ST. XAVIER'S COLLEGE(AUTONOMOUS)

Palayamkottai - 627 002

(Recognized as "College with Potential for Excellence" by UGC)

(Re-accredited with "A^{++}" Grade with a CGPA of 3.66 in IV cycle)

Affiliated toManonmaniamSundaranar University, Tirunelveli

SYLLABUS

M.Sc. ZOOLOGY

(w.e.f.June 2021-2022)

ProgrammeName :M.Sc. ZOOLOGY
ProgrammeCode : PZO

ProgrammeSpecific Objectives:

1. M.Sc. in Zoology is a Two-years post-graduate academic degree programme which focuses on the studies relating to animals. The teaching programme in the department covers the emerging areas in life sciences.
2. These include core courses like Biochemistry, Cell and Molecular Biology, Structure and Function of Invertebrates, Diversity of animals and comparative functional anatomy, Biostatistics and Computer Application, Environmental Biotechnology, Genetics, Animal Biotechnology, Evolutionary Biology, Developmental Biology, Animal Physiology, Methods in Biology, Aquaculture, Bioinformatics, Environmental Biology, Immunology and Microbiology, Applied entomology in M.Sc. teaching programme.
3. A hand on practical training to the students is one of the outstanding features of the M.Sc. Zoology programme.
4. The teaching and research laboratories in the department are very well equipped with all the required instruments / equipments and students are always encouraged to use them.
5. The department houses a library catering to the needs of the students. Special efforts are made to add latest text books and scientific journals to the collection. M.Sc. students of the department have access to the internet facilities for academic purposes.
6. In order to expose the students to research environment, every student is also required to complete a small research project during the second year of the programme.
7. Every year study tour is arranged to various places in India, as part of the M.Sc. curriculum.
8. The research activities of the department are also recognised nationally and internationally and cover areas such as aquaculture and entomology with sharp focus on molecular biology, genetics, cell and developmental biology, animal physiology etc. The faculty members of this department have received several research grants from various national and international agencies.

ProgrammeSpecific Outcomes

On completion of the M.Sc. programme in Zoology the students will be able to

1. Describe the biochemistry of bio-molecules, its metabolism and functions.
2. Understand ultra structure and functions of various cellular organelles including cancerous cells and cell signaling.
3. Demonstrate parametric and non-parametric statistics and their biological applications.
4. Outline taxonomy, diversity of animals and their comparative functional anatomy.
5. Summarize ecosystem, bio-resources and their management, role of GMOs in biodegradation of xenobiotic compounds.
6. Summarize classical and modern genetics, genetic disorders, genetic counseling, tools and applications of genetic engineering and biotechnology.
7. Describe structure and functions of various organ systems and the physiology of animals and human beings.

8. Comprehend the concepts of ecosystem and to understand the impact of environment and their management strategies.
9. Describe fundamentals of the developmental process of various organisms.
10. Trace the origin of life and evolution, evolutionary processes, major trends of evolution and future of man.
11. Describe principles, working mechanism and applications of microscopic, analytical, radio isotopic, histological, chromatography, electrophoresis, spectroscopic and immunological techniques.
12. Apply tools of information technology for all activities related to Zoology

Employment and higher studies opportunities for M.Sc. Zoology students

1. The higher studies options after M.Sc. Zoology are: Master of Philosophy in Zoology, Master of Philosophy in Life Science, Ph. D. in Zoology/Biotechnology / Life Sciences.
2. A Master degree holder is eligible for writing competitive exams like NET, SET, placement as Project Assistant, employability in Fishery Board of India and Department of Sericulture and Department of Forests, Government of Tamil Nadu, Central Silk Board, etc.
3. P.G students are eligible for B.Ed., TNPSC, IAS, IPS, IFS (Group 1 exams), Biological Laboratory Technician, Conservationist, Environmental Consultant, Herpetologist, Veterinary Technologist, Wildlife Educator, Wildlife Rehabilitator, Zoologist, etc.

COURSE STRUCTURE FOR M. Sc. ZOOLOGY

Semester	Status	Subject Code	Title	Hours	Credits
I	Core - Theory -1	21PZO11	Structure and Function of Invertebrates	5	5
	Core -Theory - 2	21PZO12	Diversity of Animals and Comparative Functional Anatomy	5	5
	Core - Theory - 3	21PZO13	Biochemistry	5	5
	Elective -1	21PZOE11	Bioinformatics/Environmental Biology	5	5
	Core -Practical- 1	21PZOP14	Structure and Function of Invertebrates & Diversity of Animals and Comparative Functional Anatomy	4	2
	Core-Practical- 2	21PZOP15	Biochemistry	4	2
			Library / Seminar	2	-
			Sub Total	**30**	**24**
II	Core - Theory -4	21PZO21	Immunology and Microbiology	5	5
	Core - Theory -5	21PZO22	Genetics	5	5
	Core - Theory-6	21PZO23	Developmental Biology	5	5
	Elective -2	21PZOE21	Biostatistics and Computer Application / Methods in Biology	5	5
	Core -Practical-3	21PZOP24	Immunology and Microbiology	4	2
	Core -Practical-4	21PZOP25	Developmental Biology & Genetics	4	2
			Library / Seminar	2	-
			Sub Total	**30**	**24**
III	Core -Theory -7	21PZO31	Evolutionary Biology	5	5
	Core -Theory -8	21PZO32	Cell and Molecular Biology	5	5
	Core -Theory-9	21PZO33	Animal Physiology	5	5
	Elective -3	21PZOE31	Plant and Animal Biotechnology/Environmental Biotechnology	5	5
	Core -Practical-5	21PZOP34	Cell and Molecular Biology&Evolutionary Biology	4	2
	Core -Practical-6	21PZOP35	Animal Physiology	4	2
			Library / Seminar	2	-
			Sub Total	**30**	**24**
IV	Core -Theory -10	21PZO41	Aquaculture	5	5
	Core -Theory -11	21PZO42	Applied Entomology	5	5
	Core -Practical -7	21PZOP43	Aquaculture	4	2
	Core -Practical -8	21PZOP44	Applied Entomology	4	2
	Elective-4	21PZOE41	Dissertation	10	4
			Library / Seminar	2	-
			Sub Total	**30**	**18**
			STAND		1
			GRAND TOTAL	**120**	**91**

Core theory -11; Core practical – 8; Elective -3 (with optional) and 1 dissertation

Extra Credit Course

Sem	Course Code	Title of the Course	Credits	Eligibility
I	21PZO ECC01	Biodiversity	4	UG- Science Students
II	21PZO ECC02	Medical Entomology	4	Any UG Students
III	21PZO ECC03	Animal Behaviour	4	UG- Science Students
IV	21PZO ECC04	Biopesticides	4	UG- Science Students

STRUCTURE AND FUNCTION OF INVERTEBRATES
(Subject Code: 21PZO11)

Semester: I	Core Theory:1	Credits: 5	Hours: 5

Course Objective: To outline the basic concepts of taxonomy, classification and body organization of selected invertebrates.

Course Outcomes: At the end of the course the students will be able to

1. Gain an overview of the classification of invertebrates.
2. Describe the structure, function and life cycle of selected invertebrates by observing live and preserved specimens
3. Predict the behaviour and examine the adaptive significance of invertebrates
4. Analyse the ecological role of representative organisms in each phyla
5. Compare and establish phylogenetic relationships between the phyla covered
6. Identify and name invertebrates with the use of literature and other resources

Unit I:Principle of Invertebrate classification 14 Hours

General Characteristics of Invertebrate; Classification ofinvertebrate phyla upto order levels, habitat of living invertebrates in global level. - Organization of coelom –Acoelomates – Pseudocoelomates - Coelomates: Protostomia and Deuterostomia

Unit II: Locomotion and Nutrition 14 Hours

Pseudopodia - Flagella and ciliary movement in protozoa - Hydrostatic movement in Coelenterata, Annelida and Echinodermata - Nutrition and Digestion - Patterns of feeding and digestion in lower metazoan - Filter feeding in polychaeta, Mollusca and Echinodermata

Unit III: Respiration and Excretion 14 Hours

Organs of respiration: gills, lungs and trachea - Respiratory pigments - Mechanism of respiration – Excretion - Organs of excretion: coelom, coelomoducts, nephridia and Malphigian tubules - Mechanisms of excretion - Excretion and osmoregulation

Unit IV:Nervous system 14 Hours

Primitive nervous system: Coelenterata and Echinodermata - Advanced nervous system: Annelida, Arthropoda (crustacean and insecta) and Mollusca (cephalopoda) - Trends in neural evolution

Unit V:Invertebrata larvae 14 Hours

Larval forms of free living invertebrates - Larval forms of parasites - Strategies and evolutionary significance of larval forms - Minor Phyla (Structural features and affinity) - Concept and significance - Organization and general characters

Textbooks:

1. Hyman, L.H. The invertebrates. Vol.l Protozoa through Ctenophora, McGraw Hill Co., New York.
2. Barrington, E.J.W. Invertebrate structure and function. Thomas Nelson and Sons Ltd., London

Reference books:

1. Jagerstein, G. Evolution of Metazoan life cycle, Academic Press, New York & London.
2. Hyman, L.H. The Invertebrates. Vol.2. McGraw Hill Co., New York.
3. Hyman, L.H. The Invertebrates. Vol.8. McGraw Hill Co., New York and London.
4. Barnes, R.D. Invertebrate Zoology, III edition. W.B. Saunders Co., Philadelphia.
5. Russel-Hunter, W.D. A biology of higher Invertebrates, the Macmillan Co. Ltd., London
6. Hyman, L.H. The Invertebrate smaller coelomate groups, Vol.V. McGraw Hill Co., New York.
7. Read, C.P Animal Parasitism. Prentice Hall Inc., New Jersey. 10. Sedgwick, A. A student text book of Zoology. Vol.I, II and III. Central Book Depot, Allahabad.
8. Parker, T,J., Haswell, W.A. Text Book of Zoology, Macmillan Co., London.

E-resources:

1. https://www.nextgurukul.in/wiki/concept/uttar-pradesh/class-6/biology/old_structure-and-functions-of-organisms-ii/locomotion-in-invertebrates-and-vertebrates/3964560
2. https://www.notesonzoology.com/invertebrates/feeding-and-digestion-in-invertebrates-zoology/1981
3. https://www.britannica.com/science/respiratory-system
4. https://courses.lumenlearning.com/wmopen-biology2/chapter/excretion-systems/
5. https://www.biologyonline.com/
6. https://www.onlinebiologynotes.com/
7. https://www.nationalgeographic.com/animals/invertebrates

DIVERSITY OF ANIMALS AND COMPARATIVE FUNCTIONAL ANATOMY
(Subject Code: 21PZO12)

Semester: I	Core Theory:2	Credits: 5	Hours: 5

Course Objectives: This course introduces the taxonomy, diversity, functional anatomy of animals.

Course outcomes: At the end of the course the students will be able to

1. Define the basic principles of taxonomy.
2. Describe the structural organization adaptive features of animals.
3. Demonstrate the concepts of methodology of animal classifications.
4. Illustrate comparative functional anatomy of skeletal and sense organs.
5. Summarize comparative functional anatomy of animals**.**
6. Integrate the structure and function of animals

Unit I: Principles and methods of taxonomy and biodiversity 14 Hours

Concepts of species and hierarchical taxa; Biological nomenclature, classical and quantitative methods of taxonomy of animals; Biological Taxonomy; Biodiversity –Types, characterization, generation, maintenance and loss; Global Biodiversity Information Facility

Unit II: Outline classification of animals 14 Hours

Contributions of Carl Linnaeus; Important criteria used for classification in each taxon; Classification of animals; Theories of biological classification; Evolutionary relationships among Peripatus, Balanoglossus and Archaeopteryx. International Code of Zoological Nomenclature (ICZN)-naming rules, phylo Code; Animal Databases- SysTax, AntWeb, FishBase, MCZBase (Brief account);mt-DNA barcoding, Type specimens.

Unit III: Levels of structural organization and anatomy 14Hours

Unicellular, colonial and multicellular forms; Levels of organization of tissues, organs and systems; general adaptive features in fishes, amphibians, birds, mammals.

Unit IV: **Comparative functional anatomy of invertebrates 14 Hours**

Digestive system, Respiratory system, Circulatory system, Reproductive system, Nervous system, Sense organs (general account)

Unit V:Comparative functional anatomy of vertebrates 14 Hours

Integument and its derivatives, Digestive system, Respiratory system, Circulatory system including heart and aortic arches, Urino-genital system, Brain and Sense organs (eye and ear).(general account).

Textbooks:

1. Supriyo Chakraborty. 2014. Biodiversity, Pointer Publishers, India, pp. 136.
2. Krishnamurthy, V. 2003. Textbook of Biodiversity, Science Publishers, India, pp. 260.

Reference books:

1. Pranay Lal. 2016. India: A Deep Natural History of the Indian Subcontinent, Penguin Book, pp. 470.
2. Casey Rand. 2009. Classification of Animals, Raintree Publisher, United Kingdom, pp.49.
3. Saxena, R.K. and Sumitra Saxena. 2016. Comparative Anatomy of Vertebrates, Second Revised Edition, Viva Books, New Delhi, pp. 556.
4. Richard Owen 2009. Lectures on the Comparative Anatomy and Physiology of the Invertebrate, Biblio Bazaar Publisher, pp. 324.
5. Simpson G.G. 1961. Principles of Animal Taxonomy, Oxford IBH Publishing Company, New Delhi.

E-resources:

1. http://ncert.nic.in/ncerts/l/kebo104.pdf
2. http://web2.uconn.edu/cyberinfra/module4/Taxonomy.pdf
3. http://kea.kar.nic.in/vikasana/bridge/biology/chap_03.pdf
4. http://research.tamucc.edu/compliance/assets/ILAR%20Journal.pdf
5. https://www.ipm.iastate.edu/files/curriculum/05%20Introduction%20to%20Plant%20Pathology_0.pdf
6. http://www.ncl.ac.uk/ohss/assets/documents/SAPOguidance.pdf
7. http://nsdl.niscair.res.in/jspui/bitstream/123456789/658/1/Revised%20INTRODUCTORY%20PLANT%20PATH.pdf
8. https://www.eolss.net/sample-chapters/C03/E6-71-04.pdf

BIOCHEMISTRY
(Sub. code: 21PZO13)

Semester: 1	Core Theory: 3	Credits: 5	Hours: 5

Course Objectives: To understand the structure and properties of essential nutrients including carbohydrates, protein, lipid, nucleic acid and to find out the metabolic pathways of various nutrient types and to know about the biochemical aspects of vitamins and hormones.

Course outcomes: At the end of the course the students will be able to

1. Describe carbohydrates, proteins and lipids; their structure, properties and function.
2. Explain the basic structure of nucleic acids and classification, structure and properties of enzymes.
3. Illustrate the metabolism of carbohydrates, proteins and lipids.
4. Classify vitamins, their sources, properties and biological role.
5. Summarize hormones and their biochemistry.
6. Develop metabolomic tools.

Unit I: Carbohydrates, Proteins and Lipids **14 Hours**

Carbohydrates: Monosaccharides - general structure and properties; oligosaccharides; Polysaccharides; Proteins: Amino acids – Peptides, Protein configuration - classification - properties; Lipids - general structure, classification, properties of fats and fatty acids.

Unit II: Nucleic Acids and Enzymes **14 Hours**

Nucleic Acids–Chemistry, nucleosides, nucleotides variants of DNA; DNAs of unusual structure - single stranded DNA; RNA - types chemistry; Enzymes - nomenclature classification, three dimensional structure mechanism of action, enzyme kinetics and enzyme regulation and Isoenzymes.

Unit III: Metabolism **14 Hours**

Glycolysis - alcoholic fermentation - pyruvate oxidation - citric acid cycle - HMP pathway - glyoxylate cycle - electron transport - oxidative phosphorylation; oxidation of even chain fatty acids (oxidation), unsaturated fatty acids and odd chain fatty acids; Amino acid metabolism, Metabolism of nucleotides.

Unit IV: Vitamins **14 Hours**

Fat soluble vitamins –characteristic features,structure,deficiency; Water soluble vitamins – characteristic features, structure, deficiency; coenzyme Q, metabolism of vitamin A and C

Unit V: Hormone Biochemistry **14 Hours**

General function, outline classification, steroid hormones, peptide hormones, amino acid derivatives, para-hormones, vasoactive peptides, pheromones, mechanism of hormone action.

Textbooks:

1. Victor Rodwell, David Bender, P. Anthony Weil, Peter Kennelly, Kathleen Botham. 2015. Harpers Illustrated Biochemistry, 30th Edition, Mc Graw Hill Publication.
2. Satyanarayana, U. and Chakrapani, U. 2007. Biochemistry, Third Edition, Books and Allied (P) Ltd, Kolkata.

Reference Books:

1. AmbikaShanmugam, 2012. Fundamentals of biochemistry for medical students, Lippincott Williams & Wilkins, pp. 763.
2. Lehninger, A. 1993. Principles of Biochemistry, CBS publishers and distributors, New Delhi.
3. Stryer, Lubert, 1975. Biochemistry- W.H. Freeman & Company, San Francisco
4. Murray, Granner, Mayes and Rodwell, 1996. Harper's Review of Biochemistry, Apleton of Large, Connecticut.
5. Jain, J. L. 2003. Fundamentals of biochemistry, S. Chand and Co. Ltd., New Delhi.

E-resources

1. http://jpkc.gmu.cn/swhx/book/Biochemistry.pdf
2. http://www.louisbolk.org/downloads/1282.pdf
3. http://library.aceondo.net/ebooks/Chemistry/lehninger_principles_of_biochemistry_4th.ed.pdf
4. http://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199730841/McKee_Chapter8_Sample.pdf
5. http://www.esalq.usp.br/lepse/imgs/conteudo_thumb/mini/Principles-of-Biochemistry-by-ALbert-Leningher.pdf

BIOINFORMATICS
(Subject Code: 21PZOE11)

Semester: I	Elective: 1 (optional)	Credits: 5	Hours: 5

Course Objectives: The aim of the course is to provide an understanding of key modern molecular technologies, their exploitation and application and the bioinformatics analyses involved.

Course outcomes: At the end of the course the students will be able to

1. Describe basic principles of bioinformatics
2. Explain historical background of bioinformatics.
3. Demonstrate sequence alignments
4. Access and use the information available in protein databases to find out protein of interest.
5. Evaluate tools for evolutionary analysis
6. Predict structure of proteins by computational methods.

Unit I: Introduction to databases **14 Hours**

Definition, history, aims and importance of bioinformatics; Introduction of databases -Concept of data, various types of databases; Biological data bases - Nucleotide Sequence Databases, Protein Sequence Databases, Macromolecular Databases and Other Databases.

Unit II: Sequence Alignment **14 Hours**

Simple alignment, scores, gaps, gap penalties, scoring matrices, Pair wise alignment-global and local, Dot plots; Multiple sequence alignment (Clustal)

Unit III: Substitution Pattern and Evolutionary Analysis **14 Hours**

Substitution matrices; pattern of substitution within genes; PAM - BlOSSUM; Molecular phylogenetics and phylogenetic trees; Distance matrix methods -UPGMA and neighbour joining methods; POPBAM: tools for evolutionary analysis

Unit IV: Protein and its Structure Prediction and DNA Sequence Analysis **14 Hours**

Pattern discovery and sequence classification in proteins: artificial neural network and hidden Markov models; pattern discovery; Gene mark and GRAIL; Secondary structure, typed, prediction: Ramachandran plot, Chou-Fasman; tertiary structure prediction: homology modeling and threading.

Unit V: Applications of Bioinformatics in various fields **14 Hours**

Drug designing, Medicine (molecular, personalized, preventive), Gene therapy, Design of microbes for various applications (waste cleanup, forensic studies, Bio-weapons), Bioengineering, Biological Computer, Computational methods of phylogenetic and molecular evolutionary analysis

Textbooks:

1. Chikhale, N.S. and Gomae, V.S. 2015. Bioinformatics: Theory and Practice, Himalayan Publishihg House, Delhi.
2. David. N. Mount.2016. Bioinformatics. Sequence and genome analysis, Cold Spring Harbor Laboratory Press, New York.

Reference Books:

1. Rastogi, S.C.,Mendriratta and Rastogi, P. 2012. Bioinformatics concepts, skills and applications, Second Editions.
2. Attwood, Teresa K. and Parry Smith, Dayid, J. 1999. Introduction to Bioinformatics, Pearson Education, Singapore.
3. Lesk, Arthur M. 2012. Introduction to Bioinformatics, Oxford University Press.
4. Mani, K. and Vijayaraj, N. 2011. Bioinformatics a practical approach, Aparna Publications, Coimbatore.

E resources:

1. https://www.ncbi.nlm.nih.gov/
2. https://www.bioinformatics.org/
3. https://www.ebi.ac.uk/
4. https://www.expasy.org/
5. https://www.rcsb.org/
6. https://molbiol-tools.ca/

ENVIRONMENTAL BIOLOGY
(Subject code: 21PZOE11)

Semester: I	Elective: 1 (optional)	Credits: 5	Hours: 5

Course Objective: To create awareness about the environment in which animals live**.**

Course outcome: At the end of the course the students will be able to

1. Describe the biotic and abiotic components of environment.
2. Comprehend the structure of ecosystem.
3. Determine the role of environment on biodiversity.
4. Classify types and components of ecosystem.
5. Summarize community, population and biogeochemical cycles.
6. Develop appropriate environment conservation and management strategies.

Unit I: The environment and ecosystem **14 Hours**

The Environment - Atmosphere, Hydrosphere, Lithosphere, abiotic and biotic factors and its interaction; Ecosystem structure and function; Natural and Man-made ecosystem, energy flow, food chain and web; Ecological pyramids, primary productivity and its measurement. Animal associations-symbiosis, commensalism, mutualism, parasitism, predators and competition.

Unit II: Population and nutrient cycles **14 Hours**

Characteristics of a population - growth curves, density, natality, mortality, age distribution; Life study tables;Factors affecting population growth, regulation of population size; Biogeochemical cycles-Carbon, Oxygen, Nitrogen, Phosphate and Sulphur cycle; Interaction between nutrient cycles.

UnitIII: Habitat and resources ecology **14 Hours**

Ecology of fresh water, marine, estuarine, terrestrial habitat, Renewable and non-renewable resources - animal resources.

Unit IV: Environmental conservation and management **14 Hours**

Principles of conservation, biodiversity management approaches, Wild life resources and protected areas, endangered and endemic animals in India; Conservation strategies (project tiger and biosphere reserve); Environmental stress and their management

Unit V: Pollution and management **14 Hours**

Environmental pollution and its biological effects; Air, water, soil and noise Pollution; Thermal radioactive and greenhouse effect; Ozone and global warming; Acid rain Biomagnifications; Biological indicators and their role in environmental monitoring and climate change.

Textbooks:

1. Saha, T.K. 2010. Ecology and Environmental biology, Books and Allied (P) Ltd., Kolkatta.
2. Mohan P Arora. 2012. Ecology, Himalaya Publishing House, India.

3. Sharma, P.D. 1999. Environmental Biology and Toxicology, W.B. Saunders Company, India.

Reference books:

1. Odum, E. P. 1976. Fundamentals of Ecology, W.B Saunders Company, Philadelphia.
2. Miller, G. T. 2006. Environnemental Science, Cenage learning. India Private Ltd., India.
3. Rajagopalan, 2005. Environmental studies, Oxford University Press.
4. Daniel. D. Chiras, 2010. Enviromental sciences, 8th edition, Jones and Bartlett Publishers.
5. Peter Stiling, 2002. Ecology Theories and Applications, 4th edition Prentice - Hall India.

E-resources:

1. https://www.learner.org/courses/envsci/unit/pdfs/unit4.pdf
2. http://ncert.nic.in/ncerts/l/lebo114.pdf
3. https://en.wikipedia.org/wiki/Habitat
4. http://www.fao.org/3/a-i3928e.pdf
5. https://fortress.wa.gov/ecy/publications/documents/97401.pdf

STRUCTURE AND FUNCTION OF INVERTEBRATES & DIVERSITY OF ANIMALS AND COMPARATIVE FUNCTIONAL ANATOMY - PRACTICAL
(Subject Code: 21PZOP14)

Semester: I	Core Practical: 1	Credits: 2	Hours: 4

1. Virtual dissection:
    a. Grasshopper - https://www.ent.iastate.edu/ref/anatomy/ihop/
    b. Starfish - http://www.k-state.edu/organismic/images/starfish_gonad.jpg
    c. Frog –https://www.emindweb.com/demo/frog/
2. Nervous system of Prawn, Crab and *Pila*
3. Digestive system of a fish & Crab - (market specimens)
4. Reproductive systems of a fish (market specimens)
5. Air bag in fish–(market specimens)
6. Mounting of marine prawn appendages
7. Mounting of Placoid Scales - Preserved specimens (Shark skin)
8. Types of scales in fishes - Preserved specimens
9. Diversity of Feathers- Preserved specimens
10. Venom study in various phylum
11. Simple phylogenetic grouping of Animals
12. Model preparation
13. Cross word puzzles for each phylum
14. Using advanced anatomical coloring manuals
15. Activity card preparation – observation of fishes, birds, mammals and their behaviour
16. Identification of poisonous and non-poisonous snakes
17. Comparative anatomy of skulls-human, horse, monkey, pig and leopard
18. Collection, preservation and submission of invertebrates (dead specimens only).

19. Spotters: *Hydra, Aurelia*, Leech, Scorpion, Centipede, *Limulus*, *Peripatus*, Star fish, Sea cucumber, Sea lily, *Amphioxus, Anguilla, Hippocampus*, Sardine, *Ichthyophis*, *Salamandra, Ambystoma, Draco*, Chameleon, Cobra, Viper, Enhyrina, Chelon-sea turtle, Testudo-sea tortoise, Crocodile; Indian spoonbill, great Indian hornbill, pelican, Hedge hog, Loris, Mongoose, bat; Osteology of Rabbit- skull dorsal view, Lower Jaw, Lumbar vertebrae, Pectoral girdle, Pelvic girdle, Fore and Hind limb.

BIOCHEMISTRY – PRACTICAL
(Subject Code: 21PZOP15)

Semester: I	Core Practical: 2	Credits: 2	Hours: 4

1. Concept of pH, Measuring pH of different solutions
2. Preparation of buffers: Acetate, Phosphate and Tris buffers
3. Estimation of Carbohydrate in fish muscles/liver
4. Estimation of salivary amylase activity
5. Estimation of protein by Lowry's method/ Bradford method
6. Estimation of protease activity on substrates
7. Estimation of amino acid (Tyrosine/ tryptophan) by spectrophotometer
8. Estimation of nucleic acids (DNA) using blood sample
9. Estimation of iodine value in edible oils
10. Determination of acid value of fats and oils
11. Determination of saponification value of fats and oils
12. Estimation of cholesterol in blood serum (colorimetric)
13. Estimation of ascorbic acid by Titrimetric method
14. Separation of lipids by TLC
15. Separation of amino acids by ascending paper chromatography

16. Spotters:Structure of glucose, Starch, Secondary structure of protein, Myoglobin, Haemoglobin , α -lecithin, Cephalin, Stearic acid, Oleic acid, Cyclic AMP, Urea cycle, Kreb cycle, Structure of DNA, Structure of RNA-types, Enzyme action- lock and key model, Induced fit model; Fat soluble vitamins and water soluble vitamins and Hormonal action, Instruments**:** pH meter, colorimeter, Paper chromatography, gel electrophoresis, spectrophotometer and centrifuge.

IMMUNOLOGY AND MICROBIOLOGY
(Subject code: 21PZO21)

Semester: II	Core Theory: 4	Credits: 5	Hours: 5

Course Objective: Immunology and Microbiology course provides an overview of the human immune system and disease causing microbes. Also provides cells, and organs involved in immunity of animals.

Course outcomes: At the end of the course the students will be able to

1. Describe the fundamentals of immune system
2. Explain the role and mechanism of immune cells and organs
3. Demonstrate immune response of various parasitic infections.
4. Classify different types of immunity
5. Summarize microbial classification, morphology and their economic importance
6. Develop microbial products of industrial and medical importance.

Unit I: Immune System **14 Hours**

Cells and organs of the immune system: B lymphocytes, T lymphocytes, Macrophages; Antigen-Antigenic determinants and their types; Immunoglobulins-structure and functions, Monoclonal antibodies; Lymphoid organs. MHC-Structure, classes and functions; Antigen antibody interactions; Complement- Classical and alternate pathway, Biological function.

Unit II: Hypersensitivity, Autoimmunity, Transplantation **14 Hours**

Hypersensitivity-Brief accounts on type I, II, III and IV reactions. Autoimmunity: Organ specific AID and non organ specific AID; Immunodeficiency-Deficiency of T and B lymphocytes, combined immunodeficiencies, deficiency of complement and phagocytic system; Transplantation-Allograft rejection, mechanism of graft rejection.

Unit III: Microbes **14 Hours**

Microorganisms-salient characteristics, bacterial classification (Bergey's system of classification); Morphology and fine structure of bacteria; General account on viruses-plant viruses, animal viruses, bacteriophages, cyanophages and mycoviruses; General characters of fungi, actinomycetes, mycoplasma, archae-bacteria, rickettsiae.

Unit IV: Microbial genetics, physiology and interaction with human **14 Hours**

Microbial genetics-Methods of genetic transfers-transformation, conjugation, transduction, and sexduction, Mapping genes by interrupted mating, fine structure of analysis of genes; Microbial Physiology-Growth yield and characteristics, strategies of microbial cell division, stress response (biotic and abiotic); Microbes on human life (contact, infection and diseases), Autochthonous microbes (brief account).

Unit V:Applications of immunology and microbiology 14 Hours

Applications of immunology and immunotechniques – immunotherapies, immunization and vaccine production, precipitation reaction, agglutination reaction, radioimmunoassay, ELISA Applications; Fermentation products - penicillin and vitamin B_{12};Bio-fertilizers and biopesticides; Role of microbes in biogas production and pollution management; Economic importance of Bacteria with special reference to industry and medicine.

Textbooks:

1. Vaman Rao, C. 2011. Immunology, Narosa Publishers, New Delhi.
2. Banerjee Banerjee. 2008. Fundamentals of Microbiology and Immunology, Second Revised Edition, New Central Book Agency, Kolkata, pp.880.
3. Chakraborty, A.K. 2006. Immunology and Immunotechnology, Oxford University Press, New Delhi.
4. Michael J. Pelczar. 2014. Microbiology, Tata McGraw Hill Education.

Reference Books:

1. Roitt, I. and Delves. 2001. Essential Immunology, Blackwell Science, London.
2. Richard Thomas, and Barbara Janis, 2003. Kuby Immunology, Fifth Editon, W. H. Freeman and company, New York, USA.
3. Khan, F.H. 2009. The Elements of Immunolgy, Pearson Education, New Delhi.
4. Dubey, R.I. and Maheshwari, D.K. 2005. A text book of Microbiology, Chand and Company New Delhi
5. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton (2011). Prescott's Microbiology. Mc-Graw Hill.
6. Tortora G, Funke B, Case C, Weber D. (2018). Microbiology in Introduction, 13th edition. Addison-Wesley Publications.
7. Subhash Chandra Parija. 2012. Textbook of Microbiology & Immunology, 2nd Edition, Elsevier India

E-resources:

1. https://en.wikipedia.org/wiki/Effects_of_parasitic_worms_on_the_immune_system
2. http://isp.tums.ac.ir/Paper/notification/172/diagnosingmedicalparasites-121220050347-phpapp01.pdf
3. http://mci.img.cas.cz/pdf/Imunity%20to%20infection%202004_an.pdf
4. http://www.csun.edu/~cmalone/pdf589/ch20_1.pdf
5. http://m-learning.zju.edu.cn/upload/843de834-6b81-4c03-9711-d7e882f1c0b5.pdf
6. http://www2.sunysuffolk.edu/kennym/Ch11Micro.pdf

GENETICS
(Subject Code: 21PZO22)

Semester: II	CoreTheory:5	Credits: 5	Hours: 5

Course Objective: To study hereditary biology, mechanism involved in hereditary diseases and disorders and also to know the fundamental processes of life.

Course outcomes: At the end of the course the students will be able to

1. Define the principles of modern genetics.
2. Explain concepts, methods and applications of gene mapping.
3. Demonstrate the basic and applied genetics of microbes and human.
4. Outline types, mechanism and implications of mutation.
5. Summarize genetic disorders and genetic counselling.
6. Integrategenetic methods with agriculture, aquaculture, animals and human welfare.

Unit I : Modern Genetics and its Principles **14 Hours**

Eukaryotic genome –C-value paradox, Repetitive DNA, General concept of a gene, Gene families, Non-coding genes; DNA polymerases, RNA polymerases; Somatic or mitotic crossing over, germinal or meiotic crossing over.

Unit II: Gene mapping methods **14 Hours**

Complete and incomplete linkage, Linkage maps, LOD score for linkage testing, Tetrad analysis, Mapping with molecular markers, Mapping by using somatic cell hybrids; Extra chromosomal inheritance- Mitochondrial inheritance, Kappa particles.

Unit III: Microbial and Human Genetics **14 Hours**

Microbial genetics-Methods of genetic transfers – transformation, conjugation, Transduction and sexduction, mapping genes by interrupted mating; Human genetics- Pedigree analysis, genetic disorders (Brachydactyly, Huntington's chorea, Sickle cell anemia); Genetic counseling - eugenics, euthenics and euphenics.

Unit IV: Mutation **14 Hours**

Mutation -Types (Spontaneous, Induced, lethal, conditional, biochemical), causes, loss of function, gain of function, Germinal versus somatic mutants, insertional mutagenesis; Quantitative genetics - Polygenic inheritance, Types of quantitative traits (continuous, meristic and threshold); examples (skin colour and height in humans), Mapping of Quantitative trait loci (QTL mapping).

Unit V: Applied Genetics **14 Hours**

Animal Selective Breeding; Crime and Law DNA Finger Printing; Agriculture (food production), Disease prediction (colour blindness and dwarfism), Aquaculture (breeding and production)

Textbooks:

1. Benjamin Lewis, 2007. Genes IX, Jones and Bartlett Publishers, U.S.A.
2. Monroe W. Strickberger, 2012. Genetics, Third Edition, Prentice Hall of India, Pvt.Ltd,India.

Reference Books:

1. Cummings, K. and William S. Klug 2016. Concepts of Genetics. 11th Edition, Pearson Education India, 896 pp.
2. Twyman, R. 2005. Gene Transfer to Animal cell, Taylor & Francis Group, CT, USA, 256 pp.
3. GurbachanMiglani2015.Essentials of Molecular Genetics, Alpha Science International Ltd., Oxford, United Kingdom.
4. Tamarin, R.H. 2002. Principles of Genetics, Tata McGraw Hill Publishing Company, New Delhi.

E-resources:

1. https://publications.nigms.nih.gov/thenewgenetics/thenewgenetics.pdf
2. http://www.agrimoon.com/principles-of-genetic-pdf-book/
3. https://archive.org/details/FundamentalsOfGenetics
4. https://archive.org/details/Concepts_of_Genetics
5. https://www.researchgate.net/publication/271197797_Essentials_of_Molecular_Genetics

DEVELOPMENTAL BIOLOGY
(Subject Code: 21PZO23)

Semester: II	Core Theory:6	Credits: 5	Hours: 5

Course Objectives: To understand the process of development in frog and chick and to know about the role of genes in development of *Drosophila*.

Course outcomes: At the end of the course the students will be able to

1. Define the basic concepts of development of animals.
2. Comprehend gametogenesis, fertilization and early development.
3. Demonstrate gastrulation and organogenesis of chosen animals.
4. Illustrate the role of genes and cytoplasm during the development.
5. Evaluate *Drosophila* developmental stages.
6. Develop protocols to observe metamorphosis and regeneration.

Unit I: Gametogenesis, Fertilization and Cleavage **14 Hours**

Spermatogenesis. Oogenesis. Egg: Polarity and gradient. Morphogenetic factors. Transcription factors. Maternal Gradient.Fertilization: Morphological, Biochemical and Physiological events. Cleavage: Types, patterns and rules. Role of yolk. Cell lineage.

Unit II: Gastrulation and Organogenesis **14 Hours**

FrogGastrulation: Fate maps, Morphogenetic movements. Metabolic events. Neurulation and formation of primary germlayers. Induction and organizer. Potency. Commitment, specification,competence, determination and differentiation. Organogenesis: Brain,eye,heart and limb in frog.

Unit III: Role of genes and cytoplasm in development **14 Hours**

Caenorhabditis elegans: Life cycle, cell lineage, cell – cell interactions and polarity, *hox* genes, genetic control and microRNAs. Ascidian: Mosaic development, cytoplasmic factors, mesenchyme and notochord development.

Unit IV: Development of *Drosophila* **14 Hours**

Early development upto hatching, Maternal genes and body axes, polarization of body axes during Oogenesis, Zygotic genes, Pattern formation: pattern of early embryo segmentation; the pair rule genes, segmentation polarity genes and Homeotic selector genes. Terminal genes.

Unit V: Metamorphosis and regeneration **14 Hours**

Frog metamorphosis: Morphological, Physiological and Biochemical changes and causation of metamorphosis in frog. Regeneration: Types, (*Hydra*, salamander and mammalian liver) mechanism and factors, Polarity and gradient. Wolffian regeneration.

Textbooks:

1. Rastogi, V.B. andJayaraj,M.S. 2002. Developmental biology, KedarNath Ram Nath, Meerut.
2. Scott F Gilbert (2020) Developmental Biology. 11th edition. Sinauer Associates, Inc., Publishers Sunderland, Massachusetts USA.
3. Lewis Wolpert (2010). Principles of Development. 3rd edition. Oxford University Press. NewDelhi.

Reference Books:

1. Twyman RM (2003). Developmental biology, Viva books Pvt. Ltd.
2. Werner A Muller (2005). Developmental biology. Springer Publications.
3. Balinsky, RJ. 1981. An Introduction to Embryology, CBS College Publishing, Holt, Rinehart and Winston.
4. Gurubachan S. Miglani (2006). Developmental genetics. IK International Publishing House.
5. Leland Hartwell, Leroy Hood, Michael Goldberg, Ann E. Reynolds and Lee Silver. 2000. Genetics from Genes to Genomes, Fourth Edition, McGraw Hill, New York.
6. Stansfield Colome 1996. Molecular and Cell Biology Schaum's Outlines, McGraw – Hill, New Delhi.

E-Resources:

1. http://biology.kenyon.edu/courses/biol114/topic_index.html
2. http://genesdev.cshlp.org/content/28/17/1859.full.pdf+html
3. https://mcb.berkeley.edu/courses/mcb141/lecturetopics/Levine/Chapter21MBoG.pdf
4. http://www.hhmi.ucla.edu/derobertis/teaching/lecture_1.pdf
5. http://www.sdbonline.org/sites/fly/aimorph/wing.htm
6. https://www.ncbi.nlm.nih.gov/books/NBK9971/

BIOSTATISTICS AND COMPUTER APPLICATION
(Subject code: 21PZOE21)

Semester: II	Elective: 2 (optional)	Credits: 5	Hours: 5

Course Objectives: To enable students to understand the various tools of biostatistics for data analysis as well as to make them know about the application of computer and statistical software.

Course outcomes: At the end of the course the students will be able to

1. Describe basic concepts of biostatistics.
2. Explain utilization of regression and correlation.
3. Solve frequency distribution data.
4. Analyse data using non- parametric tests.
5. Summarize various features of Excel.
6. Use SPSS to compute biological data.

Unit I: Basic Statistics and Parametric Tests **14 Hours**

Measures of central tendency and dispersion; The range, mean, variance, standard deviation, standard error - one sample and two samples; Tests of significances - Students 't' test (paired and unpaired), F-test; degrees of freedom –df, box plot and Venn diagram.

Unit II: Distributions, Regression and Correlation **14 Hours**

Probability distribution-Binomial, Poisson and Normal; Correlation – Karl Pearson's and Spearman's; Regression – simple and multiple; Introduction to multivariate statistics; Difference between parametric and non-parametric statistics

Unit III: Analysis of variance and Non-parametric tests **14 Hours**

Parametric tests -ANOVA - one way, two ways; Non-parametric tests- Chi-square test, Wilcoxon signed rank test, Mann-Whitney test, Kolmogorov-Smirnov tests.

Unit IV: Statistical analyses with M.S. Excel **14 Hours**

Standard tool bars and menus, statistical functions and applications (*t*, F and Z significance tests, correlations); chart and table creation, saving and printing.

Unit V: Application of Statistical Software - SPSS **14 Hours**

Data file structure – variable, editing and manipulating data, saving and printing; Charts (normal and error bar) and graphs creation; Performing ANOVA (one way and two way), MANOVA, regression, chi-square.

Textbooks:

1. Veer BalaRastogi. 2011. Fundamental of Biostatistics, Second Edition, Ane Book Pvt. Ltd., New Delhi.
2. Rajathi, A. and Chandran, P. 2010. SPSS for you, MJP Publication, Chennai.
3. SanjavSaxena2003. M.S. Office 2000 for everyone,Vikas Publications Pvt. Ltd. New Delhi.

Reference Books:

1. Ronald N Forthofer et al. (2007). Biostatistics a guide to design, analysis and discovery. Academic Press.
2. CliffforBlari, Richard A Taylor. (2009). Biostatistics for health sciences. Pearson education.
3. Negi KS. (2012). Methods in biostatistics with latest MCQs. AITBS Publishers.
4. Zar, J.H. 2003. Biostatistical analysis, Fourth edition, Pearson Education, Singapore.
5. Pagano, M. and Gauvreau, K. 2000. Principles of Biostatistics, Second Edition, Duxbury, Thomson Learning, USA.
6. Viswewara Rao, K. 1996, Biostatistics, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
7. McCall and Robert, B. 1990. Fundamental Statistics for Behaviroural Sciences, Harcourt Brace Jovanovich publishers, London.

E-resources:

1. https://www.researchgate.net/publication/280733465_A_TEXT_BOOK_ OF_BIOSTATISTICS
2. http://core.ecu.edu/ofe/statisticsresearch/Non-Parametric%20Tests.pdf
3. http://pages.stern.nyu.edu/~jsimonof/classes/1305/pdf/excelreg.pdf
4. http://www.academia.dk/BiologiskAntropologi/Epidemiologi/PDF/SPSS_Statistical_Analyses_using_SPSS.pdf

METHODS IN BIOLOGY
(Subject code: 21PZOE21)

Semester: II	Elective:2(optional)	Credits: 5	Hours: 5

CourseObjective: To learn about research plan and principles, working mechanism of various tools related to microscopy, chromatography, electrophoresis, spectrophotometry and histology.

Course outcomes: At the end of the course the students will be able to

1. Describe principles, methods and working mechanisms of microscopy,
2. Comprehend the principles, methods and working mechanisms of chromatography, electrophoresis, pH meter and spectrophotometer
3. Demonstrate principles, methods and working mechanisms of molecular techniques
4. Analyse histological and immunological techniques.
5. Summarize the application of modern bioinstruments.
6. Collect, process and write research thesis, articles and proposals.

Unit I: Microscopy **14 Hours**

Principle, working mechanism, resolving power and uses of Light, Phase contrast, Fluorescent and Electron (SEM & TEM) Microscopes, freeze-etch and freeze-fracture methods for electron microscope image processing methods in microscopy.

Unit II: Separation techniques **14 Hours**

Chromatography - Thin layer and Column chromatography, HPLC, GC and GCMS; Principles and working methods; AGE and PAGE; PCR and blotting techniques; Centrifugation – principles and types (differential and density gradient).

Unit III: Analytical techniques **14 Hours**

pH meter; Colorimeter; Visible and UV spectrophotometer; bomb calorimeter and Atomic absorption spectrophotometer; Isolation and purification of RNA; RFLP and RAPD.

Unit IV Histological and Immunotechniques **14 Hours**

Differential fixation and preservation; blocking; embedding; sectioning; staining; histochemical and histomorphological techniques; In *situ* localization by techniques using FISH; Immuno-fluorescence techniques, ELISA, RIA and EMIT.

Unit V Thesis writing **14 Hours**

Research Problem, Research Design, Developing a Research Plan, Literature survey, e-resources, documentation, Collection of Data, data processing; Parts of a thesis and thesis writing; Research report Presentation; Proof correction – symbols, M.S. word review option and other tools, plagiarism; Evaluation of a research project; Funding agencies (DST, DBT, UGC, CSIR, ICMR, ICAR, TNSCST) and research proposal writing.

Textbooks:

1. Gurumani, N. 2006. Research Methodology for biological Sciences, MJP Publications, Chennai.

2. Veerakumari, L. 2009. Bioinstrumentation, MJP Publications, Chennai.

Reference Books:

1. Boyer Rodney 2000. Modern Experimental Biochemistry, Person Education Asia, Delhi.
2. David, S.K. 1991. Handbook of histological and histochemical techniques, CBS Publishers and Distributors, Delhi.
3. Wilson, K. and Walker, J. 2000. Practical Biochemistry, Cambridge University Press, Cambridge.
4. Santosh Kumar Mondal, 2017. Manual of Histological Techniques, Jaypee Brothers Medical Publishers, PP.180.

E-resources:

1. https://cw.fel.cvut.cz/wiki/_media/courses/a6m33zsl/microscopic_techniques.pdf
2. http**://**academic.pgcc.edu/psc/chm101/separ_I.pdf
3. http://www.barc.gov.in/publications/nl/2014/2014030407.pdf
4. 2. http://www.roitt.com/pdf/Online_Chapter.pdf
5. http://w3.marietta.edu/~spilatrs/biol309/labexercises/Histology.pdf

IMMUNOLOGY AND MICROBIOLOGY – PRACTICAL
(Subject Code: 21PZOP24)

Semester: II	Core Practical: 3	Credits: 2	Hours: 4

1. Antibacterial assay using disc diffusion method
2. Separation of Lymphocytes
3. Single Radial immunosorbent technique
4. Estimation of viral load in blood samples using haemagglutination test
5. Solid and Liquid Culture media preparation
6. Isolation of bacteria - serial dilution technique
7. Plating techniques
8. Motility of microorganism (Hanging drop method)
9. Gram staining method- Identification of bacteria
10. Demonstration of Western blotting and Southern blotting technique.
11. Separation of lymphocytes from whole blood
12. Separation and Identification of T and B cells.
13. Demonstration of Mast cells.
14. Cell culture demonstration
15. Counting of Animal cells
16. Cell viability test
17. Demonstration of immunoelectrophoresis
18. ELISA –Demonstration
19. PCR-demonstration

20. Spotters: Immunology: lymphoid organ- thymus, spleen, lymph node, bursa of fabricius, peyer's patches, Macrophages, Natural killer cells, Immunoglobulin, Phagocytosis, Antibiotics, Recombinant antibiotics, Edible vaccines, Elisa, Mucosa associated lymphoid tissue, Vaccination schedule, monoclonal antibiotics. Microbiology: Pure culture techniques, Colony appearance, Culture characteristics, Anthrax, Streptococci, *Clostridium tetani*, *Vibrio cholerae*, Morphology of virus particles, Hepatitis B virus, HIV, Bacteriophage, Candidiasis, Dermatophysis, Growth curve, Biochemical events of inflammation and Microbial sources of antibiotics

Reference:

Virtual Practical developed by the Ministry of Human Resources, Govt.of India and available in the web site:www.vlab.ac.in can be utilized for demonstration.

DEVELOPMENTAL BIOLOGY &GENETICS - PRACTICAL
(Sub Code: 21PZOP25)

Semester: II	Core Practical: 4	Credits: 2	Hours: 4

1. Mounting of male/female gametes (Fish and frog).
2. Observation of developmental stages of Drosophila/ House fly and Mosquitoes.
3. Chick embryo development - preparation of whole mounts; examination of live embryos - examination of foetal membranes.
4. Regeneration of tadpole tail
5. Study of regeneration in Hydra.
6. Effects of iodine on tadpole metamorphosis.
7. Induction of abnormal development in chick.
8. Observation of developmental stages in frog
9. Development of brain, eye, ear, limb, heart and urinogenital systems from slides.
10. Identification of different embryonic stages of Drosophila, Preparation of Drosophila food.
11. Study of phenotypic variation of Drosophila
12. Estimation of calcium in egg shell by EDTA method
13. Verification of Mendel's law – monohybrid and dihybrid crosses using coloured beads
14. Hardy-Weinberg's equilibrium with complete selection (using coloured beads).
15. Hardy-Weinberg's equilibrium with partial selection (using coloured beads).
16. Quantitative inheritance - serration in neem leaves, Height and weight.
17. Poly peptide and genome analysis using D-gel software

18. Spotters: Developmental Biology: Frog -T.S. of Testis and Ovary, fertilized egg, first cleavage, 16 cell stage, blastula, gastrula, yolk plug stage, neurula, tadpole Sagital section showing optic cup; Chick embryo - primitive streak, 26 hours of chick embryo, 36 hours, 48 hours, 72 hours, 96 hours; Types of placenta -Yolk sac, Yolk stalk, Discoidal, Diffuse, Cotyledonary; Teratology-Four legged chick, Double headed shark, Bifid Tail and Anencephalic foetus.Genetics: Multiple alleles (Blood grouping), Complete linkage in Drosophila, Haemophilia, Sickle cell anemia, Rh Factor (Erythroblastosis foetalisis),Albinism, Klinefelter's syndrome, Turner's Syndrome, Down's Syndrome, Lytic and lysogenic cyle, Conjugation, Transformation, Transduction and sexduction.

EVOLUTIONARY BIOLOGY
(Subject Code: 21PZO31)

Semester: III	Core Theory: 7	Credits: 5	Hours: 5

Objective: To understand the concepts, trends and patterns of evolution as well as evolution of selected groups.

Course outcomes: At the end of the course the students will be able to

1. Describe origin of life patterns.
2. Comprehend the evolutionary forces on adaptation.
3. Illustrate natural selection and speciation.
4. Analyze the evolutionary changes in selected animals.
5. Summarize the evolution of mimicry and coloration.
6. Integrate molecular studies with evolution.

Unit I: Origin of cells and evolutionary thoughts **14 Hours**

Origin of biomolecules, chemical and biological evolution of life; origin of prokaryotes and eukaryotes, concepts of Oparin and Haldane, experimental evidences of Miller; Lamarckism, Darwinism-natural selection, mutation theory and modern synthetic theory. Factors influencing Hardy-Weinberg law.

Unit II: Palaeontology evolutionary history **14 Hours**

Evolutionary time scale: eras, period, and epoch; Major events in the evolutionary time scale, fossils; Evolution of horse, elephant; Physical and cultural evolution of Man.

Unit III: Patterns of evolution **14 Hours**

Speciation: Allopatricity and Sympatricity, Sequential and divergent evolution, isolating mechanisms; micro, macro and mega evolution; Adaptive radiation, Convergent evolution; Co-evolution migration, navigation, domestication and behavioral changes of human being.

Unit IV: Behavioural and Natural selection **14 Hours**

Natural selection in action, fitness and adaptive value, resistance of animals to environmental conditions; Variation – pre-adaptation and post adaptation; normalizing, directional and diversifying selection; Group selection, Kin selection, Reciprocal altruism; Mimicry and coloration- Batesian and Mullerian mimicry.

Unit V: Evolution and recent trends **14 Hours**

Methods of molecular evolution studies; Principles of molecular evolution studies; Molecular clock, origin of new gene functions; phylogenetics and future prospects of evolutionary biology; Gene duplication and divergence.

Textbooks:

1. Veer BalaRastogi. 2014. Organic Evolution, Medtech, New Delhi.
2. Verma, P.S. and Agarwal, V.K. 1998. Concept of Evolution, Chand and Company Ltd., New Delhi.
3. Sanjib Chattopadhyay, 2008. Life Evolution, Adaptation Ethology, Arunabha Sen Kolkatta.

Reference Books:

1. Brian K. Halland BenediktHallgrímsson. 2014. Strickberger Evolution, Fourth Edition, Jones & Bartlett publishers, Canada.
2. Dobzhansky,T, Ayala,J., Stebbins, G. and Valentine, W. 1973. Evolution, Surjeet Publication, New Delhi.
3. Charles W. fox & Wolf. 2006. Evolutionary genetics, Oxford University press, New Delhi.
4. Peter Stiling, 2002. Ecology Theories and Applications, Fourth edition, Prentice Hall, India.
5. Mohan P. Arora and Arora, H.2013. Organic evolution, Himalaya Publishing House, Mumbai.

E-Resources:

1. https://en.wikipedia.org/wiki/Evolution_of_cells
2. https://www.nationalgeographic.org/encyclopedia/paleontology/
3. http://www.sparknotes.com/biology/evolution/patternsofevolution/section1/

CELL AND MOLECULAR BIOLOGY
(Subject Code: 21PZO32)

Semester: III	Core Theory: 8	Credits: 5	Hours: 5

Course Objective: To understand the structure and functions of cell organelles and to clarify the characteristics of nucleic acids, cancer and cell signaling conditions.

Course outcomes: At the end of the course the students will be able to

1. Describe cell structure and how it relates to cell functions.
2. Comprehend the structure and function of nucleus and events of cell divisions.
3. Demonstrate mutations and DNA repair.
4. Illustrate protein synthesis and cancer.
5. Summarize cell signaling and how it regulates cellular functions.
6. Integrate the structure and function of cell organelles.

Unit I: Cell Organelles **14 Hours**

Ultra structure, organisation and functions - Plasma membrane, Mitochondria, Endoplasmic reticulum, Golgibodies, Peroxisomes, Ribosome, Lysosome, Vacuoles, Plastids, Microtubules

Unit II: Nucleus, Chromosomes, Cell cycle and Division **14 Hours**

Structural organization of Nucleus; Structure of chromatin and Chromosomes, karyotypes, euchromatin, heterochromatin, transposons, polytene and lamp brush chromosomes; Cell division and cell cycle - Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.

Unit III: Nucleic Acids, Mutations and DNA repair **14 Hours**

Nucleic acids- DNA and RNA as genetic materials; DNA replication – units of replication, enzymes involved, replication origin, fork, and fidelity; Genetic code – characteristics; DNA mutation- spontaneous, and frame-shift; DNA repair mechanism- photo reactivation, mismatch and SOS repair, excision, recombinational repair; RNA synthesis and processing.

Unit IV: Protein synthesis and cancer studies **14 Hours**

Transcription, protein synthesis-initiation, elongation and termination process, post-translation modification of proteins; Regulation of gene expression in prokaryotes and eukaryotes; Role of chromatin in gene expression and gene silencing; Tumour causes and properties, oncogenes, suppressor genes, interaction of cancer cells with normal cells and apoptosis.

Unit V: Cell signaling **14 Hours**

General principles, signaling molecules (hormones) and their receptors; cell surface receptors; Intracellular signal transduction; Activation and regulation of G-Protein coupled receptors. Adenylcyclase, Phospholipase, ion channels, activation of gene transcription.

Textbooks:

1. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. 2012. Molecular cell biology, Eight Edition, H. Freeman & Company, USA.
2. De Robertis E. D.P. and De Robertis Jr. 1999. Cell and molecular biology, Eight Edition, E.M.F. B.I. Publication Pvt. Ltd., New Delhi.
3. Power, C.B. 2010. Cell Biology, Himalaya Publishing House, Bombay

Reference books:

1. Gupta, P.K. 2005. Cell and molecular biology, Second Edition, Rastogi publications, Meerut, India.
2. Charles J. Flickinger, Brown, J.C., Hutachi, H.C. and Ogilive, J.W. 1979. Medical Cell Biology, Sounders Company, Japan.
3. Richard M. Rwyman 1988. Advanced Molecular Biology, Viva Books Pvt. Ltd., New Delhi.
4. SivaramaSastri, K.G. Padmanaban and Subramanyan, C. 1994. Text book of Molecular Biology, Macmillan India Ltd., New Delhi.
5. Cooper G.M and Hausman, R. E. 2009. The cell. A Molecular Approach. 5th Edition, Garland Publications, U.K.
6. Paul, A. 2007. Textbook of Cell and Molecular Biology, Books and Allied Publishers Pvt. Ltd., New Delhi.

E-resources:

1. https://www.nicholls.edu/biol-ds/biol155/Lectures/Cell%20Biology.pdf
2. https://www.exploringnature.org/graphics/biology/organelles_info_quiz.pdf
3. http://sciencescpk.pkru.ac.th/images/doc/mad21975_ch03.pdf
4. http://www.csun.edu/~cmalone/pdf360/Ch15-2repairtanspose.pdf
5. http://www.pc.maricopa.edu/Biology/amarti-subirana /BIO%20181/Adobe%20PDF%20files/Cell%20Cycle%20and%20Cell%20Division.pdf
6. http://www.nhri.org.tw/NHRI_ADM/userfiles/file/1010510.pdf
7. http://education.med.nyu.edu/courses/molecular/molbio/psnotes.pdf
8. http://genome.tugraz.at/MolecularBiology/WS11_Chapter_12.pdf

ANIMAL PHYSIOLOGY
(Subject Code: 21PZO33)

Semester: III	Core Theory: 9	Credits: 5	Hours: 5

Course Objective: To expound the structure, mechanism and the physiological functions of different organ systems.

Course outcomes: At the end of the course the students will be able to

1. Describe the basic constitution of food and digestion.
2. Comprehend the structure and functions of lungs, heart and thermoregulatory organs.
3. Demonstrate the structure and functions of kidney and osmo-regulatory organs.
4. Illustrate the structure and functions of nerves, muscles, phono and photo receptors.
5. Summarize the structure and functions of reproductive and endocrine organs.
6. Integrate the role of hormones with growth and reproduction.

Unit I: Nutrition and Digestion **14 Hours**

Composition of food, Biological importance of carbohydrate, protein, fat, minerals and vitamins; Calorific value, daily requirements, low and high intake implications; Digestive system - general structure of alimentary canal and digestive glands, physiology of digestion and gastro-intestinal hormones.

Unit II: Respiration, circulation and thermoregulation **14 Hours**

Respiration: Respiratory organs and pigments in animals. Structure of human lungs and mechanism of respiration; Transportation of gases; Acid base balance (buffer system).
Circulation: Types of heart (neurogenic and myogenic); Structure of human heart and blood vessels, Blood - volume composition and functions; Heart beat, cardiac cycle, ECG; circulation of blood, haemo dynamics and blood pressure; Haemostasis; Haemopoiesis; Angiogram.
Thermoregulation: Thermoregulation in ecto and endotherms.

Unit III: Excretory system and Osmoregulation **14Hours**

Nitrogenous waste materials; renal organs in animals. Structure of kidney, physiology of excretion and hormonal control of osmoregulation in Man.
Osmoregulation : Osmoregulation in aquatic and terrestrial vertebrates and invertebrates.

Unit IV: Nerves, Muscles and Sense organs **14 Hours**

Nervous system: Central nervous system - Structure of Human brain and spinal cord; peripheral nervous system; Types and ultra structure of neurons; neuronal and sympathetic transmission, action potential and neurotransmitters; Neural control of muscles and posture.
Muscles: Ultra structure-types and composition; Neuromuscular junction.
Sense organs: Gustatory, olfactory, mechano, photo and phono receptors – structure and functions; bioluminescence.

Unit V: Reproductive physiology and Endocrinology **14 Hours**

Reproductive system: Structure of Human reproductive organs – puberty, menstrual cycle, menopause.

Human endocrines: General structure, hormone and function of hypothalamus, pituitary, thyroid, parathyroid, adrenal, testes and ovary, placenta.
Arthropod endocrines: Role of hormones in growth and metamorphosis of Arthropods.

Textbooks:

1. Rastogi, S.C. 2001. Essentials of Animal Physiology, Third Edition, New Age International Publication, New Delhi.
2. William S. Hoar. 1983. General and Comparative Physiology, Prentice Hall Pvt. Ltd., New Delhi.
3. Knut Schmidt-Nielsen. 2008. Animal Physiology: adaptation and environment, Fifth Edition, Cambridge University Press.

Reference Books:

1. Eckert and Randel, D. 1982. Animal Physiology, Surjeet Publication, Delhi.
2. Robert, H. Williams, M.D. 1981. Text book of Endocrinology, Sixth Edition, Igakv-Shoin, Aaunders International Edition, Tokyo, Japan.
3. Schmidt – Nielson, K. 2002. Animal Physiology – Adaptation and Environment, Cambridge Press, Cambridge.
4. Verma, P.S., Txagi, B.S. and Agarwal, V.K. 2000. Animal Physiology, Chand and Company Ltd., New Delhi.

E-Resources:

1. http://nptel.ac.in/courses/102104042/
2. http://www.enetlearning.org/wp-content/uploads/2015/01/life_2_5_2-osmoregulation.pdf
3. http://bio.classes.ucsc.edu/bio131/Thometz%20Website/18%20Thermoregulation.pdf
4. http://readfullpdf.com/download.php?book=Ba_wAAAAMAAJ
5. https://www.saylor.org/site/wp-content/uploads/2010/11/The-Endocrine-System.pdf
6. http://www.mesacc.edu/~pamrb40461/Bio202/Chapter18.pdf

PLANT &ANIMAL BIOTECHNOLOGY
(Subject Code:21PZOE31)

Semester: III	Elective: 3(optional)	Credit: 5	Hours: 5

An interdisciplinary paper offered by the post-graduate departments of Botany and Zoology.
Components from Botany discipline: unit 1 and 2 and first half of the unit 5.
Components from Zoology discipline: unit 3, 4 and second half of the unit 5.

Course Objective: To learn the fundamentals of biotechnological tools and technologies. To understand the various plant tissue culture techniques and their applications

Course outcomes: At the end of the course the students will be able to

1. List out the basic techniques in biotechnology.
2. Describe micropropagation and somatic hybridization.
3. Apply the concepts of genetic engineering for animal well being.
4. Illustrate rDNA technology.
5. Summarize specialized areas of plant biotechnology.
6. Integrate applications of biotechnology with our day-to-day life.

Unit I: Lab Equipments, Sterilization and tissue culture media 14 Hours

Introduction - History, scope and concepts of basic techniques in plant tissue culture. Laboratory requirements and organization. Sterilization-filter, heat and chemical. Media preparation-Inorganic nutrients, organic supplements, carbon source, gelling agents and growth regulators. Totipotency, dedifferentiation and redifferentiation. Establishment of callus, dynamics of callus growth, organogenesis and embryogenesis.

Unit II:Micropropagation and Somatic hybridization 14 Hours

Micropropagation-Stages of micropropagation, factors affecting shoot multiplication, application and limitations; Production of virus free plants (cryo, chemo and thermotherapies); Somatic hybridization (Protoplast isolation and fusion- techniques and mechanism) selection of somatic hybrids, uses of somatic hybrids and cybrids; Production of haploids (anther, pollen and ovule culture) and their uses

Unit III:rDNA technology 14 Hours

Recombinant methods-construction of recombination DNA, Introduction of recombinant DNA into host cells; Selection and multiplication of recombinant host cells; Expression of cloned gene, bacterial, animal and plant vectors: plasmids – PBR322, Ti plasmids, cosmids, phages-M13, transposons, restriction enzymes, Sanger method of DNA sequencing, cDNA library.

Unit IV: Animal cell culture 14 Hours

Characteristic features of animal cells in growth; Requirement - culture media, Equipments; Isolation of animal tissue- physical and chemical methods; Establishment of cell culture - primary, secondary cell culture and cell lines; Organ and embryo culture, IVF technology.

Unit V: Biotechnological Applications **14 Hours**

Botany: Molecular farming in plants (immunotherapeutic drugs, edible vaccines, antibodies and interferons) agroinfiltration mediated expression, bio-safety issues in plant molecular farming.
Zoology: Monoclonal antibodies, DNA finger printing, interferons, Recombinant vaccines, insulin and somatotropin production, transgenic animals, Gene therapy and immunotoxins.

Textbooks:

1. Dubey,R.C. 2014. Advanced biotechnology, S.Chand& Company, New Delhi.
2. Satyanarayana, U. 2008. Biotechnology, Book and Allied Ltd, India.
3. Das, H.K. 2006. Text book of biotechnology, Fourth Edition, Wiley indiaPvt. Ltd, India.

Reference books:

1. Yadav Rajiv Tyagi, P.R. 2006. Biotechnology and Animal tissues, Discovery Publishing house, New Delhi.
2. Singh, B.D. 2014. Biotechnology expanding horizons, KalyaniPublishers, Ludhiana, Punjab
3. Prakash S. Lohar. 2012. Text book of biotechnology, MJP publishers, Chennai.
4. Sandy B. Primerose . 2006. Principles of gene manipulation and genomics, Oxford
5. Gupta, P.K. 2004. Biotechnology and Genomics,Rastogi Publication Corporation, Meeret.
6. Biswajit Ghosh 2005. Plant tissue culture, Universities press, Hyderabad.
7. Gupta, P. K. 2000. Elements of biotechnology, Rastogi Publication Corporation, Meeret.
8. Chawla H S 2004 Introduction to plant biotechnology,Second edition,Oxford and IBH, New Delhi.

E. Resources:

1. https://www.researchgate.net/publication/281773836_Animal_Biotechnology
2. http://www.lonestar.edu/departments/biotech/plant_biot_chapterwlinks.pdf
3. https://ncert.nic.in/textbook/pdf/lebo112.pdf
4. https://www.ncbi.nlm.nih.gov/books/NBK215771/
5. https://www.everycrsreport.com/reports/RL33334.html
6. https://iopscience.iop.org/book/978-0-7503-1299-8/chapter/bk978-0-7503-1299-8ch1
7. https://www.iatp.org/sites/default/files/Applications_of_Biotechnology_to_Crops_Benefit.htm
8. http://dbtindia.gov.in/sites/default/files/Remodelled-Biotech-Curricula_Main-Book.pdf

ENVIRONMENTAL BIOTECHNOLOGY

(Subject code : 21PZOE31)

Semester: III	Elective: 3 (optional)	Credits: 5	Hours: 5

Course Objective: To learn the basic ethics of environmental management and to understand the biotechnological aspects of waste water treatment and management strategies. To get a thorough knowledge on biodegradable pollutants, GEM and their products.

Course outcomes: At the end of the course the students will be able to

1. Describe ecosystems, its bio-resources and utilization ethics.
2. Comprehend the biochemistry of wastewater and its treatments with microbes.
3. Illustrate various strategies involved in wastewater treatment.
4. Demonstrate environmental pollution and management strategies.
5. Evaluate wastewater control strategies.
6. Integrate biotechnological tools with pollution and bioremediation.

Unit I: Ecosystem, Bioresources and bioethics 14 Hours

Ecosystem –types; Geoinformatics, global warming, climate changes; Ecomanagement- Environmental Impact Assessment (EIA), Environmental Management Plan (EMP), Renewable energy resources, Biosafety; Bioethics - IPR, IPP, GATT and TRIPS.

Unit II: Microbiology and biochemistry of waste water treatment 14Hours

Important microorganisms involved in waste water treatement, principles of growth, role of chemoautotrophic and photoautotrophic bacteria; Role of enzymes, biochemical path way in anaerobic digestion, plasmid-borne metabolic activities, packaged microorganisms.

Unit III: Waste water management strategies 14 Hours

Waste water characteristics, activated sledge process, aerobic digestion, secondary treatments using trickling biological filters-rotating biological contactors, fluidized beds; Anaerobic biological treatment- contact digesters, packed column reactors, membrane bioreactors; Bioremediation-types and application.

Unit IV: Pollution abatement and biodegradation 14 Hours

Reduction of CO_2 emission by photosynthesis; Reduction of CO_2 from seawater through biological calcification, algal bloom- O_2 production, biological N and P removal from waste water -biodegradation of herbicides, pesticides and hydrocarbons, bioleaching and biosorption of metals.

Unit V: Genetically engineered microbes and ecofriendly byproducts 14 Hours

GEMs in waste biotreatments - fate of GEMs, bioenergy and biofuels, Alcohol and Hydrogen, Biomass production, Biodegradable plastics and Biopesticides.

Textbooks:

1. Jogdand, S.N. 2006. Environmental Biotechnology (III Ed.), Himalayan publishing house New Delhi.
2. Scragg Allen. 2005. Environmental Biotechnology, Oxford University Press, Oxford.

Reference Books:

1. Chatterji, A.K. 2011. Introduction to Environmental Biotechnology, Prentice Hall Ltd., New Delhi.
2. Murugesan, A.G and Rajakumari, C. 2006. Environmental Science and Biotechnology MJP Publishers, Chennai.
3. Bimal, C., Bhattacharyya and RimtuBanargee 2007. Environmental Biotechnology Oxford University Press, New Delhi.

E. Resources:

1. http://en.wikipedia.org/wiki/Sustainability.
2. http://www.yale.edu/epi/files/2008EPI_text.pdf.
3. http://www.biodetergent.pdf.
4. http://www.nrel.gov/learning/re_biomass.html.
5. http://www.eia.doe.gov/emeu/aer/pdf/pages/sec10_3.pdf.
6. http://www.oecd.org/sti/biotechnology.
7. http://www.bio.org/ind/background/thirdwave.asp.
8. https://www.biotechnologynotes.com/environment/environmental-biotechnology-with-
9. http://www.actabp.pl/pdf/Supl4_11/Session_15.pdf
10. https://issuu.com/brainkart.com/docs/environmental_biotechnology

CELL AND MOLECULAR BIOLOGY & EVOLUTIONARY BIOLOGY - PRACTICAL
(Subject Code: 21PZOP34)

Semester: III	Core Practical: 5	Credits: 2 Hours: 4

1. Observation of mitotic stages – in onion root tip
2. Mitosis: Effect of colchicine on mitosis and polyploidy
3. Observation of meiotic stages in grass hopper testis
4. Salivary gland chromosome of Chironomus /Drosophila larva.
5. Demonstration of Barr body in human buccal epithelial cells by supra vital staining method
6. Alignment of human chromosomes using template (karyotype).
7. Glycerine mount of different kinds of cells (Squamous epithelial cells and goblet cells)
8. Preparation of sub-cellular fraction of rat liver by centrifugation
9. PCR-demonstration
10. Model preparation related to molecular biology.
11. Variations in left thumb impression (finger printing)
12. Molecular phylogenetic tree construction
13. Adaptive modifications in feet, beaks and wings of birds.
14. Study of ecological morphology of animals.
15. Embryological evidence for evolution
16. Serial homology in appendages of prawn
17. Study of human skull
18. Study of fossils
19. Study of Animal Skull (pig, horse, dog and deer)
20. Identification of available skeletons in the department museum
21. Visit to Athichanallur and Govt. Museum

22. Spotters: Cell and Molecular Biology-: Plasma membrane, Mitochondria, Ribosomes, Lysosomes, Endoplasmic reticulum, nucleus, Nucleolus, Golgi complex, Centrioles, Types of chromosomes, Ultra structure of chromosomes, Cell secretion, DNA double helix, Variants of double helical DNA, Protein synthesis, DNA- Replication, Structure of Lac operon, DNA repair and Cancer.Evolution Biology: Homologous, analogous organs and vestigial organs; Mesozzoic reptiles - connecting links – living fossils; Fossils: Mollusca-Gastropod(Tertiary) and Ammonite(Jurassic),

Reference:

http://biophys.med.unideb.hu/sites/default/files/student/2009/10/cell_biol_lab_manual_2003_mod_110211_pdf_26330.pdf

ANIMAL PHYSIOLOGY– PRACTICAL
(Subject code: 21PZOP35)

Semester: III	Core Practical: 6	Credits: 2	Hours: 4

1. Enumeration of Digestive enzymes profile in cockroach
2. Salt loss and salt gain in a fresh water fish
3. Effect of salinity on opercular movement of a freshwater fish
4. Effect of temperature on opercular movement of fish
5. Effect of temperature on human salivary amylase activity
6. Constituents of human blood (RBC, WBC, Platelets)
7. BMI analysis using height and weight
8. Estimation of haemoglobin
9. Haemin crystals
10. Enumeration of blood platelets
11. Estimation of blood glucose during fasting and PP.
12. Urate crystals
13. Uric acid crystals –Bird, Rat, Fish
14. Estimation of Blood Urea and Cholesterol.

15. Spotters: Human brain, heart, lungs, eye, tongue, ear, Pancreas, Kidney, circulatory system, digestive system, Pituitary gland, Thyroid gland, Parathyroid gland, Adrenal gland, L.S. of testis and Ovary, ECG, Oxygen dissociation, Endocrine glands, Menstrual cycle, Gastro intestinal hormone action and Types of muscles.

AQUACULTURE
(Subject Code: 21PZO41)

Semester: IV	Core Theory: 10	Credits: 5	Hours: 5

Course Objective: To familiarize the knowledge on fish pond construction, management, culture, feeding, breeding and disease control of fin and shell fishes.

Course outcomes: At the end of the course the students will be able to

1. Define basic principles and scope of aquaculture.
2. Describe construction and management of fish ponds.
3. Demonstrate patterns of aquaculture systems.
4. Outline fish nutrition and breeding technology.
5. Summarize various components of fish genetics.
6. Develop strategies to prevent and treat fish diseases.

Unit I: Pond construction and management **14 Hours**

Scope and principle of aquaculture - Fish pond construction: Criteria for site selection, types of ponds, construction of pond, water quality analyses, pond maintenance and management.

Unit II: Patterns of aquaculture **14 Hours**

Fresh water- Monoculture-culture of *Tilapia*; Composite fish culture, integrated fish farming and ornamental fish culture; Coastal-Traditional and modern methods, culture of marine prawns, edible and pearl oysters; culture of sea weeds.

Unit III: Feeding, Breeding and Rearing technology **14 Hours**

Culture of live feed organisms - *Artemia*, rotifers - Artificial feed - types, formulations and preparation. Induced spawning - use of natural and synthetic hormones, artificial fertilization; seed production, rearing of hatchlings, post larvae, fry and fingerlings.

Unit IV: Fish genetics **14 Hours**

Genome and genomics of fishes; Selective breeding- Hybridization, androgenesis, gynogenesis, induction of ploidy; Gene manipulation-sex reversal; Transgenic fishes; Cryopreservation.

Unit V: Diseases diagnosis and management **14 Hours**

Ecto and endo parasites; Bacterial, fungal, EUS and viral diseases - agents, causes, symptoms, control and preventive measures; vaccines and chemotherapy, resistant strain production; Environmental factors and disease spreading; Consequences of consumption of diseased fishes.

Textbooks:

1. Rath, R.K. 2011. Fresh water Aquaculture,Third Edition, Scientific Publishers Jodhpur, India
2. Vankhede G.N. and Deshmukh S.V. 2011. Freshwater fish culture, development and management, Sarup and Sons Publishers, New Delhi.

Reference books:

1. Ninawe, A.S. and Khadkar, G.D. 2009. Nutrition in Aquaculture, Narendra Publishing House, New Delhi.
2. Dubey Bandana Gosh, S.K. 2012. Fish biotechnology, Wisdom Press, New Delhi.
3. Saravanan, M. R and Santhanam K.L. 2008. Introduction to encyclopedia of fishery science and technology, Vol. 2: Fish nutrition and biochemistry; Vol. 6. Inland and freshwater aquaculture; International Scientific Publishing Academy, New Delhi.
4. Lakra W.S Abidi, S.A.S. Mukergi, S.E and Iyappan S. 2004. Fisheries Biotechnology, Narendra Publishing house, New Delhi.
5. Biswas, K.P. 2000. Prevention and control of fish and prawn diseases,Narendra Publishing House, New Delhi.
6. Sunderaraj, V. and SrikrishnaDass.2000. Cultivable aquatic organisms. Narendra Publishing House, New Delhi.
7. Jhingran V.G. 1997. Fish and fisheries of India Second Edition, Hindustan Publishers, New Delhi.

E-Resources:

1. http://www.fao.org/3/a-a1337e/a1337e04e.pdf
2. http://pdf.shoroombooks.us/?book=0813806976

APPLIED ENTOMOLOGY
(Subject Code: 21PZO42)

Semester: IV	Core Theory: 11	Credits: 5	Hours: 5

Course Objective: To learn identification, bionomics, damage, symptoms, and monitoring of economically important crop pests.

Course outcomes: At the end of the course the students will be able to

1. Identify insect with salient characters of body parts.
2. Explain the morphology and special organs of insects.
3. Classify the insects to various orders.
4. Categorize various economically important pests of locally cultivable crops, forests.
5. Summarize natural, applied and synthetic pesticides and their utility values.
6. Develop biological control concepts.

Unit I: Insect Morphology and classification **14 Hours**

General morphology of head and its segmentation (Antennae, Mouthparts); Thorax and its Segmentations; Morphology of abdomen and its appendages; Special organs-Auditory, chemo, thermo and photoreceptors -sense, tympanel, Light and Sound Producing Organs (Brief account)

Unit II: Insect classification **14 Hours**

Classification of insects up to families; General characters and economic importance of Collembola, Thysanura, Coleoptera, Lepidoptera, Hemiptera, Hymenoptera, Isoptera, Odonata, Diptera, Placoptera, Dermptera, Phasmatidea, Orthoptera, Blattodea.

Unit III: Economically important Pestiferous Insects **14 Hours**

Bionomics and damage potential, symptoms and management of crop [*Scirpophagaincertulas*, *Altherigonasoccata*, *Chiloinfuscatellus*, *Amsactaalbistriga*, *Acheajanata*, *Phenococcussolenopsis*, *Helicoverpaarmigera*, *Leucinodesorbonalis*, *Oryctes rhinoceros*, *Spodopteralitura*], stored products [*Sitophilus oryzea* and *Triboliumcastaneum*], invasive (*Leptocybeinvasa*) and forest (*Hyblacapuera*) pests

Unit IV: Natural and Applied Control and Chemical Control **14Hours**

Natural control, Applied control -Physical, cultural, mechanical and legal methods); Electronic devices; Organochlorine (DDT), Organophosphate (malathion), Cyclodiene (endosulfan), Carbamates (carbaryl); Pyrethroids (cypermethrin, neonicotinoids); Formulations - ingredients, solids (dusts, granular, wettable powder), liquid, fumigants, electronic devices for fly and mosquito management.

Unit V: Biological Control and Concepts of IPM **14Hours**

Predators and parasitoids (any three Indian example each); Microbial insecticides –*Bt*, Metarizhium, NPV's; Botanicals – (Azadirachtin, pyrethrins, rotenone, oils); Semiochemicals – Mating disruption, Diflubenzuron, Chitosan; IPM – principles, components, IPM in cotton; Bio-intensive IPM; Sterile insect technique (SIT)

Textbooks:

1. David, B.V. and Ramamoorthy, V.V. 2016. Elements of economic entomology, NP Namrutha Publications, Chennai.
2. Kalyanasundaram, S. and Kalyanasundaram, M. 2003. Pest management in field Crops/Horticultural Crops,Keran Desk Top Publisher, Vellore.
3. Robert F Morris, Edward P. Caswell-Chen and Marcos Kogan 2002. Concept in Integrated Pest Management, Prentice-Hall of India P. Ltd, New Delhi.

Reference Books:

1. Sahayaraj, K. 2014. Basic and Applied Aspects of Biopesticides, Springer, India.
2. Romoser, W.S and Stoffolano, J .G. 1998. The Science of Entomology, McGraw-Hill Company, New York.
3. Ambrose, D. P. 2007. The Insects: Beneficial and Harmful Aspects, Kalyani Publishers, Ludhiana.
4. Pedigo, L.P. 2002. Entomology and Pest Management, Pearson Education, Singapore.
5. V. Nandagopal, Anand Prakash, Jagadiswari Rao, J.S. Yadav and A.R. Prasad. 2008. Pheromones : Principles and Practices, AZRA, India, pp. 333.
6. David, B.V. and Ananthakrishnan, T.N. 2004. General and Applied Entomology, Second edition, Tata-McGraw Hill Publishing Company, New Delhi.

E-resources:

1. http://agritech.tnau.ac.in/pdf/6.pdf
2. http://books.irri.org/9712200280_content.pdf
3. http://farmer.gov.in/imagedefault/ipm/IPM%20package%20for%20Wheat.pdf
4. http://oar.icrisat.org/2424/1/Pest-Control.pdf
5. http://niphm.gov.in/Recruitments/ASO-Pathology.pdf
6. http://hau.ernet.in/hisar_admin/newspdf/1421384695eco-friendlymanagement%20.pdf
7. http://www.nasda.org/File.aspx?id=30498

AQUACULTURE - PRACTICAL
(Subject code: 21PZOP43)

Semester: IV	Core Practical: 7	Credits: 2	Hours: 4

1. Physicochemical analysis of fish culture pond water (Temperature, turbidity, pH) - demonstration in a fish farm.
2. Preparation of fish feed- Demonstration
3. Collection and preparation of pituitary extract and injection (Hypophyzation, demonstration in a fish form).
4. Study of aquatic weed, insects and predators (specimens and photos)
5. Identification of cultivable fin and shell fishes (specimens)
6. Morphometric and Meristic data of Fishes (At least 3 types).
7. Identification of bacterial diseases, parasites and fungal pathogens in fishes-(Photos and window cuttings)
8. Determination of fish age –Otolith method
9. Length weight relationship - (data analysis)
10. Population density assessment- capture and release method (Peterson's method).
11. Fecundity of fish
12. Assessment of GSI and HSI in fishes
13. Visit to aqua farm / Industries

14. Spotters: Aquaculture- Freshwater fishes - *Catlacatla, Labeorohita, Cirrhinusmrigala, Labeocalbasu, Cyprinuscarpio, Heteropneustesfossilis, Mystus* sp., *Anguilla anguilla, Channastriatus, Etroplussuratensis, Chanoschanos*; Marine fishes - *Anabas testudineus, Scomberomorussp, Pampus argenteus, Scoliodon*; Shell fishes - *Lobster, Pinctadafucata, Crassostreamadrasensis, Penaeus monodon, Macrobrachiumrosenbergii, Pernaviridis, Pernaindica, Scylla serrata*, Fish parasites - *Gyrodactylus, Cleidodiscus, Ichthyophthirius, Trichodina, Costia, Saprolegnia, Argulus*; Predatory Aquatic insects: *Laccotrephes, Lethocerus, Diplonychus, Cybister; Aquatic weeds- Spirogyra, Lemna, Myriophyllum, Jussiaea, Nymphaea, Hydrilla, Eichhornia, Azolla*; Fish diseases: Dropsy, Gill rot disease, Epizootic ulceratic diseases, Tail rot disease and Vibriosis; Techniques - Sewage fed fish farm, Composite fish culture, Induced Breeding, Integrated fish farming, Jar Hatchery, Breeding Hapa, Hatching Hapa, Simple floating cage

APPLIEDENTOMOLOGY - PRACTICAL
(Subject Code: 21PZOP44)

Semester: IV	Core Practical: 8	Credits: 2	Hours: 4

1. Identify and record the salient features of economically important insect orders (preserved specimens and paper cuttings)
2. Temporary mounting of tarsi (preserved specimens of any insect)
3. Study of mouthparts in insects (Grasshopper, plant bug, mosquito, house fly)
4. Study of sexual dimorphism in insects
5. Sting apparatus –honeybee
6. Preparation of crude kairomone extract of a pest(s)
7. Qualitative profiling of secondary metabolites of pesticidal plant (Neem extract, neem oil and commercial neem formulation).
8. Preparation of emulsifiable concentration of botanical pesticide (neem or pungam oil)
9. Determination of corrected mortality and LC_{50} using SPSS
10. Phytotoxicity of conventional pesticides/ biopesticides (seed germination method)
11. Insect box: Collection, preservation and submission of insects (Representatives of insect orders, Beneficial, Harmful and productive insects)
12. Spotters related to theory
    Harmful insects: Pests - Sap feeders (aphid, mealybug, bugs); Defoliators (lepidopteron); Borers (coleopterans); Soil pest (termites); storage pest (internal and external feeder). Vectors - animal vectors (Mosquitoes, houseflies, horsefly, Cockroaches) and plant vectors (Aphids and plant hoppers).
    Beneficial insects (preserved specimens) – predators (reduviids, dragon and damsel flies, Chrysoperla, lady bird beetle), parasitoids (*Trichogramma*), pollinators (butterflies and wasps)
    Productive insects (preserved specimens): honey bees, mulberry silkworm, eri silkworm, lac insect
13. Mini group project: Collection and model making related to biology of important insects, commercial pesticides, pest control devices.
14. Visits to Agro-ecosystems, Agriculture College/Research Institute

DISSERTATION
(Subject Code: 21PZOE41)

Semester: IV	Elective:4 (compulsory)	Credits: 4	Hours: 10

Course Objective: To promote original thinking, insemination of knowledge, modulation and innovation of thought, as an exercise, in order to transport the young minds to the expanding horizon of their chosen area of knowledge and transform them into knowledge generators.

Process and dissertation frame work

All the students must undertake dissertation work at the final semester (IV semester). Each student can select a faculty of their choice from the Department at St. Xavier's College to work on the dissertation. The topic of research should relate to the Zoology that the student intends to undertake. This process includes:

(a) The conceptualization of the independent research that will comprise the dissertation,
(b) The preparation of and satisfactory defense of the dissertation proposal,
(c) The collection, analysis and interpretation of data,
(d) Presentation of findings in the dissertation format and oral defense of the dissertation.

Dissertation activity must be completed within prescribed time frame for the semester. As regards Dissertation, the scheme of evaluation shall be as follows:

Submission, chapters and format of the report: Candidates must submit three copies of the report duly signed and endorsed by the Head and the Guide to the Head. Following is a brief guideline for the sections / chapters in the report and the formatting of the report. The report will have three main parts:

a. Initial Pages–in the following sequence.
   i. Title Page
   ii. Certificate from the guide and declaration by the candidate
   iii. Endorsement by the Head of the Department
   iv. Acknowledgement.
   v. Table of Contents
   vi. List of figures, photos, drawings, tables etc.
   vii. List of abbreviations
   viii. Abstract

b. Main body of the report consists of i.) Introduction with objectives, Background information (Literature review), ii.) Methodology, iii) Results (Data Analysis and Findings) and discussion, iv.) Conclusions Summary, v.) Recommendations and vi.) Citations (references)

c. Appendices (if any)

The system of evaluation shall be as follows:

1. Project work would be assigned at the end of Semester II or at the beginning of the III Semester to enable students to initiate work on the same.
2. It would formally begin from Semester III and shall be theoretical in nature. The candidate should submit: Tentative title, review of literature, objectives and proposed

methodology during the first week of the semester IV. This component would be evaluated for 25 marks.

3. In addition, 30 and 60 working days, the candidate should submit results and these components would be evaluated for 25 marks each
4. There shall be an open *viva-voce* examination (conducted by a board of faculty members) at the end of Semester IV on the Dissertation that shall be evaluated for 25 marks each by External and Internal examinations.
5. Project report / dissertation shall be presented by Power point.

Dissertation: 75 marks (25 + 25 + 25 **–** evaluated by the guide and another faculty member from the department**);** *Viva voce* examinations: 25 marks

Allotment of Marks

1. CIA – 1 conducted for 70 marks
2. CIA – 2 conducted for 70 marks
3. Average marks of CIA -1 and 2 will be converted to 70 marks
4. Assignment – 15 marks + *Viva voce* – 15 marks
5. Aggregate marks = 100

Question Pattern for CIA and Semester Examinations

Test Examination	Section A (1 mark)	Section B (2 marks)	Section C (5 marks)	Section D (15 marks)
	No choice	No choice	Either or	Open Choice
CIA test	10 x 1 = 10	5 x 2 = 10	4 x 5 = 20	2 x 15 = 30
Semester examinations	10 x 1 = 20	10 x 2 = 20	5 x 5 = 25	3 x 15 = 45

Question Pattern and Marks for Practical Examination

Type of questions	Marks
Major Practical Procedure-5 Marks Performance of the experiment, observation, calculation and table or graph-7 Marks and Discussion -3Marks	15
Minor Practical / Instrumentation Performance of the experiment/observation, calculation and table or graph-7 Marks and Discussion -3 Marks	10
Identification of animals / instruments / spotters (5 or 10 with 1 mark or 0.5 mark each) / Mini project / Insect Box	5
Spotters (5 x 3) -Identification – ½ mark, Diagram – ½ mark, Labelling – ½ mar (Unlabelled diagram carries no mark)and explanation - 1½ mark	15
Record note book	5
Total	50

Extra Credit Courses (ECC)

BIODIVERSITY
(21PZOECC01)

Course Coordinator: Dr. P. Selvaraj

Course Objective: To understand the basic classification, concepts of biodiversity and organization of related animals.

Course outcomes: At the end of the course the students will be able to

1. Describe principles of taxonomy.
2. Comprehend the salient features of invertebrates.
3. Demonstrate the general characters of chordates.
4. Classify animals.
5. Summarize adaptive features of highlighted animals.
6. Integrate adaptation with the survival of animals.

Unit I Principles and Methods of Taxonomy

Concepts of species and hierarchial taxa, biological nomenclatures, classical (Wittekers, five Kingdom concept) and quantitative methods of taxonomy of animals. Levels of structural organization, Zoogeographic zones.

Unit II Protozoa- Nematodes

General characters - Classification up to classes, salient features and examples of protozoa, porifera coelenterate, ctenophore and helminthes. Type study – *Paramecium caudatum,Obeliageniculata, TaeniasoliumPleurobrachia*;General topic - Affinities of Ctenophora, parasitic diseases, parasitic adaptations and life cycle.

Unit III Annelid- Echinodermata

General characters - Classification up to classes, salient features and examples of Annelida, Arthropoda Mollusca and echinoderamata. Type study- *Megascolexmauritti* and*Periplanetaamericana, Pila globosa* and *Asteriasrubens.* General topic: Larval forms, Affinities of Peripatus.

Unit IV Prochordates, Pisces and Amphibian

General characters - Classification up to classes, salient features and examples of Prochordates, Pisces and Amphibians.Type study- Amphioxus, balanoglossus, ascidia, Holocephali, dipnoi and *Rana*. General topic, metamorphosis in ascidia, migration in fishes, parental care in amphibian.

Unit-V Reptiles, Aves and Mammals

General characters - Classification up to orders, salient features with examples. Type study- *Columbia livia*, Rabbit; Poisonous and non poisonous snakes, mechanism of biting and first aid. Flight adaptation in birds, Adaptations of aquatic mammals.

Textbooks:

1. Kohli, K.S. and KavitaSahni2010. Animal Diversity and Evolution, Ramesh Book Depot, 65 Shivaji Nagar, Civil Lines, Jaipur.
2. Jordan, E.L. and Verma P.L. 2003. Invertebrate Zoology, S. Chand & Company Ltd.,Ramnagar, New Delhi.

Reference Books:

1. Jan A. Pechenik, 2002. Biology of Invertebrates, 4th edition, TATA Mc Graw-Hill Edition.
2. Kenneth V. kardong, 2005. Vertebrates, 4th edition, TATA Mc Graw-Hill Edition.
3. D.T. Anderson, 2001, Invertebrate Zoology. 2nd edition, Oxford university press.
4. Singh, B.K. 2004. Biodiversity conservation and management, Mandal Deep Publications, Jaipur.
5. EkambaranathaAyyar 1993. Outlines of Zoology,Vol. I., S. Viswanathan (Printers & Publishers) Pvt. Ltd. Chennai.
6. Kumar and Asija 2000 - Biodiversity, Principles and conservation,Agrobiol (India), Jodhpur.

E-resources:

1. http://www.cbd.int/
2. http://www.iucn.org/
3. https://www.cms.int/en/page/e-spwg-cv
4. http://biodiversitylab.ncbs.res.in/links

MEDICAL ENTOMOLOGY
(21PZOECC02)

Course Coordinator: Dr.T.Pushpanathan

Course Objective: To gain knowledge on insect borne diseases and control strategies

Course outcomes: At the end of the course the students will be able to

1. Describe biology and impacts of various species of mosquitoes.
2. Comprehend the role of flies as a vector.
3. Demonstrate the biology of bugs, lice and cockroach in human health
4. Classify diseases of non-insects likes ticks and mites
5. Summarize the economic importance of disease causing insects.
6. Integrate physical, chemical and biological methods in vector management.

Unit I: Mosquitoes

Distribution, Salient features, Morphology, Biology of medically important vector species Anopheles (*An. stephensi*), Aedes (*Ae. aegypti*), Culex (*Cx. quinquefasciatus*), Mansonia (*Ma. annulifera*), Mosquito borne diseases - Malaria, Filariasis, Dengue, Elephantiasis and Chikungunya.

Unit II: Flies and Public Health

Biology, disease transmission and control methods of Black flies**(Simuliidae),** Horse flies*(Tabanus)*, Tsetse flies *(Glossina)* and House flies (*Musca*)

Unit III: Bugs, Lice and Cockroach

Salient features, biology, disease transmission, prevention and control measures of Bed bugs, Triatomine bugs, Head and Body louse and Cockroach (Give biological names)

Unit IV: Ticks and Mites

Salient features, biology, disease transmission and management of ticks (soft and hard ticks) and mites.

Unit V: Vectors Control Methods

Physical, Chemical and biological methods; Commercial products; National and international Eradication Programmes of Vector control.

Textbooks:

1. Service. M. 2002. Medical Entomology for students,Cambridge University Press.

Reference Books:

1. Tyagi B.K. 2003. Medical Entomology, Scientific Publishers, Jodhpur.
2. Rathinasamy G.K. 1974. A Handbook of Medical Entomology and ElementryParastitology, S.Viswanathan Printers and Publication Pvt., Ltd., Chennai.
3. Parthiban, M. and B. Vasantharaj David. 2007. Manual of Household and Public Health pests and their control, Namrutha Publications, Chennai.

E-resources:

1. http://npic.orst.edu/pest/mosquito/control.html
2. http://www.fao.org/zika-virus/en/
3. http://entomology.ifas.ufl.edu/fasulo/vector/manual.htm

ANIMAL BEHAVIOUR
(21PZOECC03)

Course Coordinator: Dr. J. Ronald

Course Objective: To understand the basic concepts of animal social and reproductive behaviours and their function related environment.

Course outcomes: At the end of the course the students will be able to

1. Describe general and innate behavior of animals.
2. Understand the ecological aspect of behaviours
3. Relate habituation of animal learning to the circadian rhythms
4. Analyze social behavior of fishes, birds and mammals
5. Summarize reproductive behaviors in animals
6. Predict the behavior of animals.

Unit I: General and innate behaviour

Definitions of ethology and animal psychology - ethogram; classification of behavioural patterns - neural and hormonal control of behaviour - communication - genetic and environmental components in the development of behaviour.

Unit II: Ecological aspects of behaviour

Habitat and food selection -optimal foraging theories- aggression - homing - territoriality - dispersal- host parasite relationship

Unit III: Biological rhythms, learning and memory

Circadian and circannual migration of fishes and birds; conditioning, habituation - insight learning - association learning - reasoning - cognitive skills

Unit IV: Social behaviour

Aggregation, Schooling in fishes, Flocking in birds, Herding in mammals; Social living in bees, ants and primates

Unit IV: Reproductive behaviour

Reproductive strategies - mating systems - mate choice - sex differences - courtship - sexual selection - parental care in invertebrates and vertebrates

Text / Reference Books:

1. McFarland 1985. Animal behaviour, ECBS Longman, Essex.
2. Manning and DawkinsM. S. 1998. An Introduction to Animal Behaviour, Cambridge University Press, Foundation Books, New Delhi.
3. Alcock, J. 20060. Animal Behaviour, Sinauer Associates, INC, Sunderland, Massachusetts.

E-Resources:

1. https://www.unaab.edu.ng/attachments/Animal%20Behaviour%201.pdf

2. http://web.pdx.edu/~zelickr/animal-behavior/lecture-outlines/lectures2013fall/L10-ch05-learning-v2.pdf
3. http://krishikosh.egranth.ac.in/bitstream/1/2029302/1/IVRI%20OB%202082.pdf

BIOPESTICIDES
(21PZOECC04)

Course Coordinator: Dr.K.Sahayaraj

Course Objective: Students should know about the consequences of using pesticides and the appropriate remedy in this regard.

Course outcomes: At the end of the course the students will be able to

1. Describe impacts of pesticides on fauna and flora.
2. Understand various eco-friendly potions of microbes.
3. Illustrate economically important pests.
4. Classify different botanicals and their role in pest control.
5. Summarize predators and parasites in pest control.
6. Integrate semio-chemicals in pestiferous insects control

Unit I: Pesticide vs Biopesticides

Pesticides /Insecticides – problems (insecticide resistance, insecticide residues, associated with plants, human beings, domestic animals and wield animas); Biopesticides- definitions, advantages and limitations, types /categories

Unit II: Microbial insecticides

Special characters of bacteria, fungi and virus which possess insecticidal activity; Bacteria – *Bacillus thuringiensis*; Fungi – Metarhizium and Beauveria; Viruses – Baculoviruse, NPV

Unit III: Botanical insecticides

Advantages and disadvantages ; common plants with insecticidal value (neem, annona, pungamia, pyrethrins); commercial botanicals and their utility in pest management

Unit IV: Natural enemies

Predators and Parasitioids – definition, salient features, types, differences between predators and parasitoids, examples (Ladybird beetles, lacewings, trichogramma, tachnides), benefits and drawbacks

Unit V:Semiochemicals

Allelochemicals (interspecific) – kairomones, allomones and synomoes pest control value (short account only); Pheromones –types, Biocontrol role and pheromone traps.

Text / Reference books:

1. V. Nandagopal et al. 2008. Pheromones : principles and practices, AZRA, Cuttack.
2. B. Vasantharaj David and V.V. Ramamurthy. 2011. Elements of economic entomology. NP Namrutha Publication, Chennai.
3. J. Francis Borgio, K. Sahayaraj and I. AlperSusurluk. 2011. Microbial insecticides: principles and application, Nova Science Publisher, Inc., New York.
4. K. Sahayaraj. 2007. Indian insect predators in biological control,Daya Publishing House, New Delhi.

E-resources:

1. http://sadrabiotech.com/catalog/biopesticide%20BOOK.pdf
2. https://www.ijeart.com/download_data/IJEART01105.pdf
3. https://www.canr.msu.edu/nativeplants/uploads/files/Naturalenemy.pdf