the cultivation of microorganisms	2	Ev
CO-3	understand the structural organization and life cycle of microorganisms	2	Un
CO-4	explain the role of microorganisms in fermentation, medicine and the production of microbial products	2	Ev
CO-5	gain familiarity with the unique role of pathogens in human infectious diseases	2	Un
CO-6	identify the methodologies used in disease treatment and prevention	6	An
CO-7	demonstrate practical skills in the use of technologies and methods common to microbiology	8	Ev
CO-8	apply scientific methods in the design and execution of experiments	8	Ap

Unit I Classification

Classification of microorganism – Five Kingdom concept. Modern trends of bacterial taxonomy - ribosomal RNA and sequencing - construction of phylogenetic tree. General characters of main groups of microorganisms – analysis based on Bergey's Manual of Determinative Bacteriology (biochemical tests).

Unit II Cultivation of Microorganisms

Preparation of culture media – isolation and maintenance of pure culture - cultural and morphological characteristics of bacteria, fungi – microscopic examination of microorganisms - Gram staining - acid fast staining – spore staining - capsular staining – flagellar staining.

Unit III Microbes – Structural Organization

Structural organization of bacteria – structure of *E. coli*, virus – plant virus – Tobacco Mosaic Virus, animal virus – adenovirus - bacteriophage and fungi – yeast, penicillium - life cycle of Actinomycetes and yeast.

Unit IV Production of Microbial Products

Yeast fermentation and its products – production of alcohol, beer and wine. Mixed fermentation product - production of vinegar. Production of antibiotics - penicillin and tetracycline.

Unit V Microbial Diseases

Protozoan diseases - ameobiais and leishmaniasis. Bacterial diseases- diphtheria, tetanus and gonorrhea. Viral diseases - corona virus, dengue fever, rabies and ebola. Fungal diseases - actinomycosis, aspergillosis, ringworm and candidiasis.

Books for Reference

1. Arti Kapil. *Text Book of Microbiology*. Hyderabad: University press 9th Edition. 2016
2. Dubey R .C and D.K. Maheswari. *A Text Book of Microbiology.* New Delhi: S. Chand & Co. 2006
3. Roger Stainer, John Lingraham, Mark I Wheelis and Page R. Painter. *General Microbiology.* London: Mac Millan, Hampshire 1992.

4. Pelzer Chan and Krieg. *Microbiology.* New Delhi: Tata Mc Grow Hill Publishing Company, 2nd Edition 1998.
5. Wulf Crueger and Annellese Crueger. Biotechnology: *A Textbook of Industrial Microbiology*. New Delhi: CBS Publishers and Distributors, 3rd Edition. 2016.
6. Presscott Harley and Klein. *Microbiology.* New York: WCB Mc Graw Hill Co. 2005
7. Purohit S.S. *Microbiology – Fundamentals and Application*. India: M/S Saraswathi Publication, 1991
8. Power C.B and K.F. Daginawala. *General Microbiology*. Vol I & II. Himalaya Publishing House, 1988.
9. Ramesh. *Food Microbiology.* Chennai: MJP Publishers. 2007
10. Casida, J.R. Industrial Microbiology. New Delhi: New Age International Pvt. Ltd., 2nd Edition 2015
11. Ananthanaryanan, R and J. Panikar. *Text Book of Microbiology*, Chennai Anna Salai : Orient Longman Private Ltd., 160, 7th Edition. 2006.

PRACTICALS

Course Code 21PZOCR4

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

1. Sterilization Techniques
2. Sample handling for microbial studies
3. Preparation of culture media:

   Nutrient broth, Nutrient agar, Potato dextrose agar, Mullen- Hinters agar
4. Counting of viable cells (CFU/ ml) by serial dilution & spread plate or pour plate methods
5. Pure culture techniques - Streaking and spread plate methods.
6. Spore staining
7. Simple biochemical tests of bacteria
   a. Acid and gas production in glucose broth
   b. Starch hydrolysis
   c. Catalase
   d. Nitrate reduction
8. Dye reduction test in milk

9. Test for antibiotic sensitivity - Kirby Bauyer disc diffusion test

10. Isolation of symbiotic nitrogen fixing bacteria from root nodules

11. Observation of algae and fungi

Books for Reference:

1. Kannan N. *Laboratory Manual in General Microbiology* Palani: Palani Paramount Publications, 1996.
2. James Cappuccino and Natalie Sherman. *Microbiology: A Laboratory Manual*. Addison –Wesly - Hyman Inc,1990.
3. Dubey R.C. and D.K. Maheswari. *Practical Microbiology*. New Delhi: S Chand & Company Ltd. 2008.

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/ Sem: 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

Course Code: 21PZOCR6

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

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 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.

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.