

**Manonmaniam Sundaranar University
Tirunelveli**



**M.Sc., Zoology Syllabus
(From 2024-2025 Onwards)**

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MMSU

TANSICHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION	
Programme	M.Sc., Zoology
Programme Code	
Duration	PG-2 years
Programme Outcomes (Pos)	<p>PO1: Problem Solving Skill Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.</p> <p>PO2: Decision Making Skill Foster analytical and critical thinking abilities for data-based decision-making.</p> <p>PO3: Ethical Value Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities.</p> <p>PO4: Communication Skill Ability to develop communication, managerial and interpersonal skills.</p> <p>PO5: Individual and Team Leadership Skill Capability to lead themselves and the team to achieve organizational goals.</p> <p>PO6: Employability Skill Inculcate contemporary business practices to enhance employability skills in the competitive environment.</p> <p>PO7: Entrepreneurial Skill Equip with skills and competencies to become an entrepreneur.</p> <p>PO8: Contribution to Society Succeed in career endeavors and contribute significantly to society.</p>

	<p>PO 9 Multicultural competence</p> <p>Possess knowledge of the values and beliefs of multiple cultures and a global perspective.</p> <p>PO 10: Moral and ethical awareness/reasoning</p> <p>Ability to embrace moral/ethical values in conducting one's life.</p>
<p>Programme Specific Outcomes (PSOs)</p>	<p>PSO1 – Placement</p> <p>To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.</p> <p>PSO 2 - Entrepreneur</p> <p>To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations</p> <p>PSO3 – Research and Development</p> <p>Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.</p> <p>PSO4 – Contribution to Business World</p> <p>To produce employable, ethical and innovative professionals to sustain in the dynamic business world.</p> <p>PSO 5 – Contribution to the Society</p> <p>To contribute to the development of the society by collaborating with stakeholders for mutual benefit.</p>

First Year: Semester-I

Part	List of Courses	Credits	No. of Hours/ week	Total hours/ Semester	Internal marks	External marks	Total marks
Core Course – I	Structure and Function of Invertebrates	5	7	105	25	75	100
Core Course – II	Comparative Anatomy of Vertebrates	5	7	105	25	75	100
Core Course – III	Lab Course in Invertebrates & Lab Course in Vertebrates	4	6	90	50	50	100
Elective Course – I	A) Biochemistry	3	5	75	25	75	100
	B) Biophysics						
Elective Course – II	A) Economic Entomology	3	5	75	25	75	100
	B) Sericulture						
		20	30	450			

First Year: Semester-II

Part	List of Courses	Credits	No. of Hours/ week	Total hours/ Semester	Internal marks	External marks	Total marks
Core – IV	Cellular and Molecular Biology	5	6	90	25	75	100
Core – V	Developmental Biology	5	6	90	25	75	100
Core – VI	Lab Course in Cell Biology & Lab Course in Developmental Biology	4	6	90	50	50	100
Elective– III	A) Biostatistics	3	4	60	25	75	100
	B) Bioinformatics						
Elective– IV	A) Research Methodology	3	4	60	25	75	100
	B) Wildlife Biology						
Skill Enhancement Course [SEC] – I	Poultry Farming/Apiculture	2	4	60	25	75	100
		22	30	450			

Second Year – Semester – III

Part	List of Courses	Credits	No. of Hours/ week	Total hours/ semester	Internal marks	External marks	Total marks
Core – VII	Genetics and Evolution	5	6	90	25	75	100
Core – VIII:	Animal Physiology	5	6	90	25	75	100
Core – IX	Lab in Genetics & Evolution and Animal Physiology	5	6	90	50	50	100
Core– X	(Industry Module): Medical Lab Technology	4	4	60	25	75	100
Elective – V	A) Stem Cell Biology	3	4	60	25	75	100
	B) Applied Microbiology						
Skill Enhancement Course – II	A) Dairy Farming	2	4	60	25	75	100
	B) Bioethics and Bio Safety						
Internship	* Internship / Industrial Activity /Field visit/ Research – knowledge updating activity [Credits]	2	-	-	50	50	100
Total		26	30	450			

Second Year – Semester – IV

Part	List of Courses	Credits	No. of Hours	Total hours	Internal marks	External marks	Total marks
Core – XI	Immunology	5	6	90	25	75	100
Core – XII	Ecology	5	6	90	25	75	100
Core – XIII	Lab course in Immunology & Ecology	3	4	60	50	50	100
Elective course VI	A) Aquaculture	3	4	60	25	75	100
	B) Applied Biotechnology & Nanotechnology						
Skill Enhancement Course – III	A) Animal Behaviour	2	4	60	25	75	100
	B) Forensic Science						
	#Extension Activity	1	-	-	50	50	100
	*Project	4	6	90	50	50	100
		23	30	450			

METHODS OF EVALUATION for THEORY		
Internal Evaluation	Continuous Internal Assessment Test	25 Marks
	Assignments	
	Snap Test	
	Quiz Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Core course I: Structure and function of Invertebrates

Course Objectives:		
The main objectives of this course are:		
1.	To understand the concept of classification and their characteristic features of major group of invertebrates.	
2.	To realize the range of diversification of invertebrate animals.	
3.	To enable the students to find out the ancestors or derivatives of any taxon.	
4.	To know the functional morphology of system biology of invertebrates.	
Course	:	Core I
Course title	:	Structure and Function of Invertebrates
Credits	:	5
Pre-requisite:		
Students should know the taxonomical classification of invertebrate animals in relation to their functional morphology.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to:		
1.	Remember the general concepts and major groups in animal classification, origin, structure, functions and distribution of life in all its forms.	K1 & K2
2.	Understand the evolutionary process. All are linked in a sequence of life patterns.	K2 & K4
3.	Apply this for pre-professional work In agriculture and conservation of life forms.	K3 & K5
4.	Analyze what lies beyond our present knowledge of life process.	K4 & K6
5.	Evaluate and to create the perfect phylogenetic relationship in classification.	K5 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Units	
I	Structure and function in invertebrates: Principles of Animal taxonomy; Species concept; International code of zoological nomenclature; Taxonomic procedures; New trends in taxonomy
II	Organization of coelom: Acoelomates; Pseudocoelomates; Coelomates: Protostomia and Deuterostomia; Locomotion: Flagella and ciliary movement in Protozoa; Hydrostatic movement in Coelenterata, Annelida and Echinodermata
III	Nutrition and Digestion: Patterns of feeding and digestion in lower metazoan; Filter feeding in Polychaeta, Mollusca, and Echinodermata. Respiration: Organs of respiration: Gills, lungs, and trachea; Respiratory pigments; Mechanism of respiration

IV	Excretion: Organs of excretion: coelom, coelomoducts, Nephridia and Malpighian tubules; Mechanisms of excretion; Excretion and osmoregulation. Nervous system: Primitive nervous system: Coelenterata and Echinodermata; Advanced nervous system: Annelida, Arthropoda (Crustacea and Insecta) and Mollusca (Cephalopoda); Trends in neural evolution
V	Invertebrate larvae: Larval forms of free-living invertebrates - Larval forms of parasites; Strategies and Evolutionary significance of larval forms. Minor Phyla: Concept and significance; Organization and general characters
Reading list	
1. Barrington, E. J.W. 1979. Invertebrate Structure and Function. The English Language Book Society and Nelson, pp-765.	
Recommended texts	
1. Barnes, R. D. 1974. Invertebrate Zoology, (Second Edition), Holt-Saunders International Edition, pp-1024.	
2. Barnes, R. S. K., P. Calow, P. J. W. Olive, D. W. Golding, J. J. Spicer. 2013. The Invertebrates: A Synthesis. Third Edition. John Wiles & Sons Inc., Hoboken. New Jersey, New Delhi.	
3. Dechenik, J. A. 2015. Biology of Invertebrates (Seventh Edition). Published by McGraw Hill Education (India) Private Limited, pp-624.	

Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	S	M	S	S	S
CO2	S	S	M	M	S	S	M	M	S	S
CO3	S	M	S	M	S	S	M	M	S	S
CO4	S	M	S	M	S	S	M	M	S	M
CO5	S	M	S	M	S	S	M	M	S	M

*S - Strong; M - Medium; L - Low

Core Course II: Comparative Anatomy of Vertebrates

Course Objectives:		
The main objectives of this course are:		
1.	Exemplifying the vertebrate origin and the intermediary position of Prochordates between invertebrates and vertebrates.	
2.	Acquires the knowledge on evolution and adaptive radiation of Agnatha and Pisces.	
3.	Understanding knowledge about the first terrestrial vertebrates and the adaptive radiation of land animals	
4.	Imparting conceptual knowledge about the animal life in the air and their behaviours.	
5.	Understanding the origin and efficiency of mammals and evolutionary changes that occurred in the life of vertebrates.	
Course	:	Core II
Course title	:	Comparative Anatomy of Vertebrates
Credits	:	5
Pre-requisite:		
Students with knowledge and comprehension on zoology.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to:		
1.	Remember the general concepts and major groups in animal classification, origin, structure, functions and distribution of life in all its forms.	K1 & K2
2.	Understand the evolutionary process. All are linked in a sequence of life patterns.	K2 & K4
3.	Apply this for pre-professional work in agriculture and conservation of life forms.	K3 & K5
4.	Analyze what lies beyond our present knowledge of life process.	K4 & K6
5.	Evaluate and to create the perfect phylogenetic relationship in classification.	K5 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Units	
I	Origin of vertebrates: Concept of Protochordata; The nature of vertebrate morphology; Definition, scope and relation to other disciplines; Importance of the study of vertebrate morphology.
II	Origin and classification of vertebrates; Vertebrate integument and its derivatives. Development, general structure and functions of skin and its derivatives; Glands, scales, horns, claws, nails, hoofs, feathers and hairs.
III	General plan of circulation in various groups; Blood; Evolution of heart; Evolution of aortic arches and portal systems. Respiratory system: Characters of respiratory tissue; Internal and external respiration; Comparative account of respiratory organs.

IV	Skeletal system: Form, function, body size and skeletal elements of the body; Comparative account of jaw suspensorium, Vertebral column; Limbs and girdles; Evolution of Urinogenital system in vertebrate series.
V	Sense organs: Simple receptors; Organs of Olfaction and taste; Lateral line system; Electroreception. Nervous system: Comparative anatomy of the brain in relation to its functions; Comparative anatomy of spinal cord; Nerves- Cranial, Peripheral and Autonomous nervous systems.

Reading list	
1.	Swayam Prabha https://www.swayamprabha.gov.in/index.php/program/archive/9
2.	Yong, J. Z. 1981. The life of Vertebrates, English language Book society, London, pp-645.
3.	Romer, A.S. 1971. The Vertebrate body, W.B.S. Saunders, Philadelphia, pp-600.
Recommended texts	
1.	Waterman, A.J. 1972. Chordate Structure and Function, MacMillan Co., New York, pp.587.
2.	Parker T. J. and W. A. Haswell. 1962. A text book of Zoology, Vol. 2, Vertebrates, 7th Edition, Mac Millan Press, London, pp-750.
3.	Ekambaranatha Ayyar and T. N. Ananthkrishnan. 2009. Manual of Zoology, Vol – II, S. Viswanathan Pvt. Ltd. Chennai.
4.	Kotpal, 2019. R.L. Modern Text Book of Zoology Vertebrates, 4th Edition, Rastogi Publications, Meerut, pp-968.

Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	S	M	S	M	S	M	S
CO2	S	L	L	S	M	S	M	M	M	M
CO3	S	M	L	S	M	S	M	L	M	M
CO4	S	L	L	S	L	S	M	L	M	L
CO5	S	M	L	S	S	S	M	S	M	M

*S - Strong; M - Medium; L - Low

Core Course III: Lab course in Invertebrates & Vertebrates

Course Objectives:		
The main objectives of this course are:		
1.	Understanding the different systems in invertebrates & vertebrates.	
2.	Learning about various animal species, their phylogenetic affinities and their adaptive features	
3.	Imparting conceptual knowledge about the salient features and functional anatomy.	
4.	Developing the skill in mounting techniques of the biological samples.	
5.	Gaining fundamental knowledge on the skeletal system	
Course	:	Core III
Course title	:	Lab Course in Invertebrates & Vertebrates
Credits	:	4
Pre-requisite:		
Basic knowledge on the animals living in different habitats		
Expected Course Outcome:		
On the successful completion of the course, student will be able to:		
1.	Understand the structure and functions of various systems in animals	K2 & K4
2.	Learn the adaptive features of different groups of animals	K1 & K2
3.	Learn the mounting techniques	K2 & K3
4.	Acquire strong knowledge on the animal skeletal system	K2 & K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

INVERTEBRATES

Dissection / Virtual

Earthworm	: Nervous system
<i>Pila</i>	: Digestive and nervous systems
<i>Sepia</i>	: Nervous system
Cockroach	: Nervous system
Grasshopper	: Digestive system and mouth parts
Prawn	: Appendages, nervous and digestive systems
Crab	: Nervous system

Study of the following slides with special reference to their salient features and their modes of life

1. *Amoeba*
2. *Entamoeba histolytica*
3. *Paramecium*
4. *Hydra* with bud
5. Sporocyst – Liver fluke
6. *Cercaria* larva
7. *Tape worm (Scolex)*
8. *Ascaris* T. S.
9. Mysis of prawn

Spotters

1. Scorpion
2. *Penaeus indicus*
3. *Emerita (Hippa)*
4. *Perna viridis*

Mounting

- Earthworm : Body setae
Pila : Radula
Cockroach : Mouth parts
Grasshopper : Mouth parts

CHORDATES

Study the nervous system of Indian dog shark – Dissection / Virtual

1. Nervous system of *Scoliodon laticaudatus* – 5th or Trigeminal nerve
2. Nervous system of *Scoliodon laticaudatus* – 7th or Facial nerve
3. Nervous system of *Scoliodon laticaudatus* – 9th and 10th
or Glossopharyngeal & Vagus nerve

Study of the following specimens with special reference to their salient features and their modes of life:

1. *Amphioxus* sp. (Lancelet)
2. *Ascidia* sp. (sea squirt)
3. *Scoliodon laticaudatus* (Indian dog shark)
4. *Trygon* sp. (Sting ray)
5. *Torpedo* sp. (Electric ray)
6. *Arius maculatus* (Cat fish)
7. *Belone cancila* (Flute fish)
8. *Exocoetus poecilopterus* (Flying fish)
9. *Mugil cephalus* (Mullet)
10. *Tilapia mossambicus* (Tilapia)
11. *Rachycentron canadum* (Cobia)
12. *Tetodon punctatus* (Puffer fish)
13. *Dendrophis* sp. (Tree snake)

Study of the different types of scales in fishes

1. Cycloid scale
2. Ctenoid scale
3. Placoid scale

Study of the frog skeleton system (Representative samples)

1. Entire skeleton
2. Skull

3. Hyoid apparatus
4. Pectoral girdle and sternum
5. Pelvic girdle
6. Fore limb
7. Hind limb

Mounting

1. Weberian ossicles of fish

Text Books:

1. Lal, S.S. 2009. Practical Zoology, Rastogi Publications, pp-484.
2. Iuliis G. D. and D. Pulerà, 2007. The Dissection of Vertebrates: A Laboratory Manual. Academic Press, Imprint of Elsevier Publication, pp-416.
3. Verma, P.S. 2000. Manual of Practical Zoology: Chordates, S. Chand Publishing Company, pp-528

Reference Books:

1. Preeti, G., and C. Mridula, 2000. Modern Experimental Zoology, Indus International Publication.
2. Sinha, J., A. K. Chatterjee, P. Chattopadhyaya. 2011. Advanced Practical Zoology, Arunabha Sen Publishers, pp-1070.

Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	S	M	S	M	S
CO2	S	M	L	S	M	S	M	M	M	M
CO3	M	M	L	S	L	S	M	L	M	M
CO4	S	S	L	S	L	S	M	L	M	L
CO5	S	S	M	L	M	S	M	S	M	M

*S - Strong; M - Medium; L - Low

Elective Courses I A: Biochemistry

Course Objectives:		
The main objectives of this course are:		
1.	Students should know the fundamentals of Biochemistry	
Course	:	Elective I
Course title	:	Biochemistry
Credits	:	3
Pre-requisite:		
Understanding fundamental properties of elements, atoms, molecules, chemical bonds, linkages and structure, composition, metabolism and functions of biomolecules.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to:		
I	Learn the structure, properties, metabolism, and bioenergetics of biomolecules	K1 & K3
II	Acquire knowledge on various classes and major types of enzymes, classification, their mechanism of action and regulation	K1 & K2
III	Understand the fundamentals of biophysical chemistry and biochemistry, importance, and applications of methods in conforming the structure of biopolymers	K2 & K3
IV	Comprehend the structural organization of and proteins, carbohydrates, nucleic acids and lipids	K2 & K4
V	Familiarize the use of methods for the identification, characterization, and conformation of biopolymer structures.	K5 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Units	
I	Basics of biophysical chemistry and biochemistry: Structure of atoms, molecules and chemical bonds - Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).
II	Biomolecular interactions and their properties: Stabilizing interactions (Vander Waals, electrostatic, hydrogen bonding, hydrophobic interaction etc. - Composition, structure, metabolism and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins).
III	Bioenergetics and enzymology: Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers - Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isoenzymes
IV	Structural conformation of proteins and nucleic acids: Conformation of proteins (Ramachandran plot, secondary, tertiary, and quaternary structure; domains; motifs and folds)- Conformation of nucleic acids (A-, B-, Z-DNA), t-RNA, micro-RNA).

V	Stabilizing interactions in biomolecules: Stability of protein and nucleic acid structures - hydrogen bonding, covalent bonding, hydrophobic interactions, and disulfide linkage.
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Reading list

1. Berg, J. M., J. L. Tymoczko and L. Stryer 2002. Biochemistry. 5th Ed., W.H. Freeman & Co., New York, pp-1050.
2. Kuchel P.W. and G. B. Ralston. 2008. Biochemistry. McGraw Hill (India) Private Limited, UP, pp-580.
3. McKee T. and J. R. McKee. 2012. Biochemistry: The Molecular Basis of Life. (7th Edition). Oxford University Press, US, pp-793.
4. Nelson D.L. and M.M. Cox. 2012. Lehninger's Principles of Biochemistry. (6th Edition). W. H. Freeman Publishers, New York, pp-1158.
5. Satyanarayana U. and U. Chakrapani, 2006. Biochemistry. (3rd Edition). Books and Allied (P) Ltd. Calcutta, pp-695.

Recommended texts

1. Buchanan, B.B., W. Gruissem and R.L. Jones. 2015. Biochemistry and Molecular Biology of Plants. John Wiley and Sons Ltd., UK, pp-1280.
2. Murray, R.K., D.K. Granner, P.A. Mayes and V.W. Rodwell. 2003. Harper's Illustrated Biochemistry (26th Edition), The McGraw-Hill Companies, Inc., USA, pp-704.
3. Palmer, T. 2004. Enzymes. Affiliated East-West Press Pvt. Ltd., New Delhi, pp-416.
4. Voet D. and J.G. Voet. 2011. Biochemistry. (4th Edition). John Wiley & Sons (Asia) Pvt. Ltd., pp-1428.

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	L	S	M	S	M	M
CO2	S	S	L	S	S	S	M	M	M	S
CO3	M	M	M	S	M	S	S	S	S	L
CO4	S	M	S	M	S	M	S	S	S	M
CO5	M	S	S	M	M	S	M	L	S	M

*S - Strong; M - Medium; L-Low

Elective Course I B: Biophysics

Course Objectives:		
The main objectives of this course are:		
1.	Enlighten the students to have a glimpse of recent advances in biophysical techniques.	
Course	:	Elective I
Course title	:	Biophysics
Credits	:	3
Pre-requisite		
To Understand the important role of Biophysics for better visualization in scientific Research		
Expected Course Outcome:		
Upon completion of this course, Students would have		
CO1	Gain a solid understanding of how physical laws and concepts apply to biological systems.	K1
CO2	Learn about the forces that determines the structure of biological macromolecules	K2
CO3	Apply the knowledge to understand the behaviour and properties of biological macromolecules	K3
CO4	Focuses on the study of energy flow and transformation within biological systems	K3
CO5	Impart the recent advances in Biophysical techniques in Life science Research	K4

K1-Remember; K2-Understand; K3-Apply; K4-Analyze; K5-Evaluate; K6–Create

Units	
I	Introduction to Biophysics: Scope of Biophysics, Basic concepts of Biophysics, Structure of atoms, Isotopes, Hydrogen Ion concentration: Colloids – Description, types and properties -Electro-kinetic properties, Donnan equilibrium, Tyndall effect, Surface tension, Brownian movement, Filtration, Osmosis, Diffusion, Adsorption, Osmosis and active transport.
II	Structure of Biomolecules: Atomic Structure, Hydrogen atom, Bond Energy, Electrostatic force, Hydrophilic and Hydrophobic interactions. Chemical bonds and Molecular interactions – Primary chemical bonds – Secondary or weak bonds – ATP – Bioenergetics – NADP/NADPH Redox couple, Mitochondrial bioenergetics - Oxidative Phosphorylation, Ultra structure of Mitochondrion, Oxidative Phosphorylation and Electron Transport.
III	Photobiology: Light and Life – Nature of light – Dual Nature of Light, Electromagnetic spectrum, Corpuscular Theory, Photoelectric Emission, Radiant Energy in Biological systems. Adsorption of light – Energy states of Molecules- Spin property of electrons, Ground state and excited state, energy states and absorption spectrum of molecules, energy transfer, Photochemistry. De-excitation – Fluorescence, Phosphorescence, Delayed Light Emission.

IV	Bioenergetics: Scope and definition. Law of Thermodynamics – First Law of Thermodynamics, Internal Energy, Enthalpy, Second Law of Thermodynamics-Entropy, Entropy changes in Living systems. Oxidation Reduction Potential – Redox couples, Redox potential, Chemical energy to electrical work, Free energy change in redox reactions.
V	Principle and Applications of sensors: Laser Beam in Biomedical field – Applications of Laser in therapies and diagnosis. Magnetic Resonance Imaging (MRI). Computer Topography (CT) Scan. Ultrasound in interaction with tissues and application in therapeutics. Autoradiography – Types and techniques used and evaluation of Radiogram.

Reading List

1. Daniel. M. 1989. Basic Biophysics for Biologist. Agro Botanical Publishers, Bikaner, India.
2. Subramanian. M.A. Biophysics Principles and Techniques. MJP Publishers Chennai.
3. Thiravia Raj, 1995. Biophysics, Saras Publication.
4. Narayanan P. 2005. Introductory Biophysics, New Age Publishing Co Mumbai, India:

Recommended texts

1. Igor, Serdyuk, Nathan R. Zaccai and Joseph Zaccai. 2007. Methods in Molecular Physics, Cambridge University Press,UK.
2. Bengt N. 2004. Methods in Modern Biophysics, Springer, Germany.
3. Palanichamy S and Shanmugavelu M. 1996. Principles of Biophysics, Palani Paramount Publication.
4. Skoog, D.A. et al., 1998. Principles of Instrumental Analyses, 5th edition, Saunders College Publication.

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	S	M	M	S	M
CO2	S	S	M	S	M	S	S	S	M	L
CO3	S	M	S	S	S	S	M	L	M	S
CO4	S	S	S	S	S	M	S	M	L	S
CO5	S	M	S	M	M	S	M	S	S	M

*S-Strong; M-Medium; L-Low

Elective Course II A : Economic Entomology

Course Objectives:		
The main objectives of this course are:		
1.	Students should acquire a good understanding about the life of insects and their classification.	
Course	:	Elective II
Course title	:	Economic Entomology
Credits	:	3
Pre-requisite:		
The students with a basic background in biological sciences with a special emphasis on the study of insects including systematic, beneficial insects, destructive insects, integrated pest management and insects of medical and veterinary importance.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to		
I	Understand taxonomy, classification, and life of insects in the animal kingdom.	K1 & K2
II	Know the life cycle, rearing and management of diseases of beneficial insects.	K2 & K3
III	Know the type of harmful insects, life cycle, damage potential and management of pests including natural pest control	K2 & K3
IV	Recognize insects which act as vectors causing diseases in animals and human.	K2 & K4
	Overall understanding on the importance of insects in human life.	K2 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Units	
I	Scope and history of Entomology - branches of Entomology - Principle of insect classification. Classification of insects up to order - key Characteristics with Indian examples. Insects and their biological success. Collection and preservation of insects.
II	Beneficial insects: Silkworms - types, life history, disease management and rearing methods - Types of honeybees, life history, social organization (colonies and caste system), honeybee care and management of beehive - Lac insects-life history, lac cultivation; Pollinators, predators, parasitoids, scavengers, weed killers, soil-builders.
III	Destructive insects: Insect pests - definition - Categories of pests - Types of damage to plants by insects - Causes of pest outbreak - Economic threshold level - Biology of the insect pests - Pests of paddy, cotton, sugarcane, brinjal vegetables, coconut, stored grains and cereals.
IV	Pest management/Control strategies: Methods and principles of pest control - Natural control, Artificial control, Merits and demerits or limitations of these methods in pest control - Development and uses of pest resistant plant varieties - Integrated pest

	management - Concepts and practice.
V	Vector biology: Vectors of veterinary and public health importance - Mosquitoes as potential vectors of human disease-control measures. Man, and insects: The value of insects – insects as protein sources of human and animal feeds. Medical Entomology: Medicinal use of insects. Forensic Entomology.
Reading list	
<ol style="list-style-type: none"> 1. Ayyar, L.V. R. 1936. Hand book of Economic Entomology for South India. Narendra Publishing House. New Delhi, pp- 528. 2. Vasantharaj David, B. and V.V. Ramamurthy. 2016. Elements of Economic Entomology, Eighth Edition, Brillion Publishing, New York, pp-400. 3. Ross. H.H. 1965. A Text Book of Entomology, John Wiley & Sons Inc., New York, pp-746. 	
Recommended texts	
<ol style="list-style-type: none"> 1. Chapman, R.F., S.J. Simpson and A.E. Douglas. 2012. The Insects: Structure and Function, Fifth Edition, Cambridge University Press, pp-959. 2. Imms, A.D., O.W. Richards and R.G. Davies (Eds.) IMMS' General Textbook of Entomology, Volume I: Structure, Physiology and Development, pp-418; Volume 2: Classification and Biology, pp-934, Springer Netherlands. 3. Daly, H.V., J.T. Doyen and P.R. Ehrlich. 1978. Introduction to Insect Biology and Diversity. Mc Graw-Hill Kogakusha Ltd., Tokyo, pp-564. 4. Hill, D.S. 1974. Agricultural Insect Pests of the Tropics and Their Control. Cambridge University Press, New York, pp-746. 5. Krishnaswami, S. 1973. Sericulture Manual, Vol. I & II, Silkworm rearing, FAO Agricultural Science Bulletin, Rome. 6. Mani, M.S. 1982. General Entomology. Oxford & IBH Publishing Co., pp-912. 7. Wigglesworth, V.B. 1972. The Principles of Insect Physiology, ELBS & Chapman and Hall, London, pp-827. 	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	M	M	S	L	M
CO2	S	S	M	S	S	S	S	S	S	L
CO3	S	M	S	S	S	S	S	S	S	S
CO4	S	S	S	S	S	S	M	S	M	M
CO5	S	S	S	M	M	S	M	L	S	M

*S - Strong; M - Medium; L-Low

Elective Course II B : Sericulture

Course Objectives:		
The main objectives of this course are:		
1.	Students should know basic concepts and techniques in Sericulture.	
Course I	:	Elective II
Course title	:	Sericulture
Credits	:	2
Pre-requisite:		
Students should be aware of economic and cultural importance of sericulture.		
Expected Course Outcome:		
Upon completion of this course, Students would have		
I	To understand the various practices in sericulture. To know the needs for sericulture and the status of India in global market.	K2 & K3
II	Able to apply the techniques and practices needed for sericulture.	K1, K2 & K3
III	To know the difficulties in sericulture and be able to propose plans against it.	K5 & K6
K1- Remember; K2- Understand; K3- Apply; K4-Analyze; K5-Evaluate; K6- Create		
Units		
I	Introduction to textile fibers; types- natural and synthetic fibers; sources of silk fiber- Tasar, Muga, Anaphe, Gonometta, Fagara, spider and mussel; properties and importance of silk fiber. History, development, status, characteristics and advantages of sericulture in India.	
II	Host plants; Moriculture- distribution, morphology, propagation- seedling, cutting, grafting, layering and micropropagation methods, maintenance- irrigation, manuring and pruning, pests and diseases of mulberry.	
III	Biology of Bombyx mori; Races and voltinism. Structure of egg, larva, pupa and adult. Sexual dimorphism- larva, pupa and adult. Anatomy: Digestive system, circulatory, respiratory, Excretory, male and female reproductive system. Silk gland – Structure and Significance-Silk protein. Neuroendocrine system, neuro secretory cells, Corpora allata, Corpora cardiaca, ecdysial gland. Hormonal control of moulting and metamorphosis. Exocrine glands and pheromones.	
IV	Grainage technology: Breeding Stations - methods of industrial egg production, mother moth examination, diapausing and non-diapausing eggs. Incubation and transport of eggs. Silk worm - Rearing: Rearing House (CSB- model) and Rearing appliances. Rearing operation- Disinfection, brushing, maintenance of optimum conditions, feeding, bed cleaning, spacing, care during moulting, mounting, and Harvesting. Rearing methods: Chawki rearing and rearing of late age and mature larvae- Mounting practices.	
V	Physical and commercial characteristics of cocoons. Cocoon harvesting and marketing. Cocoon sorting, stifling, deflossing, riddling, cooking, brushing, reeling and re-reeling. Weaving. By-products of sericulture industry. Reeling operation: reeling appliances- types - raw silk – raw silk testing. Diseases of Silkworm: Fungal, Viral, Bacterial diseases; Pest of silkworm – Uzi fly and Dermestid beetles - causative agent, symptoms, prevention and control measures.	
Reading list		
1. G. Ganga and J. Sulochana Chetty. 2019. An introduction to sericulture, 2 nd edition, Oxford and		

IBH Publishing Co. Pvt. Ltd., New Delhi.

2. M. Johnson and M. Kesary. 2019. Sericulture, Saras publication, Tamilnadu.

3. Singh, Amardev & Ravinder Kumar. 2013. Sericulture handbook Vol 1, Biotech.

4. M. Madan Mohan Rao. An Introduction to Sericulture, 2nd edition, BS Publications.

Recommended websites

1. <https://agritech.tnau.ac.in/sericulture/>

2. <https://csb.gov.in/>

Mapping with Programme Outcomes*

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	L	L	L	L	L	M	S	L	L
CO2	L	M	L	M	L	M	M	S	M	L
CO3	M	S	L	L	L	M	L	L	M	S
CO4	M	S	M	S	M	M	L	L	S	S
CO5	M	M	L	M	M	L	L	L	L	M

*S - Strong; M - Medium; L- Low

Semester -II

Part	List of Courses	Credits	No. of Hours/ week	Total hours/ Semester	Internal marks	External marks	Total marks
Core – IV	Cellular and Molecular Biology	5	6	90	25	75	100
Core – V	Developmental Biology	5	6	90	25	75	100
Core – VI	Lab Course in Cell Biology & Lab Course in Developmental Biology	4	6	90	50	50	100
Elective– III	A) Biostatistics	3	4	60	25	75	100
	B) Bioinformatics						
Elective– IV	A) Research Methodology	3	4	60	25	75	100
	B) Wildlife Biology						
Skill Enhancement Course [SEC] – I	Poultry Farming/Apiculture	2	4	60	25	75	100
		22	30	450			

METHODS OF EVALUATION for THEORY

Internal Evaluation	Continuous Internal Assessment Test	25 Marks
	Assignments	
	Snap Test	
	Quiz Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Core Course IV: Cellular and Molecular Biology

Course Objectives:		
The main objectives of this course are:		
1.	To understand the ultra-structures and functions of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes and organelles.	
2.	To realize involvement of various cellular components in accomplishing cell division.	
3.	To enable a successful performance in cell biology component of CSIR-UGC NET.	
4.	To understand the ultra-structures and functions of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes and organelles.	
Course	:	Core IV
Course title	:	Cellular and Molecular Biology
Credits	:	5
Pre-requisite:		
Students should have knowledge of the basic cellular structures and their salient functions in prokaryotic and eukaryotic cells.		
Expected Course Outcome:		
Upon completion of this course, students could		
1.	Understand the general concepts of cell and molecular biology.	K2
2.	Visualize the basic molecular processes in prokaryotic and eukaryotic cells, especially relevance of molecular and cellular structures influencing functional features.	K1 & K2
3.	Perceive the importance of physical and chemical signals at the molecular level resulting in modulation of response of cellular responses.	K3 & K4
4.	Updated the knowledge on the rapid advances in cell and molecular biology for a better understanding of onset of various diseases including cancer.	K5
5.	Understand the general concepts of cell and molecular biology.	K2

K1- Remember; **K2-** Understand; **K3-** Apply; **K4-**Analyze; **K5-**Evaluate; **K6-** Create

Units	
I	General features of the cell: Basic structure of prokaryotic and eukaryotic cells - Protoplasm - cell organelles; cell theory; Diversity of cell size and shapes.

II	Cellular organization: Membrane structure and functions - Structure of model membrane, lipid bilayer and membrane proteins diffusion, osmosis, ion channels, active transport, ion pumps, mechanism and regulation of intracellular transport, electrical properties of membranes. Structure and functions of Intracellular organelles: Nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles and chloroplasts.
III	Cell division and Cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle and control of cell cycle. Molecular biology of cell: Structure of DNA and RNA; Process of DNA replication, transcription, and translation in pro- and eukaryotic cells; Genetic maps.
IV	Cell communication and cell signaling: Membrane- associated receptors for peptide and steroid hormones - signaling through G-protein coupled receptors, signal transduction pathways. General principles of cell communication: extracellular space and matrix, interaction of cells with other cells and non-cellular structures.
V	Cancer cells: Characteristic features of normal and cancer cells; Carcinogens: types and cancer induction; Metastasis; Oncogenes and tumor suppressor genes, apoptosis; therapeutic interventions of uncontrolled cell growth.
Reading list	
<ol style="list-style-type: none"> 1. Plopper, G., D. Sharp, and E. Sikorski. 2015. Lewin's Cells (Third Edition), Jones & Bartlett, New Delhi, pp-1056 2. Plopper, G. 2013. Principles of Cell Biology, Jones & Bartlett, Maryland, pp-510 	
Recommended texts	
<ol style="list-style-type: none"> 1. Karp, G. 2010. Cell Biology (Sixth Edition), John Wiley & Sons, Singapore, pp-765. 2. Lodish, H., C. A. Kaiser, A. Bretscher, <i>et al.</i>, 2013. Molecular Cell Biology (Seventh Edition), Macmillan, England, pp-1154 3. De Robertis, E.D.P. and E. M. F. De Robertis Jr, 1987. Cell and Molecular Biology. Info-Med, Hong Kong, pp-734 4. Abbas, A. K., A. H. Lichtman and S. Pillai, 2007, Cell and Molecular Immunology (Sixth Edition), Saunders, Philadelphia, pp-566 5. Loewy, A.G., P. Siekevitz and J. R. Menninger, <i>et al.</i>, 1991, Cell Structure and Function (Third Edition), Saunders, Philadelphia, pp-947 6. Watson, J. D., N.H. Hopkins, J.W. Roberts, <i>et al.</i>, 1987, Molecular Biology of the Gene (Fourth Edition), Benjamin/Cummings, California, pp-1163 7. Han, S. S. and J. Holmstedt. 1979, Cell Biology, McGraw Hill, pp-319 8. Alberts, B., A. Johnson, J. Lewis, <i>et al.</i>, 2015, Molecular Biology of the Cell (Sixth Edition), Garland Science, New York, pp-1342 9. Clark, D.P., 2005. Molecular Biology, Elsevier, China, pp-784 10. Tropp, B. 2008. Molecular Biology Genes to Proteins (Third Edition), Jones & Bartlett, US, pp-1000 	

Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	L	L	L	S	S	S	M	M	M
CO2	M	M	M	S	S	S	S	M	S	M
CO3	S	S	S	M	M	S	M	M	L	S
CO4	M	M	S	L	S	S	L	M	S	S

CO5	S	M	M	S	S	S	S	M	S	S
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*S - Strong; M - Medium; L - Low

MSU

Core Course V: Developmental Biology

Course Objectives:		
The main objectives of this course are:		
1.	Understand the process of gametogenesis, cleavage and gastrulation, embryonic development, extra embryonic membrane and placenta in various animals and human.	
2.	Learn the principles, methods and applications of cryo-preservation of gametes and embryo.	
Course	:	Core V
Course title	:	Developmental Biology
Credits	:	5
Pre-requisite:		
Students have fundamental knowledge in developmental biology.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to		
1.	Define the concepts of embryonic development	K1
2.	Observe various stages of cell divisions under microscope	K2 & K3
3.	Understand the formation of zygote	K4
4.	Differentiate the blastula and gastrula stages	K4 & K5
5.	Learn the distinguishing features of three different germ layers and formation of various tissues and organs	K4

K1- Remember; **K2-** Understand; **K3-** Apply; **K4-**Analyze; **K5-**Evaluate; **K6-** Create

Units	
I	Pattern of animal development: Chief events in animal development; History of thoughts and conceptual developments. Gametogenesis: Origin of germ cells, spermatogenesis - Sperm morphology in relation to the type of fertilization, Oogenesis - Oogenesis in insects and amphibians; Composition and synthesis of yolk in invertebrates (insects and crustaceans) and vertebrates; Genetic control of vitellogenin synthesis in amphibians
II	Fertilization: Sperm aggregation, Sperm activation, Chemotaxis, Sperm maturation and capacitation in mammals, Acrosome reaction. Sperm – egg interaction. Sperm entry into the egg - Egg activation - Intracellular calcium release - Cortical reaction - Physiological polyspermy - Fusion of male and female pronuclei - Post fertilization metabolic activation - Parthenogenesis
III	Cleavage and gastrulation: Pattern of embryonic cleavage, mechanisms of cleavage, mid blastula transition - Determinate and regulatory embryos, Factors affecting gastrulation, mechanisms and types of gastrulation in respective animal embryos (Sea urchin, Amphibians, Aves, Mammals); Fate maps - (Amphibian and Chick), Epigenesis and preformation – Formation of primary germ layers
IV	Embryonic Development; Embryonic development of fish and birds, formation of extra embryonic membranes in mammalian – Organogenesis - Development of endodermal, mesodermal and ectodermal derivatives.

	Embryonic Induction and neurulation; Formation and migration of neural crest cells - types of neural crest cells and their patterning - primary and secondary neurulation. Genetic control of segmentation – Gap genes; pair rule genes; Homeotic genes
V	Post embryonic development metamorphosis: Endocrine control of metamorphosis in insect and amphibian - Endocrine control of moulting and growth in crustaceans and insects - Neoteny and pedogenesis. Regeneration: Formation of ectodermal cap and regeneration blastoma – Types of regeneration in planaria, Factors stimulating regeneration – Biochemical changes associated with regeneration. Experimental Embryology: Mammalian reproduction: Mammalian reproductive cycle, Hormonal regulation, Cryopreservation of gametes/embryos - Ethical issues in cryopreservation

Reading list

1. Balinsky, B. I. 1981. Introduction to Embryology (5th Edition), CBS College Publishers, New York, pp-782.
2. Gilbert. S. F. 2006. Developmental Biology, 8th Edition, INC Publishers, USA, pp-785.
3. Berrill, N.J. 1974. Developmental Biology, Tata Mc-Graw Hill Publications, New Delhi, pp-535.
4. Tyler, M.S. 2000. Developmental Biology - A Guide for Experimental Study, Sunderland, MA, pp-208.
5. Subramoniam, T. 2011. Molecular Developmental Biology (2nd Edition), Narosa Publishers, India, pp-364.
6. www.easybiologyclass.com > developmental-biology-e
7. www.studocu.com > document > lecture-notes > view
8. ocw.mit.edu > courses > 7-22-developmental-biology-f.

Recommended texts

1. Wilt, F.H. and N.K. Wessel. 1967. Methods in Developmental Biology, Thomas Y Crowell, New York.
2. Slack J.M.W. 2012. Essential Developmental Biology (3rd Edition), Wily-Blackwell Publications, USA, pp-496.
3. Mari-Beffa, M. and J. Knight. 2005. Key Experiments in Practical Developmental Biology, Cambridge University Press, UK, pp-404.

Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	L	S	M	L	M
CO2	S	S	S	S	S	L	S	S	S	S
CO3	S	M	S	S	S	S	S	L	L	M
CO4	S	S	S	S	S	M	S	S	S	L
CO5	S	S	S	M	S	S	S	L	L	M

*S - Strong; M - Medium; L – Low

Core Course VI: Lab Course in Cell Biology and Developmental Biology

Course Objectives:		
The main objectives of this course are:		
1.	Practical course aims at demonstrating significant cellular and molecular biological principles, quantitative and analytical approaches that enable the students to translate the theoretical foundation in cell biology, and developmental biology into practical understanding.	
Course	:	Core VI
Course title	:	Lab Course in Cell Biology and Developmental Biology
Credits	:	4
Pre-requisite:		
Students should have acquired basic knowledge relevant to this particular lab course.		
Expected Course Outcome:		
Upon completion of this lab course, students		
1.	Acquire knowledge to differentiate the cells of various living organisms and become aware of physiological processes of cells e.g. cell divisions, various stages of fertilization and embryo development.	K2
2.	Understand and observe as well as correctly identify different cell types, cellular structures using different microscopic techniques.	K3
3.	Develop handling - skills through the wet-lab course.	K6
4.	Learn the method of culturing of <i>Drosophila</i> and identification of their wild and mutant strains	K1 & K2
5.	Acquire skills to perform human karyotyping and chromosome mapping to identify abnormalities	K1 & K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Cell and Molecular Biology

1. Determination of cell size using micrometer
2. Mitosis in root meristematic cells of plants
3. Identification of various stages of meiosis in the testes of grasshopper
4. Detection of polytene chromosome in salivary gland cells of the larvae of the Chironomus
5. Detection of sex chromatin
6. Identification of blood cells in the haemolymph of the cockroach
7. Isolation of genomic DNA from eukaryotic tissue

8. Isolation of total RNA from bacterial cells/tissues
9. Agarose gel electrophoresis of DNA
10. SDS-Polyacrylamide gel electrophoresis

Developmental Biology

Gametogenesis - Observation of gametes from gonadal tissue sections

- i. Oogenesis:
 - ✓ Section through ovary of shrimp, fish, frog and mammals
- ii Spermatogenesis:
 - ✓ Section through testis of shrimp, fish, calotes and mammals

Fertilization

- iii Induced spawning in polychaete worm *Hydroids elegans*
- iv *In vitro* fertilization and development in a polychaete worm *Hydroids elegans*
- v Observation of egg developmental stages in *Emerita emeritus*

Embryogenesis

- vi Observation and whole mount preparation of the chick blastoderm - 18 hours of development
- vii Chick embryonic stage - 24 hours of development
- viii Chick embryonic stage - 48 hours of development
- ix Chick embryonic stage - 72 hours of development
- x Chick embryonic stage - 96 hours of development

Histological observation: Section through various developmental stages in chick embryo

Experimental Embryology: Regeneration in Frog Tadpoles

- xi Blastema formation
- xii Demonstration of regenerative process in tadpole Metamorphosis
- xiii Demonstration of metamorphosis in Frog Tadpole using exogenous Iodine

Cryopreservation

- xiv Demonstration of cryopreservation of gametes of fin fish/ shell fish

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	S	S	S	L	L	M
CO2	S	S	S	S	S	M	M	M	M	M
CO3	S	S	M	S	S	L	S	M	L	M
CO4	M	M	L	M	L	M	M	S	M	L
CO5	S	S	M	L	S	M	L	S	S	S

*S - Strong; M - Medium; L – Low

Elective Course III A: Biostatistics

Course Objectives:		
The main objectives of this course are:		
1.	Students should know basic concepts in Biostatistics.	
Course	:	Elective III
Course title	:	Biostatistics
Credits	:	3
Pre-requisite:		
Students should be aware of importance of analysis of quantitative and qualitative information from biological studies.		
Expected Course Outcome:		
Upon completion of this course, Students would have		
I	Clear understanding of design and application of biostatistics relevant to experimental and population studies.	K2 & K3
II	Acquired skills to perform various statistical analyses using modern statistical techniques and software.	K3 & K4
III	Knowledge on the merits and limitation of practical problems in biological/ health management study as well as to propose and implement appropriate statistical design/ methods of analysis.	K5 & K6

K1- Remember; **K2-** Understand; **K3-** Apply; **K4-**Analyze; **K5-**Evaluate; **K6-** Create

Units	
I	Definition, scope, and application of statistics; Primary and secondary data: Source and implications; Classification and tabulation of biological data: Types and applications. Variables: Definition and types. Frequency distribution: Construction of frequency, distribution table for grouped data; Graphic methods: Frequency polygon and ogive curve; Diagrammatic representation: Histogram, bar diagram, pictogram, and pie chart.
II	Measures of central tendency: Mean, median and mode for continuous and discontinuous variables. Measures of dispersion: Range, variation, standard deviation, standard error, and coefficient of variation.
III	Probability: Theories and rules; Probability - Addition and multiplication theorem; Probability distribution: Properties and application of Normal, Binomial and Poisson distributions.
IV	Hypothesis testing: Student 't' test - paired sample and mean difference 't' tests. Correlation: Types - Karl Pearsons Co-efficient, Rank correlation, Significance test for correlation coefficients. Regression analysis: Computation of biological data, calculation of regression co-efficient, graphical representation and prediction.

V	Analysis of variance: one way and two-way classification. Data analysis with comprehensive statistical software using Statistical Package for the Social Sciences (SPSS).
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Reading list

1. Arora, P. N. and P. K. Malhan. 1996. Biostatistics, Himalaya Publishing House, Mumbai, pp-447.
2. Gurumani, N. 2005. Introduction to Biostatistics, M.J.P. Publishers, Delhi, pp-407.
3. Das, D. and A. Das. 2004. Academic Statistics in Biology and Psychology, Academic Publisher, Kolkata, pp-363.
4. Palanichamy, S. and Manoharan, M. 1990. Statistical Methods for Biologists, Palani Paramount Publications, Tamil Nadu, pp-264.

Recommended texts

1. Bailey, N. T. J. 1959. Statistical in Biology, English Universities Press, London, pp-48.
2. Sokal, R. R. and F. J. Rohlf, 1973. Introduction to Biostatistics, W.H. Freeman, London, pp-467.
3. Sokal, R.R. and F.J. Rohlf. 1981. Biometry: The principles and practice of statistics in biological research, San Francisco: W.H. Freeman, London, pp-859.
4. Zar, J.H. 1998. Biostatistical Analysis, Pearson Education (Singapore) Pvt. Ltd., Delhi, India, pp-660.
5. Bailey, N. T. J. 1994. Statistical Methods in Biology (Third Edition), Cambridge University Press, Cambridge, pp-255.
6. Wayne W. Daniel. Biostatistics: A Foundation for Analysis in the Health Sciences, John Wiley & Sons Inc, USA, pp-443.
7. Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods (Sixth Edition), Oxford & IBH Publishing Co., New Delhi, pp-593.
8. Pagano, M. and K. Gauvreau. 2008. Principles of Biostatistics (Second Edition), Cengage Learning, New Delhi, pp-525.

Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	M	S	S	M	S	M	M
CO2	S	S	S	S	S	S	S	S	S	S
CO3	M	S	S	S	S	S	S	S	S	L
CO4	M	M	S	L	M	M	M	S	L	M
CO5	M	M	S	L	M	S	M	L	S	M

*S - Strong; M - Medium; L- Low

Elective Course III B: Bioinformatics

Course Objectives:		
The main objectives of this course are:		
1.	To utilize bioinformatics tools and databases for retrieving, analyzing, understanding and managing biological data.	
2.	To learn, understand and apply the basic concepts of Bioinformatics and its significance in biological data analysis	
Course	:	Elective III
Course title	:	Bioinformatics
Credits	:	3
Pre-requisite		
To provide the student with a strong foundation for performing further research in bioinformatics.		
Expected Course Outcome:		
Upon completion of this course, Students would have		
1.	Learn about the bioinformatics databases, data format and data retrieval from the online sources	K2
2.	Acquire knowledge on the databases of local and multiple alignments.	K2
3.	Describe database similarity searching, biological file formats, and 3D structure visualization of biomacromolecules	K3
4.	Apply modelling tools and docking programs to annotate the structure of biomolecules	K4
5.	Integrate the various approaches and techniques for the analysis of comparative genomics and Proteomics	K5

K1-Remember; K2-Understand; K3-Apply; K4-Analyze; K5-Evaluate; K6–Create

	Units
I	Internet concepts, Bioinformatics a multidisciplinary approach, Scope and applications of Bioinformatics. Biological databases- Nucleic acid databases (Genbank, DDBJ and EMBL)Protein databases - primary, composite, secondary Specialized databases-SGD, TIGR, Structural databases -PDB, CATH Mod BASE.
II	Sequence similarity search (FASTA and BLAST). Significance of E-value. Introduction to ORF and primer designing. Secondary structure prediction: Hidden Markov method
III	Multiple sequence alignment (CLUSTAL W), conserved domain search (Motif). Phylogenetic analysis- phylogenetic tree construction (Neighbor Joining method and Maximum parsimony).
IV	Homology modeling - SPDB viewer. Ramachandran plot for evaluation of predicted structure. Data mining for drug designing and docking analysis. Structure visualization tool-RASMOL
V	Genomics-scope and applications of structural and functional genomics, microarray technology Proteomics scope and applications of structural and functional-2D gel electrophoresis, Mass spectroscopy and MALDI-TOF

Reading List

1. Baxevanis, A.D. and Quellette, B.F.F. 2009. Bioinformatics. A practical guide to the

- analysis of genes and proteins. II edn. Wiley-Intern Science Publication, NewYork.
2. Mount, W. 2005. Bioinformatics sequence and genome analysis. Cold Spring harbour Laboratory Press, NewYork.
 3. Pevsner, 2009. Bioinformatics and Functional Genomics. Wiley Dream tech, India.
 4. Lesk, M.A. 2008. Introduction to Bioinformatics. Oxford Univ Publishers

Recommended texts

1. Mount, D.W. 2004. Bioinformatics: Sequence and Genome analysis, 2nd Edition, CBS Publishers, New Delhi.
2. Attwood, T.K, Parry Smith, D.J. Phukan, S. 2007. Introduction to Bioinformatics, Pearson Education, UK.
3. Gromiha, M.M. 2010. Protein Bioinformatics - From Sequence to Function, Elsevier India Pvt. Ltd, New Delhi.

Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	S	M	M	S	S
CO2	S	M	M	M	M	M	M	S	M	S
CO3	M	M	S	M	S	S	L	M	M	S
CO4	S	M	S	M	S	M	S	M	M	S
CO5	S	S	M	S	L	S	M	S	L	M

*S-Strong; M-Medium; L-Low

Elective Course IV A: Research Methodology

Course Objectives:		
The main objectives of this course are:		
1.	Students understand the basic principles, methodology and applications of widely used instruments in biological sciences.	
Course	:	Elective IV
Course title	:	Research Methodology
Credits	:	3
Pre-requisite:		
Students should know the fundamentals of basic methods employed in experimental biology.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to		
1.	Understand the implications of GLP	K1
2.	Learn the working principles of different instruments	K2
3.	Gain the knowledge on techniques of histology and histochemistry	K2 & K4
4.	Acquire knowledge on the basic principle and application of various modules of light and electron microscopy	K3 & K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**- Create

Units	
I	Microscopy: Compound (Dark and Light field), Phase Contrast, Fluorescent, Polarized, Electron (Transmission and Scanning), AFM and Confocal Microscope - Micrometry.
II	Histology- Sectioning, fixation and staining of tissues. Centrifuge Clinical, Density gradient and Ultra - sedimentation coefficient. GM counter, Liquid Scintillation counter, Lyophilizer, Spectrophotometer (visible, Ultraviolet), ELISA Reader. FTIR, NMR, XRD, Atomic Absorption and Mass Spectrophotometer.
III	Chromatography: Paper, Thin layer, Column, gel filtration, ion exchange, Gas and HPLC, PAGE, Agarose Gel Electrophoresis, 2D Gel Electrophoresis, Western blotting, and PCR.
IV	Identification of research problems - Steps in formulating a research problem. Thesis writing - Introduction, Review of literature, Methodology, Results - illustrations and tables, Discussion, Bibliography.
V	Publication of research and review articles – choosing the right journal; refereed journals, open access journals, Journal metrics, citation, impact factor, SCI, H index, i10 index, software for paper formatting MS Office, Software for detection of Plagiarism.
Reading list	
1. Pearse, A.G. 1968. Histochemistry: Theoretical and Applied, Vol. I, Third Edition, J & A Churchill Ltd, pp-758. 2. Lillie, R.D. 1954. Histopathologic Technic and Practical Histochemistry, Second Edition, Blakiston, New York, pp-715.	

3. Hoppert, M. 2003. Microscopic Techniques in Biotechnology, Wiley-VCH GmbH, Weinheim, Germany, pp-330.

Recommended texts

1. Chandler, D.E. and Roberson R.W. 2009. Bioimaging: Current Concepts in Light and Electron Microscopy, Jones and Bartlet Publishers, Sudbury, MA, USA, pp440.
2. Engelbert, B. 1960. Radioactive Isotopes in Biochemistry, Elsevier Applied Science, pp-376.
3. Wolf, G. 1964. Isotopes in Biology, Academic Press, pp-173.
4. Srivastava, B. B. 2005. Fundamentals of Nuclear Physics, Rastogi Publications, pp-500.
5. Pantin, C. F. A. 1948. Microscopical Techniques, Cambridge University Press, London.

Mapping with Programme Outcomes*

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	S	M	S	M	M
CO2	S	S	M	S	S	S	M	M	M	S
CO3	S	M	S	S	S	S	S	S	S	L
CO4	S	S	S	S	S	M	S	S	S	M
CO5	S	S	S	M	M	S	M	L	S	M

*S - Strong; M - Medium; L-Low

Elective Course IV B: Wildlife Biology

Course Objectives:		
The main objectives of this course are:		
1.	To make the students equipped with the knowledge of wildlife resources of India	
2.	To strengthen the students to learn the principles and applications of various wildlife management techniques	
Course	:	Elective IV
Course title	:	Wildlife Biology
Credits	:	3
Pre-requisite		
To ignite research in student minds based on current findings, skills and knowledge in Wild Life Biology		
Expected Course Outcome:		
Upon completion of this course, Students would have		
1.	Impart knowledge on different forest types in India, their characteristics, and the biodiversity they support.	K2
2.	Comprehensive understanding of different wildlife census methods, including direct and indirect sampling techniques.	K2
3.	Skills in designing and implementing management plans for wildlife populations and habitats.	K3
4.	Inculcate and educate to bring out their ideas for creating new methodologies for population assessment and mitigating the human-wildlife conflict.	K4
5.	Knowledge of conservation principles, strategies for habitat preservation, and techniques for managing endangered species.	K4

K1-Remember; K2-Understand; K3-Apply; K4-Analyze; K5-Evaluate; K6–Create

Units	
I	Wildlife and Forestry of India - Definition of Wildlife: Economic importance of wildlife; need for wildlife conservation, Causes of wildlife depletion; Rare, endangered, threatened and endemic species in India- India as a mega wildlife diversity country. Types of Forests in India - Deforestation & Impacts; Natural and artificial regeneration of forests.
II	Wildlife Census Methods - Basic concepts and applications - census – total counts - sample counts – Direct count (block count, transect methods, point counts, visual encounter survey, waterhole survey); Indirect count (Call count, track and signs, pellet count, pugmark, camera trap, DNA finger printing and aerial photography) - Identifying animals based on indirect signs.
III	Wildlife Management Techniques -Habitat manipulation: food, water, shade improvement; impact and removal of invasive alien species. Planning wildlife management Investigations and projects; Wildlife Photography: Field Equipment: binoculars, altimeter, pedometer, field compass; radio collaring; GPS; GIS; Remote sensing; Satellite images, Drones and their applications in wildlife management.

IV	Human Wildlife Conflicts - Basic concepts, reason for conflicts, Identification of damages caused by wild animals and control measures; Chemical restraints: Advantage & Disadvantage – Basic considerations– Chemical restraints of Elephant, rhino, Gaur, Sambar, Panthera, small herbivores – post capture medical care & treatment; Translocation of Wild animals – Principles, Methods and application.
V	Wildlife Conservation - Conservation Genetics: Scope and Genetic approaches to wildlife conservation; Evolutionary genetics of natural populations- Loss of genetic diversity in small populations – Resolving taxonomic uncertainties - Genetic management of threatened species; Molecular phylogenetics of wildlife; Wildlife Crimes detection and prevention. Eco-Development, Eco- Restoration and Ecotourism programmes; Anti-poaching operations –Village Forest Council (VFC).

Reading List

1. J. M. Fryxell, R.E. Anthony Sinclair, and G. Caughley, 2014, Wildlife Ecology, Conservation, and Management, Wiley-Blackwell Publication, U.S.A.
2. A. P. Dwivedi, 2008, Wildlife Ecology and Conservation, Biotech Books.
3. R. F. Dasmann, 1964. Wildlife Biology, John Wiley & Sons in New York.
4. R. Gopal, 1992, Fundamentals of Wildlife Management, Natraj Publishers.

Recommended texts

1. B.B. Hosetti, 2002. Glimpses of Biodiversity, Daya Publishing House, Delhi-35, India
2. W.L. Robinson and E.G Bolen, 2002. Wildlife Ecology and Management, Maxmillan Publishing Company, New York.
3. S.K. Singh, 2009. Text book of Wildlife Management, 2nd edition, International book distributing Co., Lucknow.
4. S.S. Negi, 2002. Hand book of National Parks, Wildlife Sanctuaries and Biosphere reserves in India. Indus Publ., New Delhi.
5. W.A. Rodgers, 1991. Techniques for Wildlife Census in India - A Field Manual: 5. Technical Manual-T M-2. WII

Mapping with Programme Outcomes*

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	M	S	S	M	S	M
CO2	M	M	M	M	M	M	M	S	M	S
CO3	M	M	S	M	S	S	M	M	M	S
CO4	S	M	S	M	S	M	S	M	M	S
CO5	M	S	S	M	M	S	M	S	S	M

*S-Strong; M-Medium; L-Low

Skill Enhancement Courses (SEC) I: Poultry Farming

Course Objectives:		
The main objectives of this course are:		
1.	Students should know basic concepts in Poultry Farming.	
Course I	:	Skill Enhancement Course [SEC] – I
Course title	:	Poultry Farming
Credits	:	2
Pre-requisite:		
Students should be aware of economic and cultural importance of Poultry farming.		
Expected Course Outcome:		
Upon completion of this course, Students would have		
I	To understand the various practices in Poultry farming. To know the needs for Poultry farming and the status of India in global market.	K2 & K3
II	To be able to apply the techniques and practices needed or Poultry farming.	K1, K2 & K3
III	To know the difficulties in Poultry farming and be able to propose plans against it.	K5 & K6

K1- Remember; K2- Understand; K3- Apply; K4-Analyze; K5-Evaluate; K6- Create

Units	
I	General introduction to poultry farming - Definition of Poultry - Past and present scenario of poultry industry in India - Principles of poultry housing - Poultry houses - Systems of poultry farming
II	Management of chicks - growers and layers - Management of Broilers. - Preparation of project report for banking and insurance.
III	Poultry feed management-Principles of feeding, Nutrient requirements for different stages of layers and broilers - Feed formulation and Methods of feeding.
IV	Poultry diseases-viral, bacterial, fungal and parasitic (two each); symptoms, control and management; Vaccination programme.
V	Selection, care and handling of hatching eggs - Egg testing. Methods of hatching. Brooding and rearing -. Sexing of chicks. - Farm and Water Hygiene - Recycling of poultry waste.
Reading list	
<ol style="list-style-type: none"> 1. Sreenivasaiah., P. V., 2015. Textbook of Poultry Science. 1st Edition. Write & Print Publications, New Delhi 2. 2. Jull A. Morley, 2007. Successful Poultry Management. 2nd Edition. Biotech Books, New Delhi" 3. Hurd M. Louis, 2003. Modern Poultry Farming. 1st Edition. International Book Distributing Company, Lucknow." 4. Life and General Insurance Management" 	
Recommended texts	
<ol style="list-style-type: none"> 1. http://www.asci-india.com/BooksPDF/Small%20Poultry%20Farmer.pdf 2. https://nsdcindia.org/sites/default/files/MC_AGR-Q4306_Small-poultry-farmer-.pdf 3. http://ecoursesonline.iasri.res.in/course/view.php?id=335 4. https://swayam.gov.in/nd2_nou19_ag09/preview 	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	L	L	L	L	S	S	L	L
CO2	S	L	M	M	S	M	M	M	S	S
CO3	S	M	M	M	S	S	S	S	M	M
CO4	S	S	S	L	S	S	S	S	S	S
CO5	S	S	M	S	S	S	M	L	S	M

*S - Strong; M - Medium; L – Low

MSU

Skill Enhancement Courses (SEC) I: Apiculture

Course Objectives:		
The main objectives of this course are:		
1.	Students should know basic concepts in Apiculture.	
Course I	:	Skill Enhancement Course (SEC) I
Course title	:	Apiculture
Credits	:	2
Pre-requisite:		
Students should be aware of importance of honey bees and their impacts on the ecosystem.		
Expected Course Outcome:		
Upon completion of this course, Students would have		
I	Clear understanding of morphology, life cycle, characteristics of honey bees and bee keeping.	K1, K2 & K3
II	Acquired skills to perform bee keeping from managing colonies of bees in order to harvest honey and other Bee related by-products in different setups and as an Entrepreneurial venture.	K3, K4 & K5
III	Knowledge on the harvesting, preserving and processing of bee products and identification of the appropriate markets to sell the produce.	K5 & K6

K1- Remember; **K2-** Understand; **K3-** Apply; **K4-**Analyze; **K5-**Evaluate; **K6-** Create

Units	
I	Introduction to Apiculture. History, classification, types, life Cycle of different species of Honey Bees and their behavioural patterns. Social organization of bee colony
II	Bee-keeping system, tools and equipment's needed for bee keeping. Types of bee hives, structure and functional features. Criteria for site selection for apiculture and factors affecting them.
III	Identification and characteristics and Preventive measures to be taken against of different bee enemies. Diseases affecting honey bees and their control measures. Colony collapse disorder and its management.
IV	Bee products, uses and importance- Honey, Royal jelly, Propolis, Pollen and Bee venom. Harvesting, Processing, Packaging and Marketing of bee products.
V	Apiculture industry around the world and Role of Central Bee Research & Training institute in India. Apiculture as an Entrepreneurial venture.

Reading list

1. Singh, D., Singh, D. Pratap. 2006. A Handbook of Beekeeping. AGROBIOS (INDIA)
2. Sharma P.L. and Singh, S.H. Book of Bee keeping.
3. Cherian and Ramanathan, S. Bee keeping in south India.
4. Prospective in Indian Apiculture - R.C. Mishra.

Recommended texts

1. Caron, D.W. 2013 (revised from 1999). Honey Bee Biology and Beekeeping. Wicwas Press. Cheshire, CT, 368 pp.
2. Kaspar, R., C. Cook, and M. D. Breed. 2018. Animal Behaviour 142: 69-76.
3. Hendriksma, H. P., A. L. Toth, and S. Shafir. 2019. Individual and Colony Level Foraging decisions of Bumble Bees and Honey Bees in Relation to Balancing of Nutrient Needs. Frontiers in Ecology and Evolution 7: 177.
4. Steinhauer, N. et al. 2018. Drivers of Colony Loss. Current Opinion in Insect Science 26: 142-148.

5. Technology and value addition of Honey - Dr. D. M. Wakhle and K. D. Kamble.

6. ABC & XYZ of Bee culture - A. I. Root.

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	S	L	S	S	L	M
CO2	S	S	S	S	S	S	L	L	S	S
CO3	S	L	M	M	S	M	M	L	L	L
CO4	M	S	L	S	L	M	L	M	M	M
CO5	S	L	L	S	L	M	L	L	M	L

*S - Strong; M - Medium; L-Low



MMSU

Second Year – Semester – III

Part	List of Courses	Credits	No. of Hours/ week	Total hours/ semester	Internal marks	External marks	Total marks
Core – VII	Genetics and Evolution	5	6	90	25	75	100
Core – VIII:	Animal Physiology	5	6	90	25	75	100
Core – IX	Lab in Genetics & Evolution and Animal Physiology	5	6	90	50	50	100
Core– X	(Industry Module): Medical Lab Technology	4	4	60	25	75	100
Elective – V	A) Stem Cell Biology	3	4	60	25	75	100
	B) Applied Microbiology						
Skill Enhancement Course – II	A) Dairy Farming	2	4	60	25	75	100
	B) Bioethics and Bio Safety						
Internship	* Internship / Industrial Activity /Field visit/ Research – knowledge updating activity [Credits]	2	-	-	50	50	100
Total		26	30	450			

Second Year – Semester – IV

Part	List of Courses	Credits	No. of Hours	Total hours	Internal marks	External marks	Total marks
Core – XI	Immunology	5	6	90	25	75	100
Core – XII	Ecology	5	6	90	25	75	100
Core – XIII	Lab course in Immunology & Ecology	3	4	60	50	50	100
Elective course VI	A) Aquaculture	3	4	60	25	75	100
	B) Applied Biotechnology & Nanotechnology						
Skill Enhancement Course – III	A) Animal Behaviour	2	4	60	25	75	100
	B) Forensic Science						
	#Extension Activity	1	-	-	50	50	100
	*Project	4	6	90	50	50	100
		23	30	450			

METHODS OF EVALUATION for THEORY		
Internal Evaluation	Continuous Internal Assessment Test	25 Marks
	Assignments	
	Snap Test	
	Quiz Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

METHODS OF EVALUATION for Internship/Industrial/Field visit		
Internal Evaluation	Attendance	50 Marks
	Report	
	Activity	
External Evaluation	End Semester Evaluation	50Marks
	Total	100 Marks

Note: -

- ***Internship/ Industrial visit/ Field visit/ Research Knowledge updating activity (Internal: 50 Marks, External: 50 Marks).**

***A report should be submitted at the end of III – semester and evaluated by the external examiners (External – 50 Marks).**

***Internship students should submit certificate of attendance from the authorities concerned along with report (External – 50 Marks)**

***Internship programme should be executed for a minimum tenure of 10 days in a non-parental institute / recognized scientific laboratory/ Governmental/ Non-Governmental organization under the supervision of the head of the concerned Insti**

Core VII - Genetics and Evolution

Course Objectives:		
The main objectives of this course are:		
1.	To understand the principles of inheritance, genetic disorders and gene frequency.	
2.	To acquire knowledge in evolutionary mechanisms and origin of higher categories.	
Course I	:	Core VII
Course title	:	Genetics and Evolution
Credits	:	5
Pre-requisite:		
Basic knowledge on molecular biology and Genetics and Evolution		
Expected Course Outcome:		
On the successful completion of the course, student will be able to		
1.	Explain the different principles of inheritance	K1 & K2
2..	Explicate the structures and functions of chromosomes and identify the diseases caused by the chromosomal abnormalities.	K2
3.	Apply the concepts and rate of change in gene frequency through natural selection, migration and random genetic drift	K2 & K3
4.	Comprehend the concepts of variation and adaptation	K4
5.	Evaluate the process of evolution of higher taxa	K5
K1- Remember; K2- Understand; K3- Apply; K4-Analyze; K5-Evaluate; K6- Create		
Units		
I	Mendelian Principles -Monohybrid cross and law of segregation, modification of 3:1 phenotypic ratio - Codominance, incomplete dominance. Lethality and interaction of genes – Lethality, interactions involving 2 gene pairs, epistatic interactions, interaction involving more than 2 gene pairs, pleiotropy, complementary, supplementary, penetrance and expressivity. Linkage and crossing over-types – mechanism - theories, Genetic and Cytologic Mapping of Chromosomes, Linkage Maps, mapping with molecular markers and mapping using somatic cell hybrids. Polygenic inheritance, heritability and its measurements.	
II	Human Genetics: The Chromosomes: Structure, composition and organization, special type of chromosomes, B Chromosomes, karyotypes, Barr bodies. Chromosomal aberrations- Numerical aberrations - Euploidy & Aneuploidy. Structural aberrations, Inversion, Translocation, Deletion, Duplication. Chromosomal Anomalies: Down syndrome, Turner syndrome, Edward Syndrome, Klinefelter Syndrome. Pedigree analysis. Human genome project, Prenatal diagnostics – Amniocentesis, Chorionic Villus sampling. Genetic Counselling- Concepts of Eugenics & Euthenics. Sex linked, sex limited and sex influenced characters.	
III	Theories of organic Evolution - Lamarckism and Darwinism – Mutation Theory, Modern Synthesis. Sources of variation in a population – Population, Gene Pool and Gene Frequency, Variations – sources of variations – Mutations, Transposons, Recombinations, Natural Selection and other Evolutionary forces. Natural Selection, Hardy-Weinberg equilibrium, kinds of natural selection – Stabilizing, Diversifying, Directional Selection,	

	Migration, random Genetic Drift.
IV	Molecular evolution: origin of life, principles of molecular evolution studies Molecular divergence - Molecular tools in phylogeny, molecular clock. Phylogenetic trees, Multiple sequence alignment, construction of phylogenetic trees, classification identification and interpretation of trees. Phylogenetic and biological concept of species. – Speciation- Adaptive radiation - Isolating mechanisms - Allopatricity and Sympatricity - Convergent evolution - Sexual selection - Altruism and evolution.
V	Origin of Higher Categories Micro evolution, macro evolution, mega evolution and co evolution. Evolution rates, phyletic gradualism and punctuated equilibrium. Geological time scale; Evolution of man- Origin and evolution of man, Unique hominine characteristics contrasted with primate characteristics, primate phylogeny from Dryopithecus leading to Homo sapiens, molecular analysis of human origin.

Reading Lists

1. Gardner, E. J., M. J. Simmons and D.P. Snustad. 2006. Principles of Genetics. 8th Edition, John Wiley & Sons. INC. New York, pp-740.
2. Brooker, R. J. 2014. Genetics: Analysis and Principles. 5th Edition, McGraw Hill Publisher, pp-880.
3. Russell, P.J. 2005. Genetics: A Molecular Approach (2nd Edition). Pearson/Benjamin Cummings, San Francisco, pp-850.
4. https://onlinecourses.swayam2.ac.in/cec21_bt02/preview
5. <https://www.khanacademy.org/science/high-school-biology/hs-molecular-genetics/hs-rna-and-protein-synthesis/a/the-genetic-code>
6. Bergstrom, C. T. and L. A. Dugatkin. 2012. Evolution, Second MEDIA Edition. W.W. Norton & Company, International Student Edition, pp-756.
7. Jobling, M., E. Hollox, M. Hurles, T. Kivisild and C. T. Tyler Smith. 2014. Human Evolutionary Genetics. Second Edition. Garland Sciences, London, pp-650
8. Veer Bala Rostogi, 2018. Organic Evolution (Evolutionary Biology), Thirteenth Edition Vinoth Kumar Jain, Scientific International (Pvt.) Ltd, New Delhi, pp-590.
9. <https://www.flipkart.com/books/evolution~contributor/pr?sid=bks>
10. <http://www.evolution-textbook.org/>
11. <https://onlinelibrary.wiley.com/journal/15585646>
12. <http://darwin-online.org.uk/>

Recommended texts

1. Griffiths, A. J. F., H. J. Muller, D. T. Suzuki, R. C. Lewontin and W. M. Gelbart. 2012. An Introduction to Genetic Analysis. 11th Edition, W. H. Greeman. New York.
2. Snustad, D.P., Simmons, M.J. 2015. Principles of Genetics, John Wiley Publications, pp-784.
3. Klug, W. S. and M. R. Cummings, C. A. Spencer. 2005. Concepts of Genetics, Benjamin - Cummings Publishing Company.
4. Harti, D. L. 2002. Essential Genetics, A Genomic Perspective, Jones & Bartlet.
5. Krebs, J. E., E.S. Goldstein, S.T. Kilpatrick. 2018. Lewin's Genes XII, Jones & Bartlet Publisher, pp-613.
6. Verma, P.S., Agarwal, V.K. 2010. Genetics (9th ed.), S.Chand Publishing, New Delhi.
7. Watson, J. D., T. A. Baker S. P. Bell, A. Cann, M. Levine and R. Losick, 2014. Molecular Biology of Gene 7th Edition, Pearson Education RH Ltd. India.
8. Strickberger. M. W. 2000. Evolution. Third Edition, Jones Bartlett Publishers, pp-722.

9. Hall B. K. and B. Hallgrimsson. 2014. Strickberger's Evolution. Fifth Edition, Bartlett Learning, An Ascend Learning Company, pp-642.
10. Sanjib Chattopadhyay. 2008. Evolution, Adaption and Ethology. Books and Allied Pvt. Ltd., Kolkata.

Reading list

1. Gardner, E. J., M. J. Simmons and D.P. Snustad. 2006. Principles of Genetics. 8th Edition, John Wiley & Sons. INC. New York, pp-740.
2. Brooker, R. J. 2014. Genetics: Analysis and Principles. 5th Edition, McGraw Hill Publsiher, pp-880.
3. Russell, P.J. 2005. Genetics: A Molecular Approach (2nd Edition). Pearson/Benjamin Cummings, San Francisco, pp-850.
4. https://onlinecourses.swayam2.ac.in/cec21_bt02/preview
5. <https://www.khanacademy.org/science/high-school-biology/hs-molecular-genetics/hs-rna-and-protein-synthesis/a/the-genetic-code>
6. Bergstrom, C. T. and L. A. Dugatkin. 2012. Evolution, Second MEDIA Edition. W.W. Norton & Company, International Student Edition, pp-756.
7. Jobling, M., E. Hollox, M. Hurles, T. Kivisild and C. T. Tyler Smith. 2014. Human Evolutionary Genetics. Second Edition. Garland Sciences, London, pp-650.

Mapping with Programme Outcomes*

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	M	M	S	L	S
CO2	S	S	S	M	M	S	M	M	S	S
CO3	M	S	L	S	S	S	S	M	M	S
CO4	S	M	M	S	M	M	S	M	S	M
CO5	L	M	M	L	S	S	S	M	M	S

*S - Strong; M - Medium; L - Low

Core VIII - Animal Physiology

Course Objectives:		
The main objectives of this course are:		
1.	Students acquire the basic knowledge on physiology of different organs in animals and human.	
2.	Understand the functions of different systems such as digestion, excretion, blood circulatory system, respiration and nervous system of animal relating them to structure and functions of various organs.	
Course I	:	Core VIII
Course title	:	Animal Physiology
Credits	:	5
Pre-requisite:		
Students should know the fundamentals of structure and functions of organs and organ systems of animals.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to		
1.	Understand the functions of different systems of animals	K1
2.	Learn the anatomy of heart structure and functions, blood composition, regulation	K2
3.	Know the transport and exchange of gases, neural and chemical regulation of respiration and function of excretory System	K2 & K4
4.	Acquire knowledge on the organization and structure of central and peripheral nervous systems	K3 & K5
5.	Evaluate the role and mechanism of hormones	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Units	
I	Digestive system: - Human Digestive Tract & Functions – Digestion – Role of Enzymes in Digestion of Carbohydrates, Protein, Lipids, Absorption – Gastrointestinal Hormone, Intestinal villi. Balanced Diet, Mal Nutrition and BMR. Digestion, absorption, energy balance, BMR.
II	Blood and circulation: Blood corpuscles, hemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, coagglutination, haemostasis. Cardiovascular system: Anatomy of human heart, myogenic heart, Arteries and Veins, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of heart.
III	Respiratory system: Structure & Function of human lung and the respiratory tract. Respiratory Pigments, transport of gases, exchange of gases, neural and chemical regulation of respiration. Excretory system: Structure of the kidney – Nephron Renal Circulation - Urine formation, Renal disorders – Micturition and Dialysis. Regulation of water and electrolytes Balance, Acid Base Balance.

IV	Nervous system: Neurons, action potential, gross neuro-anatomy of the brain and spinal cord, central and peripheral nervous system, Muscles – classification, Ultra Structure of skeletal muscles. Mechanism of Muscular contraction. Neural control of muscle tone and function. Sense organs: Vision, hearing and tactile response.
V	Endocrinology and reproduction: Structure & Function of Endocrine glands, Basic mechanism of hormone action, Hormones & diseases, Neuro Endocrine regulation of reproduction. Thermoregulation: Comfort zone, body temperature- physical, chemical, neural regulation, acclimatization: Stress and adaptation.

Reading list

1. Prosser C. L. 1991, Comparative Animal Physiology. Part A: Environmental and Metabolic Animal Physiology. Wiley-Liss Publishers, pp-592
2. Hoar, S.W. 1983, General and Comparative Physiology, Prentice Hall Publication, pp-928.
3. Randall, D., W. Burggren, K. Frenchand R. Eckert. 2001, Animal Physiology Mechanisms and Adaptations, New York: W.H. Freeman and Co., pp-
4. Nelson K. S. 1997. Animal Physiology: Adaptation and Environment, Cambridge University Press, pp- 617.
5. https://swayam.gov.in/nd1_noc20_bt42/preview
6. <https://www.classcentral.com/course/swayam-animal-physiology-12894>
7. https://swayam.gov.in/nd1_noc20_hs33/preview
8. General and Comparative Physiology – William S. Hoar.

Recommended texts

1. Shepherd, G. M. 1994. Neurobiology, OUP USA Publisher, pp-774.
2. Hainsworth, F.R. 1981. Animal Physiology: Adaptation in function, Addison Wesley Longman Publishers, pp-669.
3. Gorden, M.S. *et al.*, 1977. Animal Physiology: Principles and Adaptation, New York, Third Edition.
4. Ahearn, G.A. *et al.*, 1988. Advances in Comparative and Environmental Physiology – 2, Springer Publishers, pp-252.
5. Hill, R.W. 1976. Comparative Physiology of Animals: Environmental Approach, Longman Higher Education Publisher, pp-656.
6. Textbook of Animal Physiology – R.Nagabhushanam, M.S Kodarkar and R.Sarojini.
7. Gayton, A.C. and Hall, J.E., A Textbook of Medical Physiology, 9th Edn., Harcourt Brace and Company Asia Pvt. Ltd., W.B. Saunders Company.

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	L	S	M	S	S
CO2	S	S	M	S	S	S	S	M	S	S
CO3	S	M	S	S	S	M	L	S	M	S
CO4	S	S	S	S	S	L	M	S	S	M
CO5	S	S	S	M	M	M	M	L	L	M

*S - Strong; M - Medium; L - Low

Core course IX - Lab course in Genetics, Evolution and Animal Physiology

Course Objectives:		
The main objectives of this course are:		
1.	To acquire practical knowledge in the principles of Genetics and Evolution and analyse the physiological processes to translate the theoretical understanding	
Course I	:	CORE COURSE IX - Lab course
Course title	:	Genetics, Evolution and Animal Physiology
Credits	:	5
Pre-requisite:		
Students should have a basic knowledge relevant to genetics, evolution and physiology.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to		
1.	Acquire knowledge in proving the laws in genetics	
2.	Understand the genetic traits in man	
3.	Apply the practical methods to verify Hardy Weinberg law.	
4.	Study the evolutionary significance of fossils.	
5.	Learn the process of salivary amylase activity in relation to temperature	

GENETICS

1. Probability and Chi – square testing for Mendel's Laws using color beads
 - a) Law of segregation
 - b) Law of independent assortment
2. Demonstration of random genetic drift using beads
3. Observation of various genetic traits in human
4. Culture of Drosophila – Demonstration
5. Preparation of buccal smear to show Barr bodies in squamous epithelial cells.

Charts/Slides/Models

1. Down's syndrome, Klinefelter's syndrome
2. Turner's syndrome, Edward syndrome
3. Drosophila mutants – White eye and vestigial wings
4. Human Pedigree Chart
5. Lac operon
6. Sex-linked inheritance: X – Linked inheritance, Y- linked inheritance
7. Lytic and lysogenic cycles
8. Blood groups and Rh factor.

EVOLUTION

1. Study of natural selection in Mendelian population using beads. Calculate Gene frequency and genotype frequency
2. Study on Evolutionary significances of any five fossils.
3. Study of analogy (wings of animals) and homology (Forelimbs and hindlimbs of vertebrates).
4. Estimation of gene and genotype frequencies in the light of Hardy-Weinberg Law based on facial traits.
5. Adaptive radiation – beaks of various birds
6. Prove Hardy Weinberg law using Single and Double-coin tossing method.

Charts / Models / Slides

- Geographical isolation
- Phylogram, Mimicry and colouration of animals
- Connecting Links – Archaeopteryx, Limulus, Peripatus

ANIMAL PHYSIOLOGY

1. Detection of haemin crystals in blood
2. Rate of salt loss and salt gain in fish
3. Effect of temperature on opercular activity of fish
4. Qualitative analysis of excretory product in ammonotelic, ureotelic, and uricotelic animals.
5. Determination of the salivary amylase activity in relation to temperature.
6. Preparation of human blood smear
7. Separation of uric acid crystals from excreta of reptiles / birds.

Charts/Slides/Models/Instrument

1. EEG, ECG, Cardiac muscle, Kymograph, Sphygmomanometer, Pituitary, thyroid, testis and ovary, adrenal, kidney, microvilli

2. Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	S	M	S	S	S	M	S	S	S
CO2	S	S	M	M	L	S	S	M	L	S
CO3	L	M	S	M	S	L	M	L	S	S
CO4	S	M	S	M	L	S	M	M	S	M
CO5	S	M	S	M	S	S	S	L	L	M

*S - Strong; M - Medium; L-Low

Core - X Industry module: Medical Laboratory Techniques

Course Objectives:		
The main objectives of this course are:		
1.	Students should understand the different protocols and procedures to collect clinical samples and to learn lab technologies.	
Course I	:	Core Industry Module
Course title	:	Medical Laboratory Techniques
Credits	:	4
Pre-requisite:		
Basic knowledge about medical laboratories and the works carried out by them.		
Expected Course Outcome:		
Upon completion of this course, Students would have		
I	Understand protocols and procedures to collect clinical samples for blood analysis and to study human physiology.	K2 & K3
II	Explain the characteristics of composition of blood and their function.	K3, K4 & K5
III	Evaluate the usage of the various instruments in clinical diagnosis.	K3, K4, K5 & K6
IV	Analyze the Procedures involved in Diagnostic Techniques	K3, K4 & K5
V	Evaluate the histological parameters of biological samples.	K3, K4, K5 & K6

K1- Remember; **K2-** Understand; **K3-** Apply; **K4-**Analyze; **K5-**Evaluate; **K6-** Create

Units	
I	Scope of medical laboratory technology. Laboratory principles-organisation of clinical Role of medical laboratory technician. Laboratory safety - toxic chemicals and biohazards waste- biosafety level- good laboratory practice -safety measures-cleaning and sterilisation methods, hospital and clinic borne infection and personnel hygiene and health issue.
II	Composition of blood and their function- haemopoiesis- types of anaemia- mechanism of blood coagulation- bleeding time- clotting time- determination of hemoglobin-erythrocyte sedimentations rate- packed cell volume- Total count of RBC & WBC- Differential count WBC- blood grouping and typing- haemostasis- bleeding disorder of man - Haemolytic disease of newborn, Platelet count, reticulocytes count, Absolute Eosinophil count. Blood banking technology, collection and storage.
III	Definition and scope of microbiology- parasites - Entamoeba- Plasmodium- Leishmania and Trypanosome.Computer tomography (CT scan) - Magnetic Resonance imaging - flowcytometry - treadmill test - PET. physiology effect of alcohol, tobacco, smoking & junk food & its treatment - biomedical waste management.
IV	Cardiovascular system- Blood pressure - Pulse - regulation of heart rate, cardiac shock. Heart sounds, Electrocardiogram (ECG) - significance - ultra sonography- Electroencephalography (EEG). Techniques of sample processing; Throat swab, sputum, blood, urine, stool, pus, CSF, other body fluids.

V	Handling and labelling of histology specimens - Tissue processing - processing of histological tissues for paraffin embedding, block preparation. Microtomes – types of microtome- sectioning, staining - staining methods - vital staining - mounting- problems encountered during section cutting and remedies - Frozen section techniques- freezing microtome.
Reading list	
<ol style="list-style-type: none"> 1. Godker, P. B. and Darshan, P, Godker, 2011. Text book of medical Laboratory Technology, Mumbai. 2. Guyton and Hall, 2000. Text Book of medical Physiology, 10th edition, Elseiner, New Delhi. 3. Mukerjee, K.L, 1999. Medical Laboratory Technology- Vol,I,II,III. Tata MC GrawHill, New Delhi. 4. Sood, R, 2009. Medical Laboratory technology, Methods and interpretation. 	
Recommended texts	
<ol style="list-style-type: none"> 1. Manoharan,A, and Sethuraman, 2003. Essential of Clinical Heamatology, Jeypee brothers, New Delhi. 2. Richard, A, McPherson, Mathew, R, Pincus, 2007. Clinical and management by laboratory methods, Elsevier, Philadelphia.Published by Tata McGraw-Hill Education Pvt. Ltd., 3. Ochei. J., A. Kolhatkar (2000). Medical Laboratory science: Theory and practice, Published by Tata McGraw-Hill Education Pvt. Ltd, First edition. 	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	L	L	M	M	L	M
CO2	S	S	M	S	S	S	L	M	S	S
CO3	M	S	S	S	S	S	S	S	S	L
CO4	S	S	M	M	L	M	L	M	M	S
CO5	M	M	S	S	M	S	L	L	S	S

*S - Strong; M - Medium; L-Low

Elective V - Stem Cell Biology

Course Objectives:		
The main objectives of this course are:		
1.	Students should know understand the basics of stem cells	
Course I	:	Elective V
Course title	:	Stem Cell Biology
Credits	:	3
Pre-requisite:		
To understand the basics of stem cells, their importance and its applications.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to		
I	Understand the basic knowledge of stem cells and their origin	K1 & K2
II	Outline the embryonic stem cells and their its Characterization and properties	K3 & K4
III	Explain the adult stem cells, their properties and characteristics	K3 & K4
IV	Understand the current stem cell therapies	K2, K3
V	Apply the current stem cell therapies for their research	K3, K4 & K5

K1- Remember; **K2-** Understand; **K3-** Apply; **K4-**Analyze; **K5-**Evaluate; **K6-** Create

Units	
I	Introduction to stem cell biology: Stem cell definition, origin and hierarchy, stem cell properties, Identification and Characterization, potency and differentiation, niche of stem cell, overview of different stem cell types (embryonic stem cells, adult stem cells and induced pluripotent stem cells).
II	Embryonic stem (ES) cell: Characterization and properties of ES cells, pluripotency and self-renewal of ES cells; molecular mechanisms regulating pluripotency and maintenance of the stem state, progressive differentiation of ES cells into ectoderm lineage organs (skin, brain and nerve), mesoderm lineage organs (heart, kidney, muscle, bone and blood), and endoderm lineage organs (lung, liver, stomach, pancreas and intestine).
III	Adult stem cells: Mesenchymal stem cells (MSCs) - sources, properties (plasticity, homing and engraftment), potency and characterization; Haematopoietic stem cells (HSCs) - sources, properties, potency and characterization; steps involved in production of induced pluripotent stem cells (iPSCs); role of Yamanaka factor in iPSCs.

IV	Stem cell and aging: aging theory; cell cycle; telomere and telomerase; senescence of stem cell; role of stem cell in aging; tissue repair and regeneration of adult stem cell.
V	Current stem cell therapies: Advantages and disadvantages of ES cells and adult stem cells (MSCs and HSCs) therapy; Ethical concern on stem cell therapy; current stem cell therapy for various diseases; clinical outcome of stem cell therapy; state of clinical trials in adult stem cells for various diseases.

Reading list	
<ol style="list-style-type: none"> 1. Kiessling, A.A. 2006. Human Embryonic Stem Cells (Second Ed.), Jones & Barlett Publishers. 2. Lanza, R. and A. Atala. 2005. Essentials of Stem Cell Biology. Academic Press, pp-712. 3. Turksen, K. 2004. Adult Stem Cells. Humana Press, Inc, pp-429. 4. Lanza, R. <i>et al.</i> 2004. Handbook of Stem Cells: Embryonic/Adult and Fetal Stem Cells (Vol. 1 & 2). Academic Press, pp-1626. 5. Institute of Medicine, 2002. Stem cells and the future of regenerative medicine. National Academy Press, pp-112. 6. Marshak, D., R.L. Gardener and D. Gottlieb. 2001. Stem Cell Biology, Cold Spring Harbour Monograph Series, 40, pp-550. 7. Booth, C. 2003. Stem Cell Biology and Gene Therapy, Cell Biology International, Academic Press. 	
Recommended texts	
<ol style="list-style-type: none"> 1. Quesenberry, P.J., G.S. Stein, B. Forget and S. Weissman. 2001. Stem Cell Biology and Gene Therapy, Wiley Publishers, pp-584. 2. Sell, S. and Totowa, N.J. 2004. Stem Cells Handbook, Humana Press, pp-534. 3. Sullivan, S., C. A. Cowan and K. Eggen. 2007. Human Embryonic Stem Cells: The Practical Handbook, Wiley Publishers, pp-424. 4. Battler, A., and Leo, J. 2007. Stem Cell and Gene-Based Therapy: Frontiers in Regenerative Medicine, Springer Publication, pp-422. 	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	S	M	S	M	M
CO2	S	S	M	S	S	S	S	S	S	L
CO3	S	M	S	S	S	S	M	L	S	M
CO4	S	S	S	S	S	M	M	S	L	M
CO5	S	S	S	M	M	S	S	S	S	S

*S - Strong; M - Medium; L-Low

Elective Course: Applied Microbiology

Course Objectives:		
The main objectives of this course are:		
1.	Enable the students to understand the classification and physiology of microbes	
2.	Provide advanced knowledge, understanding and application of various fields of Microbiology	
Course	:	Elective
Course title	:	Applied Microbiology
Credits	:	3
Pre-requisite		
Basic Knowledge on Microbial physiology and its applications		
Expected Course Outcome:		
Upon completion of this course, Students would have		
CO1	Relate the basic understanding on taxonomical classification of microbes	K1 & K2
CO2	Pursuing high skills and knowledge on bacterial isolation, Sterilization and Preservation	K3
CO3	Analyse the nutritional requirements, common microbial flora in Food	K4
CO4	Evaluate microbiological role in the manufacture of industrial products; solve environmental problems.	K5
CO5	Impart the knowledge of clinically important human diseases with respect to their causative agent.	K3
K1- Remember; K2- Understand; K3- Apply; K4-Analyze; K5-Evaluate; K6- Create		

	Units
I	History and scope of Microbiology - Theory of spontaneous generation – Germ theory of diseases - Koch’s postulates - Microbial interactions - Whittaker’s five kingdom approach – Carl Woese’s three domains concept - Microbes and their types, Viruses, Bacteria, fungi and protozoans – Morphology and classification. Abnormal forms of bacteria, archaebacteria, Mycoplasma and PPLO, Recent trends in microbial taxonomy.
II	Microbial Physiology: Nutritional Requirements and nutritional types of Microbes- - Nutrient transport mechanisms- Passive diffusion, Facilitated diffusion, Active transport, Group translocation and Specific transport system; Types of culture media- Selective, enrichment and differential media. Microbiological techniques: Microbiological Media- Types and composition of media -Sterilization techniques - Methods of pure culture technique- Staining methods – Simple, Differential and Special staining.

III	Food Microbiology Normal microbial flora of common food – food infection – food poisoning – food preservation – microbiology of milk and milk products – Bakery products – Detection of food borne pathogens – food sanitation – food control agencies – food spoilage – ISI and BIS regulations for packaged drinking water.
IV	Industrial Applications of Microbial Enzymes – Bioreactors and Types –Biopolymers – Biosurfactants – Biofertilizers, Bioleaching of metals - Biodegradation using microbial communities -Xenobiotics and Heavy metals degradation in water and soil – Sewage sludge treatment and utilization; Bioconversion of cellulosic wastes into protein and fuel.
V	Microbial diseases - Causative agents, Mode of transmission, Symptoms, Prevention & Control - Protozoan diseases: Plasmodium, Entamoeba. Fungal diseases: Mycosis - Mycotoxicosis. Bacterial diseases: Tuberculosis (TB) –Typhoid - Viral diseases: Chicken pox, Hepatitis B, AIDS, Corona and Dengue.

Reading list

1. Dubey RC and Maheswari DK (2012). A Text of Microbiology (Revised edition). S. Chand and Company Ltd., New Delhi.
2. PelczarTR M J Chan ECS and Kreig N R (2006). Microbiology. Fifth edition, Tata McGraw-Hill INC. New York.
3. GeetaSumbali and Mehrotra RS (2009). Principles of Microbiology. First edition, Tata McGraw Hill P. Ltd., New Delhi.

Recommended texts

1. Prescott L M, J P Harley and DA Klein (2005). Microbiology. Sixth edition, international edition, McGraw Hill.
2. Stanier R, Ingraham J, Wheelis M and Painter P (2014) General Microbiology. 5th Edition, Macmillan Press.
3. Kathleen Park Talaro and Barry Chess Foundations in Microbiology10th Edition. 2018. Mc Graw Hill Education Publishers, USA.
4. Gerard J. Tortora, Berdell R. Funke, Christine L. Case, Microbiology: An Introduction, 12th Edition (2017) Pearson publishers, USA

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	L	S	M	S	M	M
CO2	M	S	L	S	S	S	M	M	M	S
CO3	M	M	M	S	M	S	S	S	S	L
CO4	S	M	S	M	S	M	S	S	S	M
CO5	M	S	S	M	M	S	M	L	S	M

*S - Strong; M - Medium; L-Low

Skill Enhancement Course [SEC] – II - Dairy Farming

Course Objectives:		
To create awareness on economic importance of Dairy farming.		
Course	:	Skill Enhancement Course [SEC] – II
Course title	:	Dairy Farming
Credits	:	2
Pre-requisite: Knowledge on basic methods used in dairy farming		
Expected Course Outcome:		
Upon completion of this course, Students would have		
I	To understand the various practices in Dairy farming. To know the needs for Dairy farming and the status of India in global market.	K2 & K3
II	To be able to apply the techniques and practices needed for Dairy farming.	K1, K2 & K3
III	To gain knowledge on feed additives and to apply it in feed management in Dairy farming.	K2 & K3
IV	Understand about Milk and its products. To apply different techniques to protect milk products from getting spoiled.	K2, K3 & K4
V	Explain the methods to protect cattle from diseases and the medicines to be given if they are infected	K4 & K5

K1- Remember; **K2-** Understand; **K3-** Apply; **K4-**Analyze; **K5-**Evaluate; **K6-** Create

Units	
I	Introduction to Dairy Farming- Advantages of dairying- Classification of breeds of cattle- Indigenous and exotic breeds- Selection of dairy cattle. Breeding-artificial insemination- Dairy cattle management-General Anatomy.
II	Construction of Model Dairy House - Types of Housing - Different Managerial Parameters - Winter Management - Summer Management – Cleaning & Sanitation
III	Feedstuffs available for livestock- Roughages -Concentrates - Energy rich concentrates - Protein rich concentrates - Mineral Supplements - Vitamin Supplements - Feed additives - Feeding management - Calves Feeding - Feeding of adults - Feeding of pregnant dairy animals - Feeding pregnant heifer.
IV	Milk-Composition of milk-milk spoilage-pasteurization - Role of milk and milk products in human nutrition – Dairying as a source of additional income and employment.
V	Contagious disease - Common Bacterial - Protozoal - Helminth and Viral Diseases - Parasitic Infestation –Deworming, Dehorning, Vaccination - Biosecurity.

Reading list

1. The Veterinary Books for Dairy Farmers by Roger W. Blowey.
2. Hand Book of Dairy Farming by Board Eiri.
3. Handbook of animal husbandry TATA, S.N ed., ICAR 1990
4. Prabakaran, R. 1998. Commercial Chicken production. Published by P. Saranya, Chennai.
4. Hafez, E. S. E., 1962. Reproduction in Farm Animals, Lea & Fabiger Publisher.

Recommended texts

1. [https://agritech.tnau.ac.in/farm_enterprises/Farm%20enterprises %20Dairy%20unit.html](https://agritech.tnau.ac.in/farm_enterprises/Farm%20enterprises%20Dairy%20unit.html)
2. <https://www.google.co.in/search?tbo=p&tbm=bks&q=inauthor:%22Tata,+S.N.,+ed%22>
3. 15. James. N. Marnar, 1975. Principles of dairy processing, wiley eastern limited, New Delhi.
4. Baradach, JE. Ryther. JH. and, MC larney WO., 1972. Aquaculture. The farming and Husbandry of Freshwater and Marine Organisms. Wiley InterScience, New York.

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	L	L	S	S	M	S	L	M
CO2	M	S	S	S	M	S	M	L	S	S
CO3	M	S	S	S	S	S	S	S	S	M
CO4	M	S	S	S	M	M	L	L	M	M
CO5	S	S	S	M	S	M	S	L	S	S

*S - Strong; M - Medium; L - Low

Skill Enhancement Course [SEC] – II - BIOETHICS AND BIOSAFETY

Course Objectives:		
The main objectives of this course are:		
1.	To understand the laws governing patents, trade secrets, copy rights and trademarks with special emphasis to biotechnology at national and international level.	
2.	To understand the ethical perspective of handling biomaterials including transgenic plants and animals	
3.	To know the principles of biosafety and gain knowledge about basic and advanced laboratory practices. To follow Good Laboratory Practices during practical and research works	
Course	:	Skill Enhancement Course [SEC] – II
Course title	:	BIOETHICS AND BIOSAFETY
Credits	:	2
Pre-requisite:		
Expected Course Outcome:		
On the successful completion of the course, student will be able to:		
1.	Understand the concepts, risk, levels and types of biosafety	K1 & K2
2.	To acquire adequate knowledge in the biosafety regulations	K2 & K4
3.	To apply biosafety and bioethics in human research, genetically modified crops, and obtain ethical clearance.	K3 & K5
4.	To understand about Intellectual Property Rights (IPRs) to take measure for the protecting their ideas.	K4 & K6
5.	To evaluate the methods of patenting products and their procedures	K5 & K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Units	
I	Biosafety – Definition – Applications of Biosafety. Biosafety issues– risk assessment and risk management – safety protocols: risk groups, Personnel Protective Equipment – Biosafety levels –types of Biosafety containments - definition of GMOs& LMOs; Ethical issues in GMOs, Principles of safety assessment of transgenic plants.
II	Biosafety Regulations – National Guidelines – Regulation Framework in India, International guidelines – US, European, Canada, Australia, Africa.
III	Bioethics -Introduction. issues related to environmental animals and microorganisms – Ethical issues – Genetically modified food and crops – organ

	Transplantation and Ethical issues – Human embryonic stem cell research & ethics. Testing of drugs and human volunteers – Use of animals in research and testing, Alternatives for animals in research – Ethical Legal and Social Implications (ELSI) of Human Genome Project– Ethical Clearance – CPCSEA approval for animals - Bio warfare.
IV	Intellectual Property Right: Introduction, intellectual property: trade secret, patent, copyright, patent law, Choice and management of IPRs, advantage and limitations of IPRs.
V	Patents and patent processing: Introduction, Methods of application of Patents, Process of filing, International scenario of patents, patenting of biological materials, significance of patents in India, Patent Application Procedure in India. Patent Act (1970), Patent (Amendments) Act (2002, 2005, 2024).
Reading list	
Bioethics, by Shaleesha A. Stanley (2008). Published by Wisdom Educational Service, Chennai. 2. Bioethics and Biosafety (2013) M.K.Sateesh, I.K.InternationalPvt. Ltd, New Delhi,India, ISBN 8190675702,9788190675703 3. Intellectual Property Rights (2008) Prabuddha Ganguly, Tata McGraw Hill Publishing Company, India. ISBN: 97800700771719.	
Recommended texts	
Sree Krishna V 2007 Bioethics and Biosafety in Biotechnology, New age International publishers. 5. Goel and Parashar, IPR, Biosafety and Bioethics, 1e Paperback – 2013, Pearson	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	S	M	S	S	S
CO2	S	S	M	M	S	S	M	M	S	S
CO3	S	M	S	M	S	S	M	M	S	S
CO4	S	M	S	M	S	S	M	M	S	M
CO5	S	M	S	M	S	S	M	M	S	M

*S - Strong; M - Medium; L - Low

Semester - IV

Part	List of Courses	Credits	No. of Hours	Total hours	Internal marks	External marks	Total marks
Core – XI	Immunology	5	6	90	25	75	100
Core – XII	Ecology	5	6	90	25	75	100
Core – XIII	Lab course in Immunology & Ecology	3	4	60	25	75	100
Elective course VI	A) Aquaculture	3	4	60	25	75	100
	B) Applied Biotechnology & Nanotechnology						
Skill Enhancement Course – II	A) Animal Behaviour	2	4	60	25	75	100
	B) Forensic Science						
	#Extension Activity	1	-	-	50	50	100
	*Project	4	6	90	50	50	100
		23	30	450			

METHODS OF EVALUATION for THEORY		
Internal Evaluation	Continuous Internal Assessment Test	25 Marks
	Assignments	
	Snap Test	
	Quiz Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

METHODS OF EVALUATION for Extension activities and Project		
Internal Evaluation	Attendance	50 Marks
	Report	
	Activity	
External Evaluation	End Semester Evaluation	50Marks
	Viva –voce	
	Total	100 Marks

Note:-

#Extension activities

- **Internal: 50 Marks, External: 50 Marks (Total: 100 Marks)**
- **Individual report should be submitted at the end of IV – semester.**
- **External 50 marks will be evaluated by the external examiners.**
- **Extension activities to be done in groups, each having maximum of 4 members.**

***Project viva – voce examination**

- * **Internal: 50 Marks, External: 50 Marks (Total: 100 Marks)**
- * **Individual dissertation should be submitted**
- * **External 50 Marks will be evaluated by the external examiners.**

Core XI - Immunology

Course Objectives:		
The main objectives of this course are:		
1.	To impart conceptual understanding of functional organization of immune system and its responsiveness in health and disease.	
2.	To enable a successful performance in Immunology component of CSIR-UGC NET.	
Course I	:	Core XI
Course title	:	Immunology
Credits	:	5
Pre-requisite:		
Students would have basic knowledge in animal science, particularly functional anatomy, cell biology and developmental biology.		
Expected Course Outcome:		
Students would have acquired clear knowledge on		
1.	Various basic concepts in immunology and organization of immune systems.	K2
2.	Understanding immunogenicity, vaccines	K2
3.	Mechanisms of immune response in health and their defects in various diseases.	K2 & K4
4.	The application of immunological principles in biomedical sciences including blood transfusion, tissue grafting and organ transplantation.	K3 & K4
5.	Vaccinology and its importance in disease management	K3

K1- Remember; K2- Understand; K3- Apply; K4-Analyze; K5-Evaluate; K6- Create

Units	
I	Introduction to Immunology: An overview; Historical perspective, Concepts of external and internal defense systems; External (first line / innate) defense system: components, distribution; Internal (second line / acquired) immune system: cellular and humoral immune components- distribution, salient functions-primary and secondary immune responses; Immune tissues / organs: types, anatomical location, structure and development; lymphocyte traffic during development; Types of immunity: innate and acquired - types, functional features.
II	Antigens: Definition, characteristic features and classification; Antigenicity versus immunogenicity; Adjuvants: definition, types and applications. Vaccines: Types, Preparations, efficacies and recent developments: Complement System – Components, three major activation pathways and immune functions including Graphylaxis and inflammation.
III	Major effector components of cellular immune system: Lymphocytes - types, morphology, clones; sub-populations, distribution, T cell activation, maturation and differentiation. Steps in B cell – activation, differentiation - T cell receptors, B and T cell epitopes, Toll-like receptors; Antigen presenting cells: antigen processing and presentation, MHC molecules and their immunologic significance

IV	Major effector components of humoral immune system: Antibodies - Primary structure, classification, variants and antigen-antibody interactions; Structural and functional characteristics of various antibody classes; Generation of diversity; Monoclonal antibodies: Hybridoma Technology. Cytokines -Definition and salient functional features; Interleukins: definition, types (lymphokines and monokines), and functions. Interferons - Origin, types and functions
V	Diseases and immune responses: Hypersensitivity: definition, Types I to IV and immune manifestations; Auto-immune diseases: onset, spectrum of diseases, and major immune responses; Immunodeficiency diseases: types including SCID and consequences; Viral (HIV), bacterial (tuberculosis) and parasitic (malaria) diseases: etiology, host immune responses and evasion by pathogens; Tumour immunology, transplantation immunology.

Reading list

1. Kuby, J. 1997. Immunology. W. H. Freeman & Co., New York, pp-670.
2. Male, D. J. Brostoff, D. B. Roth and I. Roitt. 2006. Immunology (7th edition), Mosby / Elsevier, Philadelphia, pp-472
3. Abbas, A. K and A. H. Lichtman. 2007. Cellular and Molecular Immunology (6th edition), W. B. Saunders, Philadelphia, pp-564
4. Coica, R. Sunshine, G. 2015. Immunology (Seventh Edition), Wiley Blackwell, UK, pp-406.

Recommended texts

1. Weir, D. M and J. Stewart. 1997. Immunology, Churchill Livingstone, London, pp-362
2. Janeway, C. A and P. Travers. 1997. Immunology, Garland Publ. Inc., London, pp-904
3. Peakman, M and D. Vergani. 1997. Basic and Clinical Immunology, Churchill Livingstone, London, pp 366
4. Parham, P. 2009. The Immune System (Third Edition), Garland Science, USA, pp-506
5. Weissman, I. Hood, L. Wood, W. 1978. Essential Concepts in Immunology, the Benjamin/Cummings, California, pp-165.
6. Hood, L. Weissman, I. Wood, W. Wilson, J. 1984. Immunology (Second Edition), the Benjamin/Cummings, California, pp-558.
7. Coica, R and Sunshine, G. 2009. Immunology A Short Course (Sixth Edition), John Wiley & Sons, USA, pp-391.
8. Doan, T. Melvold, R. Viselli, S. *et al.*, 2013. Immunology (Second Edition), Lippincott Williams & Wilkins, Maryland, pp-376.
9. Owen, J. A. Punt, J. Stanford, S. A. 2013. Kuby Immunology (7th Edition), Macmillan, England, pp692.

Mapping with Programme Outcomes*

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	S	S	M	S	S	S
CO2	S	S	M	S	S	S	M	M	S	S
CO3	S	M	M	S	S	S	S	S	S	M
CO4	M	S	M	M	S	S	S	S	S	M
CO5	M	S	S	S	M	S	M	S	S	M

*S - Strong; M - Medium; L – Low

Core XII - Ecology

Course Objectives:		
The main objectives of this course are:		
1.	Knowing the ecology and climatic changes at world level and its impact on natural resources.	
2.	Understanding the contributing factors for pollution in the environment and the ways in controlling and restoring to natural conditions	
Course I	:	Core XII
Course title	:	Ecology
Credits	:	5
Pre-requisite:		
Students should know about the fundamentals and studied the ecology of living organisms.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to		
1.	Learn about the ecosystem, biotic communities and utilizing the energy processing	K2
2.	Study the various community and population and population control	K2 & K3
3.	Understand species interaction and ecological succession.	K2 & K6
4.	Analyse the different types of ecosystems and their energy flow.	K4 & K5
5.	Realizing the nature of pollution and the ways for its control/reduction. Impact of environmental studies on solid waste management	K2 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Units	
I	The Environment: Physical environment; biotic environment; biotic and abiotic interactions. Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
II	Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (<i>r</i> and <i>K</i> selection); concept of metapopulation-demes and dispersal, interdemec extinctions, age structured populations -action taken to control population explosion.
III	Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological succession: Types; mechanisms; changes involved in succession; concept of climax
IV	Ecosystem: Structure and function; energy flow and mineral cycling (CNP);

	primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.
V	Applied ecology: Environmental pollution; global environmental change; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches - Waste management. Conservation biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).
Reading list	
<ol style="list-style-type: none"> 1. Sharma, P.D. 2009. Ecology and Environment, Rastogi Publication, India, pp-616. 2. Calabrese, E.J. 1978. Pollutants and High-Risk Groups, John Wiley, pp-286. 3. Raven, P.H. and L.R. Berg, G.B. Johnson, 1993. Environment, Saunders College Publishing, pp-579. 4. Cunningham, W. P. and B. W. Saigo, 1999. Environmental Science, McGraw Hill Boston, 5th Edition. 5. Online courses.nptel.ac.in / noc 19 - g e 23/preview 6. Class central.com/course/swayam -ecology - and environment – 14021. 	
Recommended texts	
<ol style="list-style-type: none"> 1. Odum, E.P. 1893. Basic Ecology, Saunders & Co., Philadelphia, pp-383. 2. Barthwl, R.R. 2002. Environmental Impact Assessment, New Age International Publishers, New Delhi, India, pp-425. 3. United Nations Environment Programme (UNEP). 1995. Global Biodiversity Assessment, Cambridge University Press, pp-1140. 	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	M	S	S	M	S
CO2	S	S	M	M	L	S	S	S	M	M
CO3	S	M	M	L	M	S	L	L	S	L
CO4	M	M	S	S	M	L	L	S	S	S
CO5	M	S	S	M	S	M	L	M	L	S

*S - Strong; M - Medium; L – Low

Lab course in Immunology & Ecology

Course Objectives:		
The main objectives of this course are:		
1.	To provide hands on training to perform specific lab courses in immunology and ecology.	
Course I	:	Core – XIII
Course title	:	Lab course in Immunology & Ecology
Credits	:	4
Pre-requisite:		
Students should have basic understanding of immunological concepts and an idea of ecology.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to		
1.	Acquire ability to perform/demonstrate various basic concepts of immunology	
2.	Understand the structure and to identify WBC.	
3.	Perform expts to measure primary productivity	
4.	Analyse the marine and freshwater planktons	
5.	Evaluate the content of different water samples	

IMMUNOLOGY

1. Identification of Lymphoid organs in rat / chick – dissections.
2. Identification of various types of immune cells in peripheral blood smear.
3. Observation of WBCs.
4. Single radial immuno diffusion technique
5. Double immune diffusion
6. Agglutination titer – Determination of agglutination titer

Spotters / Charts / Models

1. ELISA
2. Western Blot, Southern Blot
3. HIV, Malaria, TB
4. IgG, IGM, IgA – Immuno globulin – Types
5. Lymphocytes – T & B Cells

ECOLOGY

1. Measurement of primary productivity in relation to biomass.
2. Estimation of dissolved O₂ and Carbondioxide in the given water samples.
3. Estimation of salinity and total alkalinity
4. Identification of fresh water / Marine planktons
5. Estimation of pH in different water samples
6. Visit and field study report on a pond/ forest / marine ecosystem (any one).

Spotters / Charts / Models

- Commensalism, Mutualism, Parasitism, food web, Inter specific and Intra specific competitions, Ecological Pyramid of number, Biomass and energy.

• Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	L	L	S	S	M	S	L	M
CO2	M	L	M	S	M	L	M	L	S	S
CO3	L	S	S	S	S	S	S	S	S	M
CO4	M	M	M	S	M	M	L	L	M	M
CO5	S	S	S	M	S	M	S	L	S	S

*S - Strong; M - Medium; L – Low

Elective Course VI (A): Aquaculture

Course Objectives:		
The main objectives of this course are:		
1.	Students should know basic concepts in Aquaculture.	
Course	:	Elective VI
Course title	:	Aquaculture
Credits	:	3
Pre-requisite:		
Students should know the fin fishes and shell fishes of commercially important candidate species.		
Expected Course Outcome:		
Upon completion of this course, Students would have		
I	To develop knowledge on the fish farm and their maintenance.	K1 & K2
II	Understand the methods of fish seed and feed production and develops knowledge on hatchery techniques	K1 & K2
III	To apply the knowledge about different culture methods in aquaculture and gain knowledge on fish and shrimp breeding techniques and larval culture	K3 & K4
IV	Identify the different fishes diseases, diagnosis and their management strategies.	K5 & K6
V	Understand the biology of freshwater and marine Ornamental fishes and activities of central aquaculture organizations	K2 & K3

K1- Remember; **K2-** Understand; **K3-** Apply; **K4-**Analyze; **K5-**Evaluate; **K6-** Create

Units	
I	Importance of aquaculture- Present status, prospects and scope in India. Freshwater aquaculture- Brackishwater aquaculture- Mariculture - Metahaline culture in India. Types of fish culture -Types of fish ponds for culture practice. Topography, site selection - soil condition and quality –pond design and layout -. Water quality management – Temperature, Salinity, Nutrients, O ₂ , pH). Control of parasites, predators and weeds in culture ponds. Fish farm implements - Secchi disc - aerator - pH meter - feeding trays – Fishing gears used in aqua farming.
II	Procurement of seed from natural resources- collection methods and segregation. Hatchery technology for major carps and freshwater prawn. Artificial breeding under controlled conditions, induced breeding techniques, hypophysation, larval rearing, packing and transportation Commercial substitute for pituitary extracts. Classification of fish feed –Types of Artificial Feed - formulation - feeding methods. Live feed- Culture of Microalgae, Spirulina, Nostoc, Rotifer, Artemia.

III	Shrimp hatchery technology - Hatchery design, brood stock management, spawning, larval rearing, Shrimp developmental stages, packaging and transportation. Culture technology - extensive culture methods semi- intensive - intensive culture methods - Bio floc technology - Culture operations (water quality, feed and health management) - harvesting, processing and marketing. Brackish water fish culture. Edible and Pearl oyster culture - pearl production. Crab culture. Economic importance of Lobster, Sea urchin and Sea cucumber - their by-products. Types of Seaweeds - species and methods of culture – by-products
IV	Fish and Shrimp diseases and health management – infectious diseases – Bacterial: Dropsy, Erythroderma – Fungal: Branchiomycosis (Gill rot), Aspergillomycosis – Viral: Epizootic Ulcerative Syndrome, Viral Hemorrhagic Septicaemia (VHS) – Protozoan: Ichthyophthiriasis (White Spot Disease), Myxozoans (Whirling Disease); Non-infectious - environmental and nutritional diseases. Diseases diagnosis, prevention and control measures.
V	Types of ornamental fishes (freshwater and marine), their breeding behavior and biology. Oviparous, Ovo-viviparous and Viviparous fishes. Setting and maintenance of freshwater Aquarium tanks. Central aquaculture research organizations- CMFRI, CIBA, CIFT, CIFA, CIFE, ICAR-NBFGR, RGCA, MPEDA and its activities.
Reading list	
<ol style="list-style-type: none"> 1. Pillay, T. V. R. (1990). Aquaculture: Principles and Practices. Blackwell Scientific Publications Ltd. 2. Santhanam, R. (1990). Fisheries Science. Daya Publishing House. 3. Sinha, V.R. P. and Srinivastava, H. C. (1991). Aquaculture Productivity. Oxford and IBH Publications CO., Ltd., New Delhi. 4. Yadav, B. N. (1997). Fish and fisheries. Daya Publishing house, New Delhi. 	
Recommended texts	
<ol style="list-style-type: none"> 1. Das M. C. and Patnaik, P. N. (1994) Brackish water culture. Palani paramount Publications, Palani, T. N. 2. Day, F (1958). Fishes of India, Vol I and Vol. II. William Sawson and Sons Ltd., London. 3. Jhingran, V. G. (1991). Fish and Fisheries of India. Hindustan Publishing Co., India 4. Maheswari. K. (1983) Common fish disease and their control. Institute of Fisheries Education, Powarkads (M.P). 	

Mapping with Programme Outcomes*										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	S	S	M	M	S
CO2	S	S	S	M	S	S	S	M	S	S
CO3	S	S	S	S	S	S	S	S	S	M
CO4	S	S	M	S	S	S	S	M	M	S
CO5	S	S0	M	S0	M	S	M	L	S	S

*S-Strong; M-Medium; L-Low

Elective Course VI(B): Applied Biotechnology and Nanotechnology

Course Objectives:		
The main objectives of this course are:		
1.	Enable the students to understand the basic concepts of Biotechnology	
2.	Familiarize the significance of Biotechnology in enriching human life	
Course	:	Elective
Course title	:	Applied Biotechnology and nanotechnology
Credits	:	3
Pre-requisite		
Propose students to gain an insight into the concepts and techniques of Plant, Animal and Microbial biotechnology and its wide industrial applications		
Expected Course Outcome:		
Upon completion of this course, Students would have		
1.	Impart knowledge on basic cloning techniques and their importance in biotechnology	K1 & K2
2.	Analyze the techniques in genetic engineering	K3
3.	Exemplify the role of biotechnology in human welfare and bioprocess technology.	K4
4.	Knowledge on basics of nanobiotechnology and its role in development of nanomedicine .	K4
5.	Evaluate the applications of nanobiotechnology in various fields.	K5

	Units
I	Introduction to Biotechnology: Tools of Genetic Engineering - Vectors - Cloning and Expression Vectors - Plasmids, Bacteriophage, Cosmids, Shuttle Vectors, Yeast Vectors. Enzymes - Restriction Endonucleases, Ligases, Reverse Transcriptases, Polymerases, Terminal Transferases and Isozymes. Nucleic acid Probes and Molecular markers - RFLP, RAPD.
II	Techniques in Genetic Engineering - selection and isolation of desired genes, gene splicing, introduction of rDNA into host, selection of clone containing DNA insert, PCR, DNA finger printing, blotting techniques, DNA sequencing, genomic library, cDNA library.
III	Biotechnology and Human Welfare: Tissue Plasminogen Activator, Erythropoietin, Interferons, Recombinant Vaccines, Monoclonal Antibodies Production. Genetically modified organisms (GEMO's) - Transgenic Mice and Cattle - Gene Pharming. Bioterrorism. Bioprocess Technology: Overview of Upstream & Downstream processing. Production of industrially important antibiotics, Single Cell Production. Role of GMOs in Biodegradation. Biotechnological Applications in Environmental Management, Biodiesel production and Bioplastics. Animal Biotechnology: Artificial Insemination in Cattle, Embryo Transfer, Cryopreservation, Stem Cell Therapy, Targeted Gene Transfer - Gene knockouts.

IV	Introduction to Nanobiotechnology: History and Scope of Nanotechnology. Nano materials - definition, types and properties. Development of nanomedicines - nanotechnology in diagnostic applications. Biochips Analytical devices. Biosensors - natural nanocomposite systems as spider silk, bones, shells.
V	Application of Nanobiotechnology: Application in green energy, environmental remediation - pollution in industrial and waste water treatment. Application of Nanotechnology in the treatment of infectious diseases, nanomaterials in cancer diagnosis and therapy.

Reading List

1. U. Sathyanarayana, Biotechnology, Books and allied P. Ltd., Kolkata, 2005
2. V. Kumaresan. A Text Book of Biotechnology, Saras Publication., 2009.
3. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age International publishers.

Recommended texts

1. V.A Saunders, Microbial Genetics Applied to Biotechnology: Principles and Techniques of Gene Transfer and Manipulation. Springer Science & Business Media. 2012.
2. Mathews and Mickee. An introduction to genetic engineering in plants, Blackwell Scientific Publishers. London. 2015.
3. Ramadass. P., Animal Biotechnology: Recent Concepts and Developments. Publishers, India. (2008).
4. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	S	S	M	S	S	S	M	S
CO2	S	M	S	S	L	S	M	S	M	S
CO3	M	M	M	S	L	S	M	S	S	S
CO4	S	M	S	M	S	M	S	S	S	M
CO5	M	S	S	M	M	S	M	S	S	M

*S - Strong; M - Medium; L-Low

Skill Enhancement Course [SEC] – III (A): Animal Behaviour

Course Objectives:		
The main objectives of this course are:		
1.	Students should understand basic concepts in Animal behaviour.	
Course I	:	Skill Enhancement Course [SEC] - III
Course title	:	Animal Behaviour
Credits	:	2
Pre-requisite:		
Students should be aware of ecology and the animals in their respective environments.		
Expected Course Outcome:		
Upon completion of this course, Students would have		
I	Recall and record genetic basis and evolutionary history of behaviour.	K1 & K2
II	Analyze and identify innate, learned and cognitive behaviour	K3 & K4
III	Evaluate the behaviour of Animals in changing environments	K3 & K4
IV	Classify movement and migration behaviours	K1, K4 & K5
V	Understanding circadian system and Chrono pharmacology	K2, K4 & K5

K1- Remember; **K2-** Understand; **K3-** Apply; **K4-**Analyze; **K5-**Evaluate; **K6-** Create

Units	
I	Genetic material, Genes and chromosomes, Genetic variation, Single and Polygenic inheritance of behaviour, Heritability of behaviour, Natural selection and behaviour, Frequency distribution of phenotypes, Darwinian fitness, Evolution of adaptive strategies.
II	Sexual selection, Altruism, Sexual strategy and social organization, Animal perception, Neural control of behaviour, Sensory processes and perception, Visual adaptations to unfavourable environments.
III	Coordination and Orientation, Homeostasis and Behaviour, Physiology and Behaviour in changing environments, Animal Learning, Conditioning and Learning, Biological aspects of learning, Cognitive aspects of learning.
IV	Instinct and learning, Displacement activities, Ritualization and Communication, Decision making behaviour in Animals, Complex behaviour of honey bees, Evolutionary optimality, Mechanism of Decision making. The mentality of Animals: Languages and mental representation, non-verbal communication in human, mental images, Intelligence, tool use and culture, Animal awareness and Emotion.
V	Organization of circadian system in multicellular animals; Concept of central and peripheral clock system; Circadian pacemaker system in invertebrates with particular reference to Drosophila; Photoreception and photo- transduction; Molecular bases of seasonality; The relevance of biological clocks for human welfare - Clock function (dysfunction); Human health and diseases – Chrono pharmacology, chrono medicine, chronotherapy.

Reading list

1. David McFarland, 1985. Animal Behaviour, Longman Scientific & Technical, UK. 576pp.
2. Harjindra Singh, 1990. A Text Book of Animal Behaviour, Anomol Publication, 293pp.
3. Hoshang S. Gundevia and Hare Govind Singh, 1996. Animal Behaviour, S. Chand & Co, 280pp.
4. Shukla, J. P 2010, Fundamentals of Animal Behaviour, Atlantic, 587pp.
5. Vinod Kumar, 2002. Biological Rhythms. Narosa Publishing House, Delhi.

Recommended texts

1. Michael D. Breed and Janice Moore, 2012. Animal Behaviour, Academic Press, USA, 359pp.
2. Aubrey Manning and Martin Stamp Dawkins, 2012. An Introduction to Animal Behaviour, 6th Edition, Cambridge University Press, UK. 458pp.
3. Davis E. Davis, 1970. Integral Animal Behaviour, Mac Millan Company, London, 118pp.
4. Jay, C. Dunlap, Jennifer, J. Loros, Patricia J. De Coursey (ed). 2004. Chronobiology Biological time Keeping, Sinauer Associates Inc, Publishers, Sunderland, MA.

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	L	M	M	L	L
CO2	S	M	L	L	S	L	M	M	L	M
CO3	M	L	M	L	S	S	M	S	M	S
CO4	S	S	S	S	M	S	L	L	L	M
CO5	S	L	L	L	M	L	L	S	M	S

*S - Strong; M - Medium; L- Low

Skill Enhancement Course [SEC](B) III: Forensic Science

Course Objectives:		
The main objectives of this course are:		
1.	To understand the different aspects of Forensic Biology and some very specific areas such as DNA forensics, Wild Life Forensics and Forensic Entomology.	
2.	To learn in details, the Forensic Examination of body fluids, and Hair and its significance	
3.	Use tools and techniques required for detection of deception.	
Course		
Course title	:	Forensic Science
Credits	:	2
Pre-requisite:		
Students should know the taxonomical classification of invertebrate animals in relation to their functional morphology.		
Expected Course Outcome:		
On the successful completion of the course, student will be able to:		
1.	Remember the knowledge of some of the basic facts, concepts and principles and significance of forensic science	K1 & K2
2.	Understand the role of the forensic science and physical evidence within the criminal justice system.	K2 & K4
3.	Justify the role of DNA in paternity identification, DNA profiling, Finger printing	K3 & K5
4.	Apply chemical and biological techniques in analysing toxicological evidences.	K4 & K6
5.	Familiarize with new trend named Wildlife Forensics aid in conserving natural resources an importance of biological & Entomological evidences in Forensic Science	K5 & K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

Units	
I	Introduction to Forensic Science Forensic Science-definition, history, development and scope. Concepts, functions and need of forensic science. Principles and Methods of Forensic Science. State and Central Forensic Science Laboratories. Mobile Forensic Science Laboratory. Locard's Exchange Principle.
II	Forensic Importance of Body fluids and evidence Common body fluids. Collection and preservation of blood evidence. Distinction between human and non-human blood. Forensic characterization of bloodstains. Typing of dried stains. Semen. Forensic significance of semen. Collection, evaluation and tests for identification of semen. Composition, functions and forensic significance of saliva, sweat, milk and urine. Tests for their identifications. Nature and importance of biological evidence. Significance of hair evidence. Transfer, persistence and recovery of hair evidence. Comparison of human and animal hair.

III	<p>DNA Forensics and Finger printing: DNA Forensics: DNA as biological blueprint of life. DNA testing in disputed paternity, Application and Forensic Significance of DNA Profiling. Finger printing: Biological basis of fingerprints. Formation of ridges. Fundamental principles of fingerprinting. Types of fingerprints. Fingerprint patterns. Fingerprint characters. Plain and rolled fingerprints. Classification method for fingerprint record keeping. Automated Fingerprint Identification System.</p>
IV	<p>Fundamentals of Forensic Medicine and Toxicology Forensic Medicine- Definition, nature and scope. Inquests. Medico Legal documents. Evidences- Dying declarations- Identification of dead and living persons. Medico-legal autopsy and its importance. Toxicology: Significance of toxicological findings. Techniques used in toxicology. Toxicological analysis and chemical intoxication tests. Postmortem Toxicology. Human performance toxicology</p>
V	<p>Wildlife Forensics and Forensic Entomology Wildlife Forensics: Fundamentals of wildlife forensic. Significance of wildlife forensic, Identification of physical evidence pertaining to wildlife forensics. Forensic Entomology: Basics of forensic entomology. Insects of forensic importance. Collection of entomological evidence during death investigations.</p>

Reading list

Houck, M. M & Siegel, J. A 2006. Fundamentals of Forensic Science Academic Press, London.
James, S. H and Nordby, J. J. 2003. Forensic Science- An Introduction to Scientific and Investigative Techniques. CRC Press, USA.
Saferstein 2007. An Introduction of Forensic Science Prentice HallInc, USA.
Basu R. 2019. Fundamentals of forensic medicine and toxicology. Books & allied (P) LTD.-Kolkata.

Recommended texts

Narayana Reddy (1981). Introduction to Forensic Medicine and Toxicology. Calcutta.
William G. Eckert., (1997) Introduction to Forensic Sciences, CRC press New York.

Mapping with Programme Outcomes*

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	S	M	S	S	S
CO2	S	S	M	M	S	S	M	M	S	S
CO3	S	M	S	M	S	S	M	M	S	S
CO4	S	M	S	M	S	S	M	M	S	M
CO5	S	M	S	M	S	S	M	M	S	M

*S - Strong; M - Medium; L - Low
