Name of the Department : Department of Animal Science

Name of the Programme : M.Sc. Zoology

1. VISION AND MISSION OF UNIVERSITY:

Vision

- " To provide quality education to reach the un-reached "

Mission

- To conduct research, teaching and outreach programmes to improve conditions of human living
- To create an academic environment that honours women and men of all races, caste, creed, cultures and an atmosphere that values intellectual curiosity, pursuit of knowledge, academic freedom and integrity
- To offer a wide variety of off-campus educational and training programs, including the use of information technology, to individuals and groups.
- To develop partnership with industries and government so as to improve the quality of the workplace and to serve as catalyst for economic and cultural development
- To provide quality / inclusive education, especially for the rural and un-reached segments of economically downtrodden students including women, socially oppressed and differently abled

2. VISION AND MISSION OF DEPARTMENT

Vision

- To attain Academic Excellence in Animal Science and Manpower Development

Mission

- To provide quality education and research in the area of Animal Science
- Generating Research Grant &Establishing high end research facilities.
- Understanding the impact of Global warming on distribution, diversity and metabolic process of animals
- Enhancing the animal health through novel eco-friendly bio-molecules from renewable and bio-waste resources.
- Assessing Genetic variations and Barcoding of Animals

3. PREAMBLE

It is now evident that animals are abundantly distributed in diversified environments. On diversity aspect also animals are numerous, and so many aspects of animal life have been uncovered. More than 99 percent of all species, amounting to over five billion species, that have evolved on Earth are estimated to be extinct. Estimates on the number of Earth's current species range from 10 million to 14 million of which about 1.2 million have been documented over 86 percent have not yet been described. Scientists have reported that animals occupied 63% of the life in this planet. One trillion species are estimated to be on Earth of which only one-thousandth of one percent described.

Study of Zoology is the basic for understanding of the fauna of the world. Zoology is the branch of biology that includes the study of animals and animal life, including the taxonomy and diversity of animals, evolutionary significance, functional morphology, their physiology, reproduction, genetical hereditary lineages and their curative measure.

Zoology has diversified into a countless of allied sciences including cell and molecular biology, microbiology, biochemistry and immunology. Zoological Knowledge and theories are applicable to maintain health and diversity of animal and also to control the epidemic diseases. Various types of living organisms are closely associated in a particular environment and interaction of prey-predator relationship, food chain in the biodiversity. Various by-products of animals such as coral, pearl, honey, wax, silk, lac, shell of turtle, bones, feather, tusk, leather and fur are of high demand. These products can be increased from our knowledge. The improvement of farm/domestic animals is one of the major tasks of zoologists. Application of zoological science in fisheries, cattle, poultry farming and pests management in agriculture and stored food grains are well known. It is the study of economic zoology for the higher production of food crops and fisheries to meet the challenge of protein rich food materials at the reasonable cost. An education in Zoology enables one to start a career working in any of the broad levels of life, from working on the cellular level, to working on a specific species or individual animal, or all the way up to working on total ecosystems or the whole biosphere.

Scope for Zoologist

The Service of the trained zoologist is the need of the hour because of the development of advanced technologies in uncounteless areas. Due to global warming and climate change and also due to pollution, environment is getting deteriorate day by day. Both national and State pollution control board required the service of Zoologist for the proper assessment of environmental damage (EIA study) and also to propose strategies for environment management and systematic documentation. Zoologists are also hired in various National and International agencies involved in zoological survey and conservation like WWF, IUCN, ZSI, WII, NBA, MoEF. Zoologists do have scope in Zoo keeping, Zoo Curation, Wildlife services, Botanical gardens, National parks, nature reserves, universities, laboratories, aquariums, animal clinics, fisheries and aquaculture, museums, research, pharmaceutical Companies, veterinary hospitals and Food Corporation of India (FCI) etc. Zoologist are also engaged as Animal Behaviorists, Animal breeders, Animal Trainers, Animal Caretakers, Animal and Wildlife Educators, Conservationists, Documentary Maker, Forensic Experts, Lab Technicians, Researcher, Wildlife Biologists, Veterinarian, and many more. Thus the scope of applied Zoology is innumerable. Zoologist can also work in Zoological Teaching and Research, Medicine, Dentistry, Veterinary Medicine, Medical Technology, Nursing, Museum Work, Environmental Science and Conservation. Further, channels like National Geographic, Animal Planet, Discovery Channel is in constant need of Zoologists for research and documentaries.

Eligibility for Admission:

Those who have passed and secured $\geq$ 50 percentage marks in the following courses *viz*., B.Sc. Zoology, B. Sc. Advanced Zoology, B.Sc. Applied Zoology, B.Sc. Animal Science and Biotechnology, B.Sc. Advanced Zoology and Biotechnology, B.Sc. Life Science and B.Sc. Biology (Hons.) from recognized University are eligible to apply.

4. PROGRAMME STRUCTRURE FOR THE P.G. DEGREE M.Sc. ZOOLOGY IN UNIVERSITY DEPARTMENT (With effect from the academic year 2022-2023 onwards)

MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI

Course Structure under Choice Based Credit System

Semester	Subject Status	Subject Title	Course Code	Contact Hrs./Week	Credit
I	Core-I	Structure and function of Invertebrates	NZOC11	4	4
	Core-II	Comparative anatomy of chordates	NZOC12	4	4
	Core-III	Environmental Biology	NZOC13	4	4
	Core-IV	Animal Biodiversity	NZOC14	4	4
	Core Pract I	Course covering Core I & II	NZOL11	4	2
	Core Pract II	Course covering Core III & IV	NZOL12	4	2
	Elective I – (E-Pathsala-1)	Animal Cell Biotechnology (E-Pathsala-1)	NZOEPA	3	3
	Elective-I	1. Entrepreneurial Mushroom Cultivation 2. Apiculture 3. Seaweed culture and its Bioprospecting 4. Aquaculture	NZOEA NZOEB NZOEC NZOED	3	3
		Sub Total		**27**	**23**
II	Core V	Biochemistry	NZOC21	4	4
	Core VI	Cell and Molecular Biology	NZOC22	4	4
	Core VII	Developmental Biology	NZOC23	4	4
	Core VIII	Microbiology	NZOC24	4	4
	Core Pract III	Course covering Core V & VI	NZOL21	4	2
	Core Pract IV	Course covering Core VII & VIII	NZOL22	4	2
	Internship	15-20 days (80-100 hours) training/mini project during the vacation period with compulsory report submission	NZOI21	-	2
	Supp. Course I	MOOC-1		3	3
		Sub Total		**27**	**25**
III	Core IX	Comparative Animal Physiology	NZOC31	4	4
	Core X	Immunology	NZOC32	4	4
	Core XI	Genetics	NZOC33	4	4
	Core XII	Bioinstrumentation	NZOC34	4	4
	Core Pract V	Course covering Core IX & X	NZOC31	4	2
	Core Pract VI	Course covering Core XI & XII	NZOC32	4	2
	Elective II	1. Essentials of Biological Research 2. Applied Entomology 3. Biofouling and Bioremediation 4. Fish Processing Techniques	NZOEE NZOEF NZOEG NZOEH	3	3
	Supp. course II	MOOC-2		3	3
		Sub Total		**30**	**26**
IV	Core- XIII	Evolution	NZOC41	4	4
	Core- XIV	Biostatistics & Computer Application	NZOC42	4	4
	Elective - ii (E-Pathsala-2)	Computational Biology (E-Pathsala-2)	NZOEPB	3	3
	Core Pract VII	Course covering Core XIII & XIV	NZOL41	4	2
		Project		12	6
		Sub Total		**27**	**19**
		Total		**111**	**93**

5. EVALUATION SCHEME

Practical Examination:

M.Sc. Zoology Core Practical Examination having the following marks:

Internal – 50

Major Practical	=	20 marks
Minor Practical	=	10 marks
Spotters (ABC&D) 4 x 5	=	20 marks
Total	**=**	**50 marks**

External – 50

Major Practical	=	15 marks
Minor Practical	=	10 marks
Spotters (ABC&D) 4x5	=	20 marks
Record & Viva-voce	=	5 marks
Total	**=**	**50 marks**

Theory Examination:

The M.Sc. Zoology core and Elective theory Examination having the following marks.

Internal Marks – 25

Test	=	15 marks
Assignment	=	5 marks
Seminar	=	5 marks
Total	**=**	**25 marks**

External Marks – 75

Section A: 10x 1 (Q.No. 1 to 10)	=	10 marks
Section B: 5 x 5 (Q.No. 11 to 15)	=	25 marks
Section C: 5 x 8 (Q.No. 16 to 20)	=	40 marks
Total	**=**	**75 marks**

Grading System

Distribution of Credits	No. of papers	Credits	Hours	Total Credits	Total Grade Points
Core Theory	14	4	4	56	5600
Practical Papers	7	2	4	14	1400
Electives	3	3	6	9	900
Supportive courses	2	3	3	6	600
Internship/Mini Project	1	2	90	2	200
Dissertation/Project /Viva Voce	1	6	12	6	600
Cumulative Grade Points Average (CGPA) = Grade Points /Total Credits				9300/93	100 %

Evaluation of performance of students is based on ten-point scale grading system as given below

S.No	PERCENTAGE OF MARKS	LETTER GRADE	GRADE POINT	PERFORMANCE
1	90-100	O+	10	Outstanding
2	80-89	O	9	Excellent
3	70-79	A+	8	Very Good
4	60-69	A	7	Good
5	55-59	B+	6	Above average
6	50-54	B	5	Pass
7	0-49	RA	-	Reappear
8	0	AA	-	Absent

$$\text{Cumulative Grade Point Average} = \frac{\Sigma(C \times GP)}{\Sigma C}$$

CGPA for a semester is awarded on cumulative basis by including all the courses upto that semester provided the candidate has passed all he courses

5. MODEL QUESTION PAPER

QUESTION PAPER PATTERN FOR UNIVERSITY EXAMINATION
M.Sc. Zoology Degree Examination

Total: 3 Hours **Max. Marks: 75**

PART – A **(10 X 1 = 10 marks)**

Choose the correct answer
Each question carries equal marks

1. Identify the microscope which is best suited to get the surface topography of a sample.
a. Phase contrast Microscope b. Fluorescent Microscope
c. Scanning Electron Microscope d. Compound Microscope

2. The acidity and alkalinity of a solution is determined by....
a. TLC b. pH meter
c. Blotting d. All the above

3. Which of the following is NOT considered as stationary phase in column chromatography?
a. Cellulose and Dextran b. Polyacrylamide and Polystyrene
c. Polyimidine and Sericin d. Silica gel

4. The process by which protein gets separated on the basis of their net charge is called..
a. Affinity chromatography b. Ion exchange chromatography
c. HPLC d. GC-MS

5. If the protein is initially at a pH range below its isoelectric point the protein will be....
a. Positive b. Negative
c. Neutral d. Zwitterionic

6. Identify the correct pair of molecular weight for protein and DNA.
a. 1 aminoacid = 109 Da and 1Kb = 101 bp b. 1 aminoacid = 120 Da and 1Kb = 110 bp
c. 1 aminoacid = 100 Da and 1kb = 1010 bp d. 1 aminoacid = 110 Da and 1Kb = 1000bp

7. Glowing of GFP in jelly fish is due to occurrence of ..... amino acids.
a. Serine, Leucine and Aspartic acid b. Serine, Tryptophan and Glutamic acid
c. Sericin, Tyrosine and Isoleucine d. Serine, Tyrosine and Glycine

8. The process of binding of primer to the denatured DNA strand is called as....
a. Denaturation b. Renaturation
c. Annealing d. None of the above

9. Molecules containing radioisotopes are employed in.....
a. Isoelectric focusing b. Chromatography
c. Autoradiography d. Gram staining

10. Mass number of atom is the sum of number of .....
a. Electrons and protons b. Electrons and neutrons
c. Neutrons and positrons d. Neutrons and protons

PART – B

Answer ALL the Questions choosing either (a) or (b) (5 X 5= 25 Marks)

11.a. Briefly explain the principle and working of light microscope.

(or)

b. List out the sequential steps involved in Gram staining.

12. a. Explain briefly the principle and instrumentation of HPLC.

(or)

b. Describe the principle and working of anion exchange chromatography.

13. a. Write a brief account on separation of nucleic acids by Agarose gel electrophoresis.

(or)

b. Write short notes on Isoelectric focusing.

14. a. Describe briefly the working mechanism and applications of fluorescence spectroscopy.

(or)

b. Differentiate between Turbidometry and Nephlometry.

15.a. Describe how the concentration of antigen is measured by RIA technique.

(or)

b. Give a brief account on autoradiography.

PART – C

Answer ALL questions, choosing either (a) or (b) (5 X 8= 40 marks)

16. a. Describe various components of SEM and its working mechanism.

(or)

b. Explain in detail about the construction and working of pH meter.

17.a. Write a detailed account on Gas chromatography.

(or)

b. Describe the instrumentation and working of FPLC.

18. a. What is PCR? Describe various stages of amplification of DNA by PCR technique.

(or)

b. Write an elaborate account on Western blotting.

19. a. Describe the working methodology and applications of AAS.

(or)

b. Explain the principle, components and working of UV-Vis spectroscopy.

20. a. Explain how GM counter is used to detect and measure ionizing radiations.

(or)

b. Write an essay on radioactive decay and its types.

7. PROGRAMME OUTCOME (POS)

The programme aims to

1. Develop an individual from rural, unreached socio-economically downtrodden society with academic integrity, values and ethics.

2. Impart high level of education and understand the multidisciplinary, innovative, contemporary knowledge and will be able to do independent and applied research to be competent at national and international level.

3. Motivate and develop a passion for lifelong learning with capability in technique and analytical methods in the core and applied research.

4. Impart skill based, value added, employable, entrepreneurial, research oriented programmes to be self reliant.

5. Offer a milieu for basic and advanced research to develop research outputs that are transferrable technologies, patents and publications.

6. Offer courses and impart hands on scientific training for designing and execution of experiments to acquire higher education, research skills and employability in the reputed regional, national and international institutions

8. PROGRAMME SPECIFIC OUTCOMES (PSO)

After the successful completion of M.Sc. Zoology programme, the students will be able to

PSO1	Identify the diversity of organisms, differentiate them phylogenetically, morphologically and understand their habit and habitat, evolutionary significance, and their economic importance
PSO2	Understand the cellular and molecular mechanisms of organisms, know the microbial interactions and biochemical modifications in various organisms.
PSO3	Understand the cell differentiation, genetic inheritance, developmental process of an organism, and know the modern techniques viz. rDNA, Tissue engineering and the Artificial Reproductive Technology process.
PSO4	Learn the basics of the animal physiology, know the immune cells and immune organs, process of innate and acquired defence mechanisms and their role in allergy and organ transplantation.
PSO5	Design the experiments, know the methods of data collection and execute the experiments with modern instruments and interpret the data with recent statistical tools.
PSO6	Acquire knowledge on computational biological tools, know the biological database and sequence analysis methods, able to do molecular modelling and pharmacophore generation.
PSO7	Understand the structure and functional properties of manmade ecosystems, impact of climate change and global warming on living organisms, and conservation of natural resources, able to do EIA analysis.
PSO8	Acquire skill based aquaculture techniques, value added post harvest storage methods of fishery biology, employable animal husbandry techniques, and entrepreneurial apiculture and sericulture methods. Economic importance of animal species.

CORE PAPER I: STRUCTURE AND FUNCTION OF INVERTEBRATES

Semester	**I**
Course Type	**CORE PAPER I**
Title of the Course	**STRUCTURE AND FUNCTION OF INVERTEBRATES**
Course Code	**NZOC11**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC11	**STRUCTURE AND FUNCTION OF INVERTEBRATES**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
Know the salient features and life history of invertebrates.

CODE: NZOC11	**STRUCTURE AND FUNCTION OF INVERTEBRATES**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To impart knowledge on the structure and functional characteristics of diverse group of invertebrates. ➢ To illustrate the roots of invertebrate taxonomy and their classification. ➢ To identify the ecology, ethology and reproductive system of invertebrates. ➢ To know the medically importance of non-chordates. ➢ To learn about the adaptive radiation of invertebrates. ➢ To understand the evolutionary biology of invertebrates				

Unit I	**PRINCIPLE OF ANIMAL TAXONOMY**	**15 hours**

General characteristics of animal phyla- Classification of animal phyla upto order levels.Species concept- Taxonomic procedures- Animal collection, handling and preservation- Taxonomic Keys- Zoological Nomenclature: Nature of scientific names – Synonyms and Homonyms –Meanings of Authors in Brackets – Types: Holotypes, Paratype, Lectotype, Syntype, Neotype and Allotype – ICZN and its rules-New trends in taxonomy - Organization of coelom –Acoelomates – Pseudocoelomates - Coelomates: Protostomia and Deuterostomia.

Unit II	**LOCOMOTION AND FEEDING**	**14 hours**

Pseudopodia - Flagella and ciliary movement in protozoa - Hydrostatic movement in Coelenterata, Annelida and Echinodermata - Nutrition and Digestion - Patterns of feeding and digestion in lower metazoan - Feeding diversity in insects -Filter feeding in Polychaeta, Mollusca and Echinodermata.

Unit III	**RESPIRATION AND EXCRETION**	**13 hours**

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

Unit IV	**NERVOUS SYSTEM & CHEMICAL COORDINATION OF INVERTEBRATES**	**16 hours**

Primitive nervous system: Coelenterata and Echinodermata - Advanced nervous system: Annelida, Digestive Systems - Nervous and sensory system and Reproductive systems of invertebrates. **CHEMICAL COORDINATION:**Neurohumours-Hormones and Neuro Hormones-Endocrine Regulation in Crustaceans, Insects and annelids-Evolution of Endocrine system.		
Unit V	**LARVAL FORMS**	**14 hours**
Mode of larval development- larval forms of Protostome and Deuterostome Larvae- larval rms of free living parasites - evolutionary significance of larval forms - Minor Phyla -Structural features and affinity - Concept and significance - Organization and general characters.		
ReferenceBooks ➢ Hyman, L.H.1967 The invertebrates. Vol.l Protozoa through Ctenophora, McGraw Hill Co., New York. ➢ Barrington, E.J.W. 1979Invertebrate structure and function. Thomas Nelson and Sons Ltd., London ➢ Jagerstein, G.1979. Evolution of Metazoan life cycle, Academic Press, New York & London. ➢ Hyman, L.H.1967 The Invertebrates. Vol.2. McGraw Hill Co., New York. ➢ Hyman, L.H. 1969.The Invertebrates. Vol.8. McGraw Hill Co., New York and London. ➢ Barnes, R.D. 2006.Invertebrate Zoology, III edition. W.B. Saunders Co., Philadelphia. ➢ Russel-Hunter, W.D. 1979.A biology of higher Invertebrates, the Macmillan Co. Ltd., London ➢ Sedgwick, A. A.2000. student text book of Zoology. Vol.I, II and III. Central Book DePSOt, Allahabad. ➢ Parker, T,J., Haswell, W.A.2003. Text Book of Zoology, Macmillan Co., London		
Web Source:	https://study.com/academy/topic/invertebrates.html https://nptel.ac.in/courses/102106035 https://adlonlinecourses.com/product/courses/natural-sciences/animal-care/invertebrate-zoology-	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Describe the basics of taxonomy and nomenclature system and organization of body plan of invertebrates	K1, K2
CO2	Understanding the locomotory structure and their function of the diverse groups of non-chordates	K1,K2
CO3	Learn the physiology of respiratory and excretory system of invertebrates	K1,K2
CO4	Knowledge on the structure and function of nervous and reproductive system of invertebrates	K1, K2
CO5	Learn the evolutionary significance of larval forms of major and minor phyla of invertebrates.	K1,K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	L	M	L	L	L	L
CO2	M	H	L	L	L	L	L	L
CO3	H	L	L	M	L	L	L	L
CO4	H	H	L	L	L	L	L	L
CO5	M	H	L	L	L	L	L	L

(H-High, M-Medium, L-Low)

CORE PAPER II: COMPARATIVE ANATOMY OF CHORDATES

Semester	**I**
Course Type	**CORE PAPER II**
Title of the Course	**COMPARATIVE ANATOMY OF CHORDATES**
Course Code	**NZOC12**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC12	**COMPARATIVE ANATOMY OF CHORDATES**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should have a basic knowledge on systemic and biological importance of vertebrates and understanding on evolutionary significance.

CODE: NZOC12	**COMPARATIVE ANATOMY OF CHORDATES**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To have a comprehensive knowledge and get familiar with the general features and classification of animal kingdom. ➢ To learn about the adaptive features of chordates and understand diversity of vertebrates. ➢ To understand the medical importance of various classes of chordates and the economic importance of each phylum of chordates.				
Unit I	**ORIGIN OF CHORDATA**				**15 hours**
General characters Classification up to level of order- habits and habitats of chordates, Systematic position, phylogeny and Affinities of *Balanoglossus*- Protochordata : Concept of protochordata,Significance, food and feeding mechanism- Representative types and important features of Hemichordata- Affinities and systematic position of Herdmania- Characteristic features of Urochordata- Degenerate and Specialised characters of *Branchiostoma*- Cephalochordata:Primitive, Specialised characters of Branchiostoma.					
Unit II	**ORIGIN AND SYSTEMIC POSITION OF ANCESTRY VERTEBRATES**				**15 hours**
Diversity and Evolutionary history of vertebrates: Origin and Ancestry of Vertebrates, Importance of the study of vertebrate morphology- Ostracoderms: Silurian and Devonian Ostracoderms, Biological significance of Ostracoderms, Systematic and external features of Petromyzon, Structural peculiarities of Cyclostomata,- Earliest jawed vertebrates, importance features of Placodermi – Systemic and Economic importance of Scoliodon.					
Unit III	**ADAPTIVE RADIATION IN VERTEBRATES**				**12 hours**

Origin of the following: Amphibian, Reptiles, Birds, Mammals- Adaptive radiation in Chordates: Aquatic, Terrestrial, Aerial, Arboreal, Fossoria- Migration of birds, Flightless birds, -Fossil bird Archaeopteryx and its evolutionary importance- Bony fish:Distribution, Integument, Economic importance.

Unit IV	FUNCTIONAL SYSTEMS OF VERTEBRATES	15 hours

Respiratory system - Characters of respiratory tissue - Internal and external respiration - Comparative account of respiratory organs Excretory Systems: Urinary System- Structure and function of the Mammalian Kidney- Nervous system: Peripheral Nervous System and Central Nervous Systems- Sensory Organs: Components of a sensory organs- General sensory organs.

Unit V	VERTEBRATE INTEGUMENT AND SKELETAL SYSTEMS	15 hours

General features of the Vertebrate integument and its derivatives; Development, general structure and functions of skin and its derivatives - Glands, scales, horns, claws, nail, hoofs, feathers and hairs- Phylogeny-Specialization of the Integument-Skeletal System: The Skull- Introduction-Overview of Skull Morphology, Skull in various classes of vertebrates, Girdles and Limbs in Tetrapoda.

ReferenceBooks

- Kotpal, RL. 2019. Mordern Text Book of Zoology Vertebrates, 4th edition, Rastogi Publications, Meerut.
- E. L. Jordan and P.S. Verma, 2011.Chordate Zoology, S.Chand & CompanyLtd, New Delhi,.
- Alexander, R.M. 2005.The Chordata. Cambridge University Press, London. Miller and Harley: Zoology (6^{th} ed., W.C. Brown)
- Weischert, C.K., 1965. Anatomy of Chordates, McGraw Hill Book Co., Inc., N.Y.
- Pough Harvey F, Christine M .Janis and John B. Heiser. 2002.Vertebrate Life, Pearson Education Inc. New Delhi.
- Route and Solanki.2002.Learning Prochordata- Mammalia –Theoryand Practice Dominant Pub. & Distributors, New Delhi.

Web Source:	https://nptel.ac.in/courses/102106035

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Know the general characters, taxonomy and Classification upto level of order of vertebrates.	K1, K2
CO2	Understand Diversity and Evolutionary history of vertebrates,	K1,K2
CO3	Understand the adaptive radiation in Chordates Aquatic, Terrestrial, Aerial, Arboreal vertebrates.	K1,K2
CO4	Understand the functional system of vertebrates and association with comparative anatomy of chordates.	K1, K2, K4
CO5	Able to understand the development and function of integument system of vertebrates.	K1, K2, K4

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	L	L	L	L	L	L
CO2	H	H	L	M	L	L	L	L
CO3	H	L	M	M	L	L	L	L
CO4	H	H	L	M	L	L	L	L
CO5	M	L	L	H	L	L	L	L

(H-High, M-Medium, L-Low)

CORE PAPER III: ENVIRONMENTAL BIOLOGY

Semester	**I**
Course Type	**CORE PAPER III**
Title of the Course	**ENVIRONMENTAL BIOLOGY**
Course Code	**NZOC13**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC13	**ENVIRONMENTAL BIOLOGY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should possess basic knowledge on ecosystem, environmental pollution, natural disaster and conservation methods.

CODE: NZOC13	**ENVIRONMENTAL BIOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**

Course Objectives

- To understand the life processes, adaptation and habitats, interactions and biodiversity of organisms.
- To know the impact of pollution and strategies to control and mitigate the effects of pollution on public health.
- Enable to understand the impact of climate change and global warming on living organisms and conservation of natural resources.

Unit I	**ENVIRONMENT AND ECOSYSTEM**	**15 hours**

Biotic and abiotic interactions – Habitat and Niche: Concepts of habitat and niche – Niche width and overalp – Fundamental and realize niche, resource partition – **Ecosystem**: Concept – structure – Importance - Food chain and food web – Energy flow – Trophic structure and levels – Pyramids – Biogeochemical cylces: Complete and Incomplete biogeochemical cycles – Sedimentary cycle in tropics.

Unit II	**POPULATION AND COMMUNITY ECOLOGY**	**15 hours**

Characteristics of population; population growth curve; population regulation – Life history strategy (r and k – selection) – Species interaction – Types of interaction; Interspecific, competition, herbivory, carnivory, pollination, symbiosis – Community structure and attributes; Levels of species diversity and its measurement; edges and ecotones – Ecology succession: types – mechanism.

Unit III	**ECOLOGY OF ECOSYSTEM**	**12 hours**

Structure and function of ecosystem – terrestrial (Forest and grassland) and aquatic (freshwater, marine and estuarine) – Biological features of coral reefs, seaweeds, seagrasses and mangroves – Natural resources and their management.

Unit IV	**ENVIRONMENTAL POLLUTION AND CONTROL**	**14 hours**

Types of environmental pollution (Air, water, soil, marine and radioactive) – sources, causes, biological effects and control – Biological indicators and their role in environmental monitoring – Roles of microbes in bioremediation – Environmental education and awareness – Environmental Laws and Regulations.

Unit V	ENVIRONMENTAL CONSERVATION, DISASTER AND MANAGEMENT	16 hours
Man and animal conflict – species extinction – Ethics and conservation – *In situ* conservation: wild life sanctuaries, biosphere reserves, national park – Ex situ conservation: Zoo, Botanical garden, Aquaria and Gene banks – Germplasm conservation and cryopreservation –Indian case studies on conservation on conservation/management strategy (Project Tiger, Biosphere reserve) –Effects of climate change, global warming and its effect on living organisms: Tsunami, Cyclone Earthquake, flood: causes, consequences, control and management.		
ReferenceBooks ➢ Allan M. Jones, 1997. Environmental Biology, Routledge, UK. ➢ Kailash Thakur, 1997. Environmental Protection Law and Policy in India, Deep & Deep Publications, New Delhi. ➢ Verma, P.S. and Agarwal, V.K. 2000.Environmental Biology (Principles of Ecology) S. Chand & Company Ltd., New Delhi. ➢ Eugene P.Odum and Gary W. Barrett, 2005. Fundamentals of Ecology (5^{th} Edition), Cole Publishing Co. ➢ Michael Begon, Colin R. Townsend, John L. Harper, 2006. Ecology: From Individuals to Ecosystems, Wiley Blackwell. ➢ Sakesna, D.N. and Gaidhane, D.M. 2010. Environmental Biology, Stadium Press, New Delhi. ➢ Singh, J.P., Singh, S.P. and Gupta, S.R. 2017. Ecology, Environmental Science and Conservation, S. Chand & Company Ltd., New Delhi. ➢ Anubha Kaushik, Kaushik, C.P. 2021. Perspectives in Environmental Studies, New Age International (P) Ltd. Publishers, New Delhi.		
Web Source:	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3352627/ https://www.nios.ac.in/media/documents/SrSec338new/338_Book2_New.pdf https://testbook.com/learn/ecology-and-ecosystem/	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Describe the interaction of living organisms with the environment, energy transfer between the trophic level and know the cycling of elements in the environment.	K2
CO2	Understand the complex dynamics and spatial patterning of populations and of entire assemblages of multiple species across diverse environment.	K1, K2
CO3	Know the types of living organisms in various each ecosystem, conservation and sustainable utilization of natural resources.	K1, K2
CO4	Know the impact of pollution in the environment and its control measures; acquire knowledge on environmental education and environmental laws.	K3, K4, K5
CO5	Understand various methods of environmental conservation, disaster and management techniques.	K, K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	L	L	L	L	H	L
CO2	H	H	L	L	L	L	M	L
CO3	H	L	L	L	L	L	H	L
CO4	H	H	L	L	L	M	H	L
CO5	L	L	L	L	L	L	H	L

(H-High, M-Medium, L-Low)

CORE PAPER IV: ANIMAL BIODIVERSITY

Semester	**I**
Course Type	**CORE PAPER IV**
Title of the Course	**ANIMAL BIODIVERSITY**
Course Code	**NZOC14**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC14	**ANIMAL BIODIVERSITY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should possess basic knowledge on various components and conservation aspects of biodiversity.

CODE: NZOC14	**ANIMAL BIODIVERSITY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To understand the ecosystem, diversity of organisms and their ecological relationship. ➢ Know the genetic relationship of animals, animal distribution and biological hotspot areas. ➢ Inculcate conservation strategies of ecosystem and various enactments related to conservation policy at national and international level. ➢ To know how to measure biodiversity.				

Unit I	**BIOLOGICAL DIVERSITY**	**15 hours**

Species – Origin of new species, Community and ecosystem diversity, Genetic diversity, Systematics in Diversity – Environment and Genetic Variations – Biological Classification – Phylogenetic Relationship – Ecological Biodiversity –Species Concept – Biological and Phylogenic Concepts; Species Inventory – Biodiversity hot spots.

Unit II	**SPECIES DIVERSITY**	**15 hours**

Global distribution of species – Tropical species diversity- Diversity in terrestrial, marine and fresh water – Species extinction and Endangered Species; Threats to biodiversity; Extinction – Past rate of extinction – Human caused extinctions – Endemic species –Man and animal conflicts.

Unit III	**REMOTE SENSING AND BIODIVERSITY**	**14 hours**

Definition – Basic concepts of remote sensing – Electromagnetic radiation and Electromagnetic spectrum – Types of Remote sensing- Principles and applications – Principles and components of GIS – Application of Remote sensing and GIS: Animal biodiversity conservation and management.

Unit IV	**BIODIVERSITY REGULATING AGENCIES**	**14 hours**

National Biodiversity authority, function and powers of the national biodiversity authority. State biodiversity authority – Duties of central and State Government biodiversity management committees-Hurdles in enforcement of existing laws.

Unit V	BIODIVERSITY INDICES	14 hours
Basic Measurement methods, Computation of species richness, Biodiversity indices – Univariate method –Shannon Weiner Index, Simpson Index, Similarity and Dissimilarity index - Graphical/distributional techniques. Multivariate Method – Cluster analysis.		
ReferenceBooks	➢ Dadhich, L.K. and A.P. Sharma, 2002.Biodiversity –Strategies for Conservation, APH Publishing Corporation, New Delhi. ➢ Chaudhuri, A.B. and D.D. Sarkar, 2003. Mega diversity Conservation, flora, Fauna and Medicinal Plants of India's hot spots, Daya Publishing House, Delhi. ➢ Anne Maczulak, 2009. Biodiversity: Conserving Endangered Species (Green Technology). Facts on File Publishers. ➢ Hickman Jr., Cleveland, Larry Roberts, Susan Keen, Allan Larson, and David Eisenhour, 2011. Animal Diversity. McGraw-Hill Companies, Inc. New York. ➢ Zhi-Qiang Zhang (ED), 2012. Animal Biodiversity: An outline of higher-level of classification and survey of taxonomic richness, Mongolia Press. ➢ Anne E. Magurran, 2013. Measuring Biological Diversity, Wiley-Blackwell. ➢ Mark F. Watson, Chris Lyal and Colin Pendry, 2015. Descriptive Taxonomy: The foundation of Biodiversity Research, Cambridge University Press. ➢ George Joseph and Jegannathan, C., 2018. Fundamentals of Remote Sensing, The Orient Blackswan Publishers.	
Web Source:	➢ https://www.ugc.ac.in/oldpdf/modelcurriculum/Chapter4.pdf ➢ https://en.wikipedia.org/wiki/Biodiversityhttps://en.wikipedia.org/wiki/Vitamin ➢ http://nbaindia.org/ ➢ http://www.bsienvis.nic.in/database/biodiversity-hotspots-in-india_20500.aspx	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Understand the types of biodiversity, biological classification system, Phylogenetic relationship of organisms and Global Biodiversity hotspots.	K1, K2
CO2	Acquire knowledge on diversity and types of organisms in various ecosystems, threats to biodiversity, rate of extinction of species and IUCN red list of species.	K1, K2, K4
CO3	Learn about basics of concepts of remote sensing, components of GIS and its application in biodiversity conservation and management.	K1, K2
CO4	Know about the importance, duties, functions and powers of various biodiversity regulating agencies.	K1, K2
CO5	Analyze and measure the diversity of organisms using various computation methods.	K2, K3, K4, K5

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	L	M	L	M	H	L	L
CO2	H	L	L	L	L	L	M	H
CO3	L	L	L	L	L	H	H	L
CO4	L	L	L	L	L	M	H	L
CO5	H	L	L	L	L	M	L	L

(H-High, M-Medium, L-Low)

CORE PRACTICAL I: STRUCTURE AND FUNCTION OF INVERTEBRATES & COMPARATIVE ANATOMY OF CHORDATES

Semester	**I**
Course Type	**CORE PRACTICAL I**
Title of the Course	**STRUCTURE AND FUNCTION OF INVERTEBRATES & COMPARATIVE ANATOMY OF CHORDATES**
Course Code	**NZOL11**
Practical Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOL11	**STRUCTURE AND FUNCTION OF INVERTEBRATES & COMPARATIVE ANATOMY OF CHORDATES**	**Credits: 2**	**Max. Marks: 100**

Course Prerequisites:
The student should have a basic knowledge on structural and functional morphology of Invertebrates and chordates

CODE NZOL11	**STRUCTURE AND FUNCTION OF INVERTEBRATES & COMPARATIVE ANATOMY OF CHORDATES**	**L**	**T**	**P**	**C**
		-	**-**	**4**	**2**
Course Objectives	➢ To explore the knowledge on basic life forms of Invertebrates and medical significance of invertebrates. ➢ To understand the connecting links of Invertebrates and chordates. ➢ To Known the structure and function of Nervous system, digestive system and reproductive system of invertebrates and chordates. ➢ Understand the salient features and structural affinities protochordates. ➢ To aware about reproductive mechanism and nervous system of various classes of chordates and appreciate the economic importance.				

List of Practicals

STRUCTURE AND FUNCTION OF INVERTEBRATES - 36 Hours

1. Identification and study of selected Protozoan and Helminthes of medical importance
2. Identification and study of larval forms of:
3. Trochophore larva, ii) Nauplius larva iii) Zoea larvae of Prawn and crab iv) Bipinnaria larva.
4. Identification and study of larval forms from all major phyla of invertebrates (Fresh water, Marine water larval forms and Insect larval forms).
5. Mounting of mouth parts of Honey bee, House fly and Placoid scales.
6. Mounting the appendages of Prawn.
7. Dissection of nervous system of: Prawn, any insect (cockroach), Pila.
8. Dissection of reproductive system of any insect: Cockroach
9. Mounting of a. Sting of Honey bee b. Pedicellaria of Sea urchin c. Aristotle lantern of Sea urchin

COMPARATIVE ANATOMY OF CHORDATE - 36 Hours

1. Study of the following skull types with reference to jaw suspensions
2. a) Fish b). Frog c). Snake d) Calotes d)Rat/Rabbit
3. Study of the following specimens with Reference to their adaptive features for their respective modes of life:

   a). Echeneis b). Ichthyophis / Uraeotphlus c) Hyla d). Draco e) Pigeon f) Bat
   d). Adaptive radiation feathers e). Adaptive radiation fins in fish
   f). Adaptive radiation in the beak and hind limbs of birds
4. Study of the salient features and structural affinities of the following specimens:
   Amphioxus b) Balanoglossus c) Ascidian d) Peteromyzon
5. Dissection:
   A. Aortic Arches in Teleost
   B. Reproductive system of Rat (Demonstration)

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	To learn the epidemiology of protozoans and helminthes parasites.	K1, K2
CO2	To analyze the evolutionary significance of life stages of major and minor phyla of invertebrates	K1,K2
CO3	Understand the salient features, structural affinities and evolutionary significance of various vertebrates.	K1,K2
CO4	Develop the skill on handling, mounting techniques of mouth parts of Honey bee.	K2, K3
CO5	Acquire the skill of Mounting the appendages of Prawn and know the handling techniques of dissection of nervous system and reproductive system.	K1, K2, K6

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	M	L	L	M	H	L	L	L
CO2	M	L	L	M	M	L	L	L
CO3	H	L	L	M	L	L	L	L
CO4	L	L	L	M	M	L	L	M
CO5	L	L	H	M	L	L	L	M

(H-High, M-Medium, L-Low)

CORE PRACTICAL – II - ENVIRONMENTAL BIOLOGY AND ANIMAL BIODIVERSITY

Semester	**I**
Course Type	**CORE PRACTICAL II**
Title of the Course	**ENVIRONMENTAL BIOLOGY AND ANIMAL BIODIVERSITY**
Course Code	**NZOL12**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOL12	**ENVIRONMENTAL BIOLOGY AND ANIMAL BIODIVERSITY**	**Credits: 2**	**Max. Marks: 100**

Course Prerequisites:
Basic knowledge on Environmental Biology and Animal Biodiversity

CODE: NZOL12	**ENVIRONMENTAL BIOLOGY & ANIMAL BIODIVERSITY**	**L**	**T**	**P**	**C**
		0	**-**	**4**	**2**
Course Objectives	➢ To impart knowledge on primary productivity in an ecosystem ➢ To assess various water quality parameters. ➢ To identify plankton and measure its diversity. ➢ To preserve the collected faunal samples.				

List of Practical

ANIMAL BIODIVERSITY -36 Hours

1. Measurement of Aquatic Primary Productivity by Light and Dark bottle.
2. Estimation of Dissolved oxygen
3. Collection, Isolation and identification of planktons.
4. Diversity of Phytoplankton
5. Diversity of Zooplankton.
6. Fish community study: Species Identification – Diversity – Density – Abundance Distribution.
7. Study of museum specimens / lab specimens – Invertebrates and vertebrates (List the studied items with brief description – Diagrams necessary).

ENVIRONMENTAL BIOLOGY - 36 Hours

1. Estimation of salinity
2. Estimation of Nitrate
3. Estimation of Phosphate
4. Estimation of alkalinity
5. Analysis of Industrial effluent – TDS, TSS, BOD.

6. Field Visit to
   i. Drinking water treatment plant
   ii. Sewage treatment plant.

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Acquire knowledge on primary productivity in an aquatic ecosystem.	K1, K2
CO2	Develop skill to analyze physico-chemical parameters of water.	K2, K4, K5
CO3	Measure and assess the diversity, density and richness of the species through biodiversity index.	K2
CO4	Understand various steps to remove contaminants from the waste water.	K1, K2
CO5	Know the process of preserving fauna using various methods.	K1, K2,

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	L	L	L	L	L	L	H	L
CO2	L	L	L	L	L	L	H	L
CO3	L	L	L	L	L	M	H	L
CO4	L	L	L	L	L	L	H	L
CO5	L	L	L	L	L	L	H	L

(H-High, M-Medium, L-Low)

ELECTIVE I: ANIMAL CELL BIOTECHNOLOGY (E- PATHSALA-1)

Semester	**I**
Course Type	**ELECTIVE I (E- PATHSALA-1)**
Title of the Course	**ANIMAL CELL BIOTECHNOLOGY**
Course Code	**NZOEPA**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

NZOEPA	**ANIMAL CELL BIOTECHNOLOGY**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
The student should have a basic knowledge on genes, genetic engineering, microbiological aseptic practices.

CODE: NZOEPA	**ANIMAL CELL BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	➢ To give understanding on cell culture, requirements for animal cell laboratory ➢ To teach the concepts of tissue culture, organ culture tissue engineering its ethics and applications ➢ Tools used in genetic engineering, transgenic animal an their applications ➢ Concepts and applications of genetic engineering RNA interference (RNAi), Antisense oligodeoxynucleotide Technology, ene knock out/ gene targeting; generation of transgenic animals ➢ Assisted reproductive technology, animal conservation, Good laboratory practices.				
Unit I	**INTRODUCTION & SCOPE OF ANIMAL CELL CULTURE**				**8 hours**
Introduction and History of Cell Culture, types of cell culture, Laboratory Requirements for Animal Cell Culture in animal cell biotechnology, Media & Reagents Used in Animal Cell Biotechnology, Instruments and analytical techniques; Secondary Cell Culture and Cell Lines and Application of Animal Cell Culture.					
Unit II	**BASICS OF ANIMAL CELL CULTURE**				**10 hours**
The basic concept of tissue culture , Organ culture & applications, Different organ culture methods, Applications of organ culture; The basic concept of tissue engineering; Materials required for tissue engineering & their selection criteria; Applications of tissue engineering in generation of various organs; Ethical implication of tissue engineering.					
Unit III	**MODIFYING ENZYMES AND USES IN ANIMAL CELL BIOTECHNOLOGY**				**14 hours**

Modifying enzymes, different classes of modifying enzymes and their uses in animal cell biotechnology/ genetic engineering- Basic concept of transgenic animals , method of transgenic animal creation, ethical, social and legal concern related to transgenic animals, applications of transgenic animals in medicine, agriculture and industrials- Methods for construction of recombinant animal viral vectors for gene transfer into cell lines; structure of different animal viral vectors. application and future perspective of animal viral vectors

Unit IV	**CONCEPTS OF GENETIC ENGINEERING**	**12 hours**

Concept of Genetic Engineering, Methods in genetic engineering, Applications of Genetic Engineering, Future prospects of Genetic Engineering- Gene Expression in Eukaryotes Techniques in manipulation of gene expression in eukaryotes, RNA interference (RNAi), Antisense oligodeoxynucleotide Technology, Designed transcription factor- Collection and Purification Process of Recombinant Proteins- gene knock out/ gene targeting; generation of transgenic mouse, Applications of the gene knock out/ targeting.

Unit V	**ASSISTED REPRODUCTIVE TECHNOLOGIES**	**10 hours**

Sperm and Embryo sexing and disease transmission; Pregnancy Diagnosis in Animals; Stem Cell Technology and Therapeutics; Cell Cryopreservation and Animal Conservation; Animal cell culture, Tissue culture, Biosafety level, Different level of Bio-safety, Good Laboratory Practice Ethical Issues related to the Animal Cell

ReferenceBooks

- Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K and J.D. Watson. 1994. Molecular Biology of the Cell. (3rd Edn.), Garland Publishing Inc., New York.
- Ed. John R.W. 2000. Masters, Animal Cell Culture - Practical Approach, 3rd Edition, Oxford University Press.
- Griffth, A.J.F., Wessler, S. and R. Carroll. 2000. An Introduction to Genetic Analysis (7th Edn.)., W.H. Freeman & Co.
- Srinivastava, A. K., Singh, R. K. and M. P. Yadav. 2005. Animal Biotechnology, Oxford and IBH Publishing Co. CFA Bryce Pvt. Ltd.
- Yadav, P.R. and R. Tyagi. 2006. Biotechnology of Animal Tissue. Discovery Publishing House, New Delhi.
- Ramadass, P. 2008. Animal Biotechnology: Recent Concepts and Developments. MJP Publishers, India.
- Ian Freshney, R. 2010. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, John Wiley and Sons

Web Source:	➢ https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=t5vt4STquHRj94mcOBMr5g==

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Know the history of animal cell culture, laboratory requirements, equipments and media requirements for animal cell culture and applications of animal cell culture technique.	**K1, K2, K3**
CO2	Understand the basic concept of tissue culture, organ culture, tissue engineering, application of tissue engineering in organ generation and ethical implication in tissue engineering.	K2,K4,K5
CO3	Types modifying enzymes their uses in animal cell biotechnology. concept of transgenic animals , ethical, social and legal concern related to transgenic animals, applications of transgenic animals, Construction of recombinant animal viral vectors, different animal viral vectors. application of animal viral vectors	K1,K2,K3,K6
CO4	Concept & Methods of Genetic Engineering, manipulation of gene expression in eukaryotes, generation of transgenic animals; RNA interference (RNAi), Antisense oligodeoxynucleotide Technology - gene knock out/ gene targeting, Applications of the gene knock out/ targeting.	K1, K2, K3
CO5	Pregnancy Diagnosis in Animals; Sperm and Embryo sexing; Stem Cell Technology and Therapeutics; Cell Cryopreservation and Animal Conservation; GLP Ethical Issues related to the Animal Cell culture.	K2, K3,K4

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	L	M	H	M	L	L	L	L
CO2	M	H	H	L	L	L	L	L
CO3	M	H	H	H	L	L	L	L
CO4	M	H	H	H	L	L	L	L
CO5	M	H	H	M	L	L	L	L

(H-High, M-Medium, L-Low)

ELECTIVE I: 1. ENTREPRENEURIAL MUSHROOM CULTIVATION

Semester	**I**
Course Type	**ELECTIVE I**
Title of the Course	**ENTREPRENEURIAL MUSHROOM CULTIVATION**
Course Code	**NZOEA**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

NZOEA	**ENTREPRENEURIAL MUSHROOM CULTIVATION**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
Have basic knowledge of the aseptic handling in microbiology and entrepreneurial interest

CODE: NZOEA	**ENTREPRENEURIAL MUSHROOM CULTIVATION**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**

Course Objectives

- To teach the types of mushroom, life cycle, nutritive, medicinal value of mushroom in
- To teach the infrastructural requirements for mushroom culture
- To make understand the edible and medicinal mushroom production
- To teach the Disease management and Post harvest processing in mushroom cultivation
- To teach the various value added products from Mushroom

Unit I	**MORPHOLOGY AND IMPORTANCE OF MUSHROOM**	**10 hours**

Introduction to Mushroom –Role in nature and society, Basic structure and morphology of mushroom, Nutritive value of mushroom, Medicinal mushroom-Pharmaceutical value Types of mushroom (Edible, Non-edibe and poisonous), Life cycle of mushroom, Identification of wild mushroom

Unit II	**INFRASTRUCTURE, SKILL AND REQUIREMENTS FOR ARTIFICIAL CULTURE OF MUSHROOM**	**10 hours**

farm, -Spawn Unit, Production Unit, Cropping Unit and post-harvest handling unit, Machinery, Equipments and instruments in mushroom production and processing, Farm Design for mushroom production unit –Layout and construction materials, Laboratory requirements – Instruments and equipments, Pure culture of mushroom and its preservation techniques, Raw materials , Formulation and Sterilization

Unit III	**COMMERCIAL PRODUCTION OF EDIBLE MUSHROOM AND MEDICINAL MUSHROOM**	**12 hours**

Spawning and casing and culture practice of White button mushroom *(Agaricus bisporus),* Ingredients ,formulation of substrate preparation and crop management of oyster mushroom *(Pleurotus ostreatus),* Traditional and modern cultivation technologies of paddy straw mushrooms *(Volvariella volvacea),* Cultivation of milky mushroom (*Calocybe indica*), Production technology of the medicinal mushrooms: *Lentinus edodes* (Shiitake) and *Ganodorma lucidum* (Reishi), *Flammulina velutipes* (Winter mushroom) and *Cordyceps militaris* (Entomopathogenic fungus)

Unit IV	POST HARVEST TECHNOLOGY OF MUSHROOM AND DISEASE MANAGEMENT	10 hours
Growth regulators for mushroom yield enhancement, Quality traits and consumer acceptability, Post-harvest handling of fresh mushrooms, Recycling of spent mushroom waste, Microbial diseases of mushroom and their managements-bacterial, fungal and moulds and fungal diseases, Pest mushroom management (Insect and nematode)		
Unit V	**VALUE ADDED PRODUCTS AND MUSHROOM MARKETING**	**12 hours**
Ingredients and preparation of Mushroom soup powder ,mushroom nuggets, Mushroom ketch-up, Mushroom candy, mushroom pickle and mushroom preserve (murabba),mushroom Chips, Art of mushroom cooking : Mushroom tomato soup, mushroom onion soup, mushroom pakoda ,kadai mushroom, mushroom curry, mushroom tomato sauce,mushroom cabbage salad,mushroom dum biryani, Marketing of mushroom :Global and domestic, Entrepreneurial capital, SWOT analysis ,Licences legal frame work , Government Schemes		
ReferenceBooks ➢ Marimuthu, T. et al. 1991. Oster Mushroom. Department of Plant Pathology. Tamil Nadu Agricultural University, Coimbatore. ➢ Nita Bhal, 2000. Handbook on Mushrooms. 2nd ed. Vol. I and II. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi ➢ Pandey R.K, S. K Ghosh, 1996. A Hand Book on Mushroom Cultivation. Emkey Publications. ➢ Pathak, V. N. and Yadav, N. 1998. Mushroom Production and Processing Technology. Agrobios, Jodhpur. ➢ Tewari Pankaj Kapoor, S. C., 1988. Mushroom Cultivation. Mittal Publication, New Delhi. ➢ Tripathi, D.P., 2005. Mushroom Cultivation, Oxford & IBH Publishing Co. PVT.LTD, New Delhi. ➢ Pathak, V.K., Nagendra Yadav and Maneesha Gaur, 2000. Mushroom Production and Processing Technology/ Vedams Ebooks Pvt Ltd., New Delhi.		
Web Source:	➢ https://en.wikipedia.org/wiki/Mushroom ➢ https://en.wikipedia.org/wiki/Edible_mushroom	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Will understand the structure and morphology of mushroom, Nutritive value of mushroom, Pharmaceutical value Types of mushroom -Life cycle of mushroom	K1, K2
CO2	Will know the different units in Mushroom cultivation-Machinery, Equipments and instruments in mushroom production, Farm Design for mushroom production- Pure culture of mushroom and its preservation techniques, Raw materials and Sterilization	K1,K2
CO3	Will understand the pawning and casing and culture practice-Ingredients, formulation of substrate preparation and crop management of oyster mushroom, Traditional and modern cultivation technologies of paddy straw	K1,K2

	mushrooms.	
CO4	Will understand the Growth regulators for mushroom yield enhancement, Post-harvest handling of fresh mushrooms, Recycling of spent mushroom waste, Microbial diseases of mushroom and their management.	K1, K2
CO5	Will understand the Value added products preparation of Mushroom, Marketing of mushroom :Global and domestic, Entrepreneurial capital, SWOT analysis, Licenses legal frame work , Government Schemes	K1,K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	L	M	L	L	L	L
CO2	M	H	L	L	L	L	L	L
CO3	H	L	L	M	L	L	L	L
CO4	H	H	L	L	L	L	L	L
CO5	M	H	L	L	L	L	L	L

(H-High, M-Medium, L-Low)

ELECTIVE I: 2. APICULTURE

Semester	**I**
Course Type	**ELECTIVE I**
Title of the Course	**APICULTURE**
Course Code	**NZOEB**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

NZOEB	**APICULTURE**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites: Inclination for taking up Bee Keeping as a self employment activity

CODE: NZOEB	**APICULTURE**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	➢ Will gain the knowledge of different species and races of honey bees ➢ Will be able to identify flora and location of sites for Bee hives ➢ Understand the requirement of different bee species and preparing flowering calendar. ➢ Understand the using Bee boxes including cleaning of Boxes and various tools and equipment used in Bee keeping ➢ Understand the importance of health and hygiene in Bee keeping				
Unit- I	**HISTORY OF BEE KEEPING**				**8 hours**
Introduction to Apiculture - scope, importance - History of bee keeping: Definition, Bee keeping in worldwide, In India. Traditional bee keeping, Modern beekeeping, Urban or backyard beekeeping- Apiculture development in India - institutions involved. Role of Central Honey Bee Research & Training Institute.					
Unit II	**LIFE CYCLE OF HONEY BEE**				**10 hours**
Honey Bee morphology, Anatomy and Life cycle - Basic concepts of morphology of Honey bees - indigenous, exotic-Honey bee species and identification. Origin, systematic and distribution of honey bees. Types of honey bees, Species of honey bees. Bee identification-Social organization in honey bees: Colony life and social organization – Queen, drone, worker. Annual biological cycle of the bee colony.					
Unit III	**PESTS AND DISEASES MANAGEMENT**				**12hours**
Honeybee Enemies and Diseases-Bee enemies and diseases: An introduction, Bee enemies – Wax Moth, Ants, Wasps, Microorganisms, Pests. Diagnosis and Identification. - Mites attacking honey bees: Varroa mites, Mite Biology, Controlling Varroa Mites, Mechanical control, Mite-tolerant stocks, Biopesticides, Chemical (synthetic pesticide) treatments. - Bacterial, viral, fungal & protozoan diseases: Bacterial disease - American Foulbrood, European Foulbrood, Viral disease - Deformed Wing Virus, Sacbrood Virus, Black Queen Cell Virus, Kashmir Bee Virus, Acute Bee Paralysis Virus; Fungal disease - Chalkbrood, Stonebrood; Protozoan disease - *Nosemosis, Nosema cerana*.					
UnitIV	**PROPERTIES OF HONEY**				**12hours**

Honey - its properties and application in various fields- Honey - its medicinal properties - application in various fields - other valuable by products of honey bees-Value added honey products. Properties of honey products, Nutrients and composition of honey, Acid content and flavor effects.-Types of value added honey product		
Unit V	**HONEY PROCESSING AND ECONOMICS**	**12hours**
Honey Processing and Bee Hive Products-Honey extraction & handling - Quality control standards - Honey testing kit -Processing of honey. Other valuable by products of honey bees-Bee venom & Royal jelly extraction. Economics of bee keeping: Economics in small scale and large scale bee keeping. Economic Value of Commercial Beekeeping. - Preparing bankable bee keeping project: Steps involved in starting a beekeeping project, Funding sources for beekeeping projects.		
Reference Books ➢ Prost, P. J. 1962. Apiculture. Oxford and IBH, New Delhi. ➢ Bisht D.S.,2000 Apiculture, ICAR Publication. ➢ Singh S., 2002.Beekeeping in India, Indian council of Agricultural Research, New Delhi. ➢ Delaplane, K.S. 2006. Honey Bees and Beekeeping: A Year in the Life of an Apiary, 3rd Edition. ➢ Ross, C., 2007. The Georgia Center for Continuing Education, Athens, USA. Natural Beekeeping : Organic Approaches to Modern Apiculture, White River Junction, London, UK. ➢ Dadant C.P., Dadant C.C., Dadant M.G., Dadant J.C. (eds.) 2011. The Hive and The Honeybee. Dadant and Sons, Inc. Hamilton, USA. Sammataro D., Avitabile A. The Beekeeper's Handbook, 4th edition. Cornell University Press, USA.		
Web Source:	https://onlinecourses.swayam2.ac.in/nos19_as10/preview http://ecoursesonline.iasri.res.in/course/view.php?id=166	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to–	Cognitive Level
CO1	Analyze major trends in a given economic sector / sub-sector and identify Business Opportunities	K1, K2
CO2	Develop effective personal management skills like time management and communication skills.·	K1,K2
CO3	Devise a simple marketing and sales strategies and plan for a small business	K1,K2
CO4	Knowledge on the processing of honey and byproducts of honey.	K1, K2
CO5	Work out Business plan and economics of the project	K1,K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	L	M	L	L	L	L
CO2	M	H	L	L	L	L	L	L
CO3	H	L	L	M	L	L	L	L
CO4	H	H	L	L	L	L	L	L
CO5	M	H	L	L	L	L	L	L

(H-High, M-Medium, L-Low)

ELECTIVE I: 3. SEAWEED CULTURE AND ITS BIOPROSPECTING

Semester	**I**
Course Type	**ELECTIVE I**
Title of the Course	**SEAWEED CULTURE AND ITS BIOPROSPECTING**
Course Code	**NZOEC**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

CODE: NZOEC	**SEAWEED CULTURE AND ITS BIOPROSPECTING**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
The student should know about basics of phycology.

CODE: NZOEC	**SEAWEED CULTURE AND ITS BIOPROSPECTING**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	➢ Acquire knowledge on the importance and cultivation aspects of commercially important seaweeds. ➢ To know the nutraceutical and pharmaceutical potential of seaweeds. ➢ To learn the immunemodulatory property of seaweed derived products against aquaculture pathogens.				
Unit I	**BIOLOGY OF SEAWEEDS**				**10 hours**
Classification (Green, Brown and Red seaweed) – Life cycle – General characteristics – Occurrence and distribution of seaweed – Indian and Global production status - Unique features of seaweeds.					
Unit II	**SEAWEED CULTIVATION**				**11 hours**
Seaweed cultivation potential in India – Seaweeds of cultivation importance – Types of seaweed cultivation (Monoline, Floating raft, Polythene Bag, Long line, Vertical line, Hanging line, Pen, Cage and sack bag culture) – Factors influencing the growth of seaweeds -Challenges in seaweed harvesting.					
Unit III	**NUTRACEUTICALS FROM SEAWEEDS**				**10 hours**
Nutraceutical importance of seaweeds: Minerals and Vitamins – Proteins – Polysaccharides (Carageenan, Alginate, Agar), Lipids, Pigments, Phenolic compounds. Seaweeds as Human food: Nori, Kombu, Ogo, Irish moss, Kombu, Wakame – Utilization of seaweed as fish and animal feed – Cosmetics.					
Unit IV	**PHARMACEUTICALS FROM SEAWEEDS**				**11 hours**
Pharmacological activities of bioactive compounds derived from seaweeds – Antimicrobial, antioxidant, anticoagulant, anticancer, antiviral, anti-allergic, anti-inflammatory, antidiabetic, antigenotoxic activity – Treatment of Alzhemier disease and osteoporosis.					
Unit V	**SEAWEED POLYSACCHARIDES FOR AQUATIC DISEASE MANAGEMENT**				**12 hours**

Methods of extraction and characterization of polysaccharides (Fucoidan, Alginic acid, Carageenan) from seaweeds. Administration of polysaccharides in aquafeed for commercially important shellfish and finfish – Evaluation of growth performance – Immune response and diseases resistance.

ReferenceBooks

- Christopher S. Lobban and Paul J. Harrison, 1994. Seaweed Ecology and Physiology, Cambridge University Press.
- Vitor H. Pomin, 2004. Seaweed: Ecology, Nutrient Composition and Medicinal uses. Hauppauge Publishers, New York.
- Christian Wiencke and Kai Bischof, 2012. Seaweed Biology: Novel Insights into Ecophysiology, Ecology and Utilization, Springer.
- Herminia Dominguez, 2013. Functional Ingredients from Algae for Foods and Nutraceuticals, Woodhead Publishing Ltd.
- Degmar B. Stengel and Solene Connan, 2015. Natural products from marine algae, Humana Press.
- Joel Fleurence and Ira Levene, 2016. Seaweed in Health and Disease Prevention, Academic Press.
- Venkatesan, J., Anil, S. and Se-Kwon Kim, 2017. Seaweed Polysaccharides – Isolation, Biological and Biomedical Applications, Elsevier
- Luigi Salvay, 2018. Marine Algal Bioactives, Scitus Academics, USA.

Web Source:	https://www.fao.org/3/y4765e/y4765e04.htm#bm04.2 https://www.seaweed.ie/descriptions/

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	Cognitive Level
CO1	Understand the classification, biology and global status of seaweeds.	K1, K2
CO2	Acquire knowledge on various methods of cultivating commercially important seaweeds.	K3
CO3	Learn about the nutraceutical potentials of seaweed derived compounds.	K1, K2
CO4	Know about the pharmacological activity of active principles obtained from seaweeds.	K1, K2
CO5	Know the methods of extraction, characterization of polysaccharides from seaweeds and their immunomodulatory property in finfish and shell fish culture.	K4

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	L	L	M	L	M	L
CO2	M	L	L	L	L	L	L	L
CO3	L	L	L	L	H	L	L	H
CO4	L	L	L	H	H	L	L	H
CO5	L	L	L	L	H	M	L	M

(H-High, M-Medium, L-Low)

ELECTIVE I: 4. AQUACULTURE

Semester	**I**
Course Type	**ELECTIVE I**
Title of the Course	**AQUACULTURE**
Course Code	**NZOED**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

CODE: NZOED	**AQUACULTURE**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
The student should have a basic knowledge on importance of aquaculture and culture techniques

CODE: NZOED	**AQUACULTURE**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	➢ To learn the scope and importance of aquaculture at national and international level. ➢ To know the methods of constructing pond for cultivable fishes. ➢ To acquire knowledge on the cultivation aspects of live feed culture and fish disease management. ➢ To learn the method of preparing artificial fish feed and storage techniques.				
Unit I	**BASICS AND SCOPE OF AQUACULTURE**				**8 hours**
Scope and importance of Aquaculture- Introduction to fin fish and shell fish aquaculture-types of aquaculture-Global and Indian scenario. Major cultured species, systematic and biology (age and growth), breeding and reproduction. Biology and physiology of Indian major carps.					
Unit II	**HATCHERY AND AQUA FARM ENGINEERING**				**12 hours**
Types of hatchery, design, construction and maintenance-Brood stock selection and maintenance, maturation –larval stages-larval rearing- Post larvae management-larval feed (Artimia, Rotifer, Dhapnia and Microalgae) water quality management in hatchery. Selection of site, designing, layout and construction of aqua farms-Integrated fish farming- Modern approach of composite fish culture.					
Unit III	**AQUACULTURE NUTRITION**				**10 hours**
Importance of nutrition; nutritional requirements of cultivable fin and shell fish-carbohydrates, proteins and lipids, vitamins, minerals and their importance. Live feed culture- phytoplankton and zooplankton; culture of spirulina, Rotifers , Artemia, Daphnia and Moina. Artificial feed types - feed ingredients and feed formulation. Probiotics, prebiotics and their use in aquaculture.					
Unit IV	**AQUACULTURE DISEASE MANAGEMENT**				**12 hours**
Hormonal and genetic approach to modern aquaculture-fish genetics- fertilization -seed selection and stocking- RAS and biofloc technology-Aquamimicry- fish and shrimp disease management-fish breeding and hybridization-Role of ovaprim, Ovatide in induced breeding - Zoea syndrome, disease management and -uses of probiotics in hatchery.					

Unit V	NEW TECHNIQUES AND BIOSECURITY	12 hours
Role of PCR in health assessment (hatchery and farm)- Genetic engineering (Monosex and ploidy)-SOP- HACCP- Development of new techniques for aquaculture - Cryopreservation techniques for sperms- Application of remote sensing in conservation and management of fish faunal diversity- vaccines for aquaculture- Biosecurity measures in Aquaculture.		
Reference Books ➢ Michael, B.N. and Singholka, B. 1985. Freshwater Prawn Farming. A manual of culture of *Macrobrachium rosenbergii*. Daya Publishing House, New Delhi. ➢ Sinha, V.R.P. 1993. A Compendium of Aquaculture Technologies for Developing Countries. Center for Science and Technology and Oxford and IBH Publishing Co., Pvt., Ltd., New Delhi. ➢ Pillai, TVR. and M. N. Kutty., 2005. Aquaculture: Principles and Practices, Wiley-Blackwell. ➢ Robert R. Stickney, 2009. Aquaculture: An Introductory Text, CAB International Publishers. ➢ Dunham, A. Rex. 2011. Aquaculture and Fisheries Biotechnology, 2nd Edition, CAB International Publishers. ➢ Neha Charan, 2012. Fresh Water Fish Culture and Training, Random Publications. ➢ Pillay, T.V.R., 2013. Aquaculture and the Environment, Wiley Blackwell. ➢ Lucas, J.S. and Southgate, P.C. 2012. Aquaculture, 2nd Edition, Wiley-Blackwell ➢ Chandrasekhar Y.S, 2013. Fish Nutrition in Aquaculture, Swastik Publications.		
Web Source:	➢ https://www.openlearning.com/courses/aquaculture-sta2473-/?cl=1 ➢ https://www.udemy.com/course/becoming-aquaculture-expert-part-1/?utm_source=adwords&utm_medium=udemyads&utm_campaign=LongTail_la.EN_cc.INDIA&utm_content=deal4584&utm_term=_._ag_118445032537_._ad_533094112755_._kw__._de_c_._dm__._pl__._ti_dsa-1212271230479_._li_9040209_._pd__._&matchtype=&gclid=Cj0KCQjw1N2TBhCOARIsAGVHQc7pVvUHaiHOBJKUcapOtNXSj83fYxnmyWUKphRh7b9eEVo64rqd1a4aAqs9EALw_wcB ➢ https://www.udemy.com/topic/aquaculture/	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	Cognitive Level
CO1	Know the scope and importance of Aquaculture and structure of fin fish and shell fish, understand the types of aquaculture-Global and Indian scenario. Major cultured species, systematic and biology breeding and reproduction.	K1, K2
CO2	Understand the different types of hatchery - Design, construction and maintenance larval stages-larval rearing-Post larvae management. Know the larval feed and water quality management in hatchery. Designing, layout and construction of aqua farms.	K1,K2
CO3	Know the importance of nutrition, nutritional requirements of cultivable fin, shell fish. Understand the culture aspects Preparation and formulation of artificial feed – Utilization of probiotics in aquaculture.	K1,K2
CO4	Be acquainted with physiology of hormone and genetic approach to modern aquaculture and fish genetics-understand the fertilization and seed selection and stocking. Improve RAS and Biofloc technology.	K1, K2
CO5	Know the importance of PCR in health assessment - Development of new techniques for aquaculture cryopreservation techniques for sperms- Application of remote sensing in conservation of management of fish faunal diversity.	K1, K2, K4,K5

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	M	L	L	M	L	L	L	H
CO2	L	L	L	L	L	L	L	H
CO3	L	L	L	L	L	L	L	H
CO4	L	L	L	M	L	L	L	H
CO5	L	L	L	L	L	L	L	H

(H-High, M-Medium, L-Low)

CORE PAPER V: BIOCHEMISTRY

Semester	**II**
Course Type	**CORE PAPER V**
Title of the Course	**BIOCHEMISTRY**
Course Code	**NZOC21**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC21	**BIOCHEMISTRY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should have basic knowledge on principles, concepts of biochemistry and structure of biomolecules.

CODE: NZOC21	**BIOCHEMISTRY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To explore the chemistry of living organisms and other molecular bais for the changes occurring in living cells. ➢ To understand the metabolism of biomolecules. ➢ To diagnose and manage disease through analysis of blood, urine and other body fluids.				
Unit I	**CARBOHYDRATE**				**14 hours**
Classification, structure, properties and functions – Metabolism of carbohydrate : Glycolysis – TCA cycle – Glycogenolysis – Glycogenesis – Gluconeogenesis – HMP shunt pathway – Oxidative Phosphorylation.					
Unit II	**PROTEINS AND ENZYMES**				**15 hours**
Proteins : Structure – Classification and properties of amino acids – Structure of protein (Ramachandran plot, Primary, secondary, Tertiary, Quartenary, Domain, Motif & Folds) – Types of Bonds (Vanderwaals, electrostatic, hydrogen and hydrophilic bonds) – Biological significance – Enzymes : Types, classification and properties of enzymes – Enzyme kinetics - Enzyme inhibition – Mechanism of Enzyme catalysis – Isoenzymes - Coenzymes – Enzyme regulation – Inborn errors of metabolism.					
Unit III	**LIPIDS**				**14 hours**
Classification – structure, properties and biological functions of lipid – Biosynthesis of fatty acids, Triglycerides, Triacylglycerol, cholesterol, Phospholipids, Ketogenesis – Long chain fatty acids – Beta oxidation of fatty acids.					
Unit IV	**NUCLEIC ACIDS**				**14 hours**
Structure of nucleic acids – helix (A,B,Z), tRNA and microRNA – Synthesis and degradation of purine and pyrimidines (Denovo and salvage pathways) – Vitamins: Classification, Structure and metabolism of vitamins.					
Unit V	**HORMONES AND REGULATION**				**15 hours**

Structure, classification, hormones and their receptors – Steroid hormone receptor, peptide hormone receptor, signalling through G-protein coupled receptors – Signal transduction pathway, cAMP, cGMP, phospatidyl, inositol and calcium as secondary messenger – Hormonal regulation and signal transduction.

ReferenceBooks

- Frunton J.S. Simmonds, S. General, G. And Dol, R.H. 1987. Outlines of Biochemistry, John Wiley & Sons.
- Dubey, R.C. 1989. Biochemistry, MacMillan Publishing company. NY.
- Jain, J.L., Jain, S. and Jain, N., 2000. Fundamentals of Biochemistry, S. Chand & Company.
- RastoBiogi, S.C., 2003. Biochemistry (2nd Edition), Tata McGraw Hill Publishing Company Ltd.
- Voet, D. and Voet, J.G., 2004. Biochemistry, John Wiley & Sons, USA.
- David L. Nelson and Michael M. Cox., 2004. Lehninger Principles of Biochemistry, W.H. Freeman & Company, USA.
- Garrett, R.H. and Grisham, C.M., 2016. Biochemistry Cengage Learning Inc, USA.
- Satyanarayana, U. and Chakrapani, U., 2022. Biochemistry (6th Edition), Elsevier India.

Web Source:	➢ https://bio.libretexts.org/Bookshelves/Biochemistry/Supplemental_Modules_(Biochemistry)/6._Lab_Notes_Part_2/6.2%3A_Enzyme_kinetics ➢ https://opentextbc.ca/biology/chapter/18-1-types-of-hormones/#:~:text=There%20are%20three%20basic%20types,such%20as%20estradiol%20and%20testosterone. ➢ https://en.wikipedia.org/wiki/Vitamin ➢ https://bio.libretexts.org/Bookshelves/Biochemistry/Book%3A_Biochemistry_Free_For_All_(Ahern_Rajagopal_and_Tan)/02%3A_Structure_and_Function/2.08%3A_Structure_and_Function_-_Lipids_and_Membranes

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Understand the structure, function and metabolic pathways of carbohydrates	K1, K2
CO2	Learn the classification, structural organization of proteins, types of bonds involved in protein stabilization and to understand types of enzymes, mechanism of enzyme action, regulation and inhibition.	K2, K4, K5
CO3	Acquire knowledge on the basic lipid biochemistry and further to understand the properties, biological functions and important disorders of lipid metabolism.	K2
CO4	Know the structure of nucleic acids, various forms of DNA, RNA and understand the structure and metabolism of vitamins.	K1, K2
CO5	Learn about the structure of endocrine glands, different types of hormones, receptors and its role in signal transduction.	K1, K2,

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	L	H	M	L	L	L	L	L
CO2	L	H	L	H	M	H	L	L
CO3	L	H	L	L	L	L	L	L
CO4	H	L	M	L	L	M	L	L
CO5	L	M	H	M	L	L	L	L

(H-High, M-Medium, L-Low)

CORE PAPER VI: CELL AND MOLECULAR BIOLOGY

Semester	**II**
Course Type	**CORE PAPER VI**
Title of the Course	**CELL AND MOLECULAR BIOLOGY**
Course Code	**NZOC22**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC22	**CELL AND MOLECULAR BIOLOGY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should know the basic structure and function of cells, tissues and organs of an animal.

CODE: NZOC22	**CELL AND MOLECULAR BIOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**

Course Objectives

- To understand the cell and its function, transportation of molecules in and out of the cell.
- To equip knowledge on the biological significance of cell cytoskeleton and other cellular process.
- To learn the mechanism of cell signaling pathway, cell division and cell death process.
- To understand the structure and function of gene, gene expression and mechanism of gene regulation.

Unit I	**BIOMEMBRANE**	**14 hours**

Introduction-Chemical Composition of plasma membrane-Models for structure of Plasma membrane membranes –Membrane Transport- Types of Transport – Different types of Transport ATPase-Secondary Active Transport- - Co-transport by symptoms or antiporters - Transport across epithelia- Membrane Potential.

Unit II	**CYTOSKELETON**	**14 hours**

Introduction-Microfilaments, microtubules and Intermediate Filaments-structure, Assembly and dynamics-Motor Proteins-Actin Motors-Microtubular motors-Disease associated with motor protein defects–Biochemical composition of cytoskeletons-Functions of cytoskeleton-Role of cytoskeleton on Mitosis.

Unit III	**CELL- CELL SIGNALLING**	**15 hours**

Signalling Mechanism-Types of cell signalling: Endocrine-autocrine-Paracrine and Juxtacrine signalling-Signal Molecules- Forms of Intercellular signalling- Cell surface receptors- G-Protein coupled receptors. Signal transduction pathways: Second messengers, Lactoferrin. MAP Kinase Pathway- Regulation of signalling pathways. Cellular communication: Principle, Cell adhesion, Gap junctions, Cell matrix adhesion- APSOptosis-Biology of Ageing.

Unit IV	**GENOME ORGANIZATION**	**14 hours**

Chromosomal organization of coding and non-coding DNA – Chromosome types, structure - Regulation of gene expression - Morphological and functional elements of eukaryotic chromosomes– Organelle Genome: Genome in Mitochondria-genetic code of Mitochondria-TransPSOson elements		
Unit V	**PROTEIN CHARACTERIZATION AND SEQUENCE DETERMINATION**	**15 hours**
Proteomics- Protein Structure-Sequencing strategy- Protein Identification and Sequence analysis by Mass Spectrometry-MALDI. Protein Structure determination in Higher orders: Instrumentation for Three-dimensional Protein Structure-Determination of secondary and Tertiary structures of Protein		
ReferenceBooks	➢ Darnell, H. Lodish and D. Baltimore, 1986. Molecular Cell biology. Scientific American Book, Inc., USA ➢ Alberts, B., Bray, D., Lewis, J., Ratf, M., Roberts, J and, J. D. Watson, 2002. Molecular Biology of the Cell. Garland Publishing Inc., New York. ➢ Rastogi, S.C. 2010. Cell and Molecular Biology. New Age International Publishers. New Delhi ➢ Ajoy Paul, 2011 Text Book of Cell and Molecular Biology. Books and Allied Pvt.Ltd.Kolkatta. ➢ Aminul Islam, 2011. Text Book of Cell Biology. Books and Allied Pvt.Ltd.Kolkatta ➢ Prakash S. Lohar, 2019. Cell and Molecular Biology. GF Books Inc, USA.	
Web Source:	https://nptel.ac.in/courses/122103039 https://nptel.ac.in/courses/102103012	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	The understand the structure and function of cell and mechanism of transportation of molecules in and out of the cell	K1, K2
CO2	Learn the role of cytoskeleton on ordering the cell division process and apoptosis.	K1,K2, K3
CO3	Know the mechanism of cell communication, signalling receptors and its pathway	K1,K2, K3, K4
CO4	Describe the genome organization, chromosome structure, functioning of coding and non coding genes, gene expression and regulation	K2, K3, K4
CO5	Learn the technique for identify, structure and function of proteins and understand the mechanism of ageing.	K2, K3, K4, K5

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	M	L	L	L	L	L
CO2	H	H	M	L	L	L	L	L
CO3	M	H	M	H	L	M	L	L
CO4	H	H	M	M	L	M	M	L
CO5	M	H	H	L	L	L	M	L

(H-High, M-Medium, L-Low)

CORE PAPER VII: DEVELOPMENTAL BIOLOGY

Semester	**II**
Course Type	**CORE PAPER VII**
Title of the Course	**DEVELOPMENTAL BIOLOGY**
Course Code	**NZOC23**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC23	**DEVELOPMENTAL BIOLOGY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should have a basic knowledge on embryonic developments and concepts of gamete formation also, understanding on reproductive technology.

CODE NZOC23	**DEVELOPMENTAL BIOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To have a comprehensive knowledge and get familiar with development of organism and understand the cellular mechanism. ➢ To learn about the pattern formation and development of postembryonic stages. ➢ To understand the process of regeneration, metamorphosis and be familiar with the recent advancement of reproductive technology.				
Unit I	**ORIGIN AND BASIC CONCEPTS**				**14 hours**
The origin of developmental biology- cell theory, mosaic and regulative development, discovery of induction, basic concepts of developmental biology- cell division, cell differentiation, signaling, patterning, Potency, commitment, cytoplasmic determinants.					
Unit II	**CONCEPTS OF GAMETOGENESIS**				**14 hours**
Gametogenesis-fertilization and early development: Production of gametes, zygote formation, cleavage, blastula formation, gastrulation and formation of germ layers in animals; Spermatogenesis,embryogenesis Oogenesis: synthesis and storage of maternal transcripts, transcription lampbrush chromosomes, vitellogenesis.					
Unit III	**PATTERN FORMATION AND ORGANOGENESIS**				**14 hours**
Species specific sperm attraction, recognition of egg and sperm, acrosome reaction, Types of eggs and cleavage patterns: Concepts in Pattern formation, animal vegetal axis, gradients, origin, and specification of germ layers – Blastulation – Gastrulation.					
Unit IV	**POSTEMBRYONIC DEVELOPMENT**				**15 hours**
Polarity and Gradiants-Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*- post embryonic development- larval formation- Cell proliferation-Growth hormones-Metamorphosis in insects- hormonal control of insect metamorphosis-Imaginal discs- Amphibian metamorphosis- Morphological changes in amphibian					

metamorphosis-hormonal control of amphibian metamorphosis- Environmental regulation of normal development; sex determination.		
Unit V	**VERTEBRATE INTEGUMENT AND SKELETAL SYSTEMS**	**15 hours**
Regeneration in various animals. Asexual reproduction: Occurrence and forms of asexual reproduction. Regeneration: Regenerative capacity in the Animal Kingdom – Factors influencing regeneration – Stimulation and Suppression – Cryo-preservation of gametes and embryos -aging and senescence - Assisted Reproductive Technology (ART) – Male infertility – Sperm abnormalities – Superovulation – IVF, ICSI, GIFT – Screening of genetic disorders.		
ReferenceBooks ➢ Scott F. Gilbert. 2006. Developmental Biology, 8th edition, Sinauer Associates, Inc. Massachusetts, USA ➢ B. I. Balinsky. 2012. An Introduction to Embryology, 5th edition, Thomson Brooks Cole Publishing, Pvt Ltd., ➢ P S Verma & V K Agarwal. 2012. Chordate Embryology, 1st edition, S. Chand Publishing, India. ➢ D.R. Khanna, Advanced Embryology, Discovery Publishing House DPH, India ➢ T. Subramoniam, 2011, Molecular Developmental Biology, Second Edition, Alpha Science International Ltd, UK ➢ Julian S. Huxley and G. R. de Beer, 2015. The Elements of Experimental Embryology, Cambridge University Press, UK. ➢ T.H. Morgan, 2010. Embryology and Genetics, 1st edition, Agrobios India publishers, Jodhpur, India ➢ Bruce Carlson, Human Embryology and Developmental Biology, 2nd Edition, SPRINGER-VERLAG ➢ Rm Twyman, 2003, Instant Notes Developmental Biology, Viva Books Private Limited, India		
Web Source:	Introduction to Developmental Biology, Prof. Subramaniam K, IIT Madras, https://nptel.ac.in/courses/102/106/102106084/]	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Understand the origin and basic concepts of developmental biology-cell theory, mosaic and regulative development, cell division, differentiation, signaling, patterning, Potency, commitment and cytoplasmic determinants.	K1, K2
CO2	Develop the knowledge of gametogenesis early development zygote formation, cleavage formation of blastula, germ layer Spermatogenesis,embryogenesis, vitellogenesis and storage of maternal transcripts, transcription of lampbrush chromosomes,	K1,K2
CO3	Familiar with the awareness of Species specific sperm attraction, recognition of egg and sperm, acrosome reaction, Types of eggs and cleavage patterns and Concept in Pattern formation.	K1,K2

CO4	Understand the developmental mechanism of polarity gradiants, cell aggregation differentiation, sex determination and pattern formation in various organisms, metamorphosis and role of hormones in environment regulation of development.	K1, K2
CO5	Aware the regenerative capacity in the Animal Kingdom in various animals, Asexual reproduction, factors influencing regeneration knowledge of cryo-preservation of gametes and enable of aging and senescence also, importance of assisted reproductive technology related with Screening of genetic disorders.	K1, K2, K4

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

Mapping with PSO:

COs	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	L	H	H	L	L	L	L	L
CO2	L	M	H	L	L	L	L	L
CO3	L	L	H	L	L	L	L	L
CO4	L	H	H	M	L	L	L	L
CO5	M	L	M	M	L	L	L	L

(H-High, M-Medium, L-Low)

CORE PAPER VIII: MICROBIOLOGY

Semester	**II**
Course Type	**CORE PAPER VIII**
Title of the Course	**MICROBIOLOGY**
Course Code	**NZOC24**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC24	**MICROBIOLOGY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should have a basic knowledge on Prokaryotes and Eukaryotes and understanding on cell biology.

CODE: NZOC24	**MICROBIOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To give brief history and scope of Microbiology, culture of microbes, types of media, staining and identification methods-Physical and chemical methods of Sterilization. ➢ Understand the microbial pathogenesis, antibiotics types based on mode of action and their antimicrobial resistance. ➢ To familiarize the role of microorganisms in the productivity of ecosystem - cycling of Nutrients, bio-remediation, meta-genomics, bio-conversions and food spoilage microbes and food borne pathogens. ➢ To give exposure to industrially important microbes and the microbial fermentation products.				
Unit I	**HISTORY AND DEVELOPMENT OF MICROBIOLOGY**				**14 hours**
History and Scope of Microbiology- Whittaker's five kingdom concept- Classification of bacteria, fungi, yeast and virus – Ultra Structure and function of bacteria and viruses.- Media preparation Microbial cultivation composition of media, types of media, Phases of bacterial growth curve-					
Unit II	**STERILIZATION**				**14 hours**
Physical Methods of Sterilization-Dry heat, moist heat, filtration, pasteurization, radiation, Chemical methods of Sterilization– Methods of collection of sample – Methods of estimation of microorganisms in soil, water and air – Isolation and identification of bacteria- microbial Staining methods – Simple Staining, Grams's staining, Negative Staining, Acid fast Staining, Endo-spore, Capsule staining and flagellar staining.– Biochemical tests and fermentation tests.					
Unit III	**MICROBIAL PATHOGENESIS**				**14 hours**

Bacterial, viral, fungal and protozoan diseases – Host parasite interaction- Mode of transmission–Control and preventive measures – Antimicrobial therapy & antimicrobial resistance., Classification and mode of action of antibiotics.		
Unit IV	**MICROORGANISMS DISTRIBUTION**	**14 hours**
Role of microorganisms in the productivity of ecosystem -cycling of Nutrients- Carbon, Nitrogen, Phosphorus, Sulfur Cycles- Factors influencing the distribution of microorganisms – Metagenomics concepts and significance. Food Spoilage microbes and Food pathogens (bacterial, Viral, fungal, protozoan)		
Unit V	**INDUSTRIAL MICROBIOLOGY:**	**16 hours**
Industrially important microorganisms – Fermentation-Definition, types-upstream and downstream process. Bioconversion –Bioremediation–Food and additives- Single cell protein - Production of industrial microbial products – Antibiotics-Penicillin, ethanol-vinegar, vitamin B12 – Citric acid and glutamic acid production.		
ReferenceBooks	➢ Pelzar, M.J.J., Chan, ECS and Kerig, NR. 1993. Microbiology – Concepts and Applications. ➢ Prescott, L.M., Harley, J.D and Klein, D.A. 1999. Microbiology, WEB Mc Graw – Hill. ➢ Dubey, H.C., 2004. A text book of fungi, bacteria and viruses, Vikas Publishing House. ➢ Atlas, R.M. 1995. Principles of Microbiology. Mosby - Year Book Inc. ➢ Ananthanaryanan, T and Paniker, J.C.K. 2000. Text Book of Microbiology Oriental Longman Ltd., Madras ➢ Rheinhemer, G. 1980. Aquatic Microbiology, John Wiley and Sons. ➢ Davis, D., Dulbecco, R., Eisen, H.N and Ginsberg, H.S. 1980. Microbiology, Third Ed., Harper and Row Publishers, Hagertown. ➢ George, W. Burns. 1980. The Science of Genetics: An introduction to Heredity, Fourth Edition, Mc Milan Publishing Co., Inc., New York. ➢ Tewari, 2000. Advances in Microbial Technology, APH, New Delhi. ➢ Rajni Gupta and Mukherji, 2001. Microbial Technology, APH, New Delhi.	
Web Source:	https://nptel.ac.in/courses/102103015 http://ecoursesonline.iasri.res.in/mod/page/view.php?id=5146 https://nptel.ac.in/courses/102105058 https://en.wikipedia.org/wiki/Antimicrobial_resistance https://courses.lumenlearning.com/microbiology/chapter/biogeochemical-cycles/ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6604998/	

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Know the taxonomy and Classification of bacteria, fungi, yeast and virus – Ultra Structure and function of bacteria and viruses.- Phases of bacterial growth curve- Different Staining methods	K1, K2, K4
CO2	Understand the physical and chemical methods of Sterilization– Media preparation – Methods of collection of sample – Methods of estimation of microorganisms– Isolation and identification of bacteria – Biochemical tests.	K2,K4,K5
CO3	Be aware of the microbial Pathogenesis– Host parasite interaction- Epidemiology and Control of microbial diseases– Antimicrobial therapy & antimicrobial resistance, types and mode of action of antibiotics.	K1,K2,K4
CO4	Understand the ecological significance of microorganisms ecosystem - Microbial interactions between plant and animals– Metagenomics concepts-Food borne diseases and Microbial Food pathogens	K1, K2, K4
CO5	Recognize the industrially important microorganisms – Fermentation process-. Bioconversion –Bioremediation– Food and additives- Single cell protein - Production of industrial microbial products –	K1, K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	M	L	L	L	L	L
CO2	H	H	M	L	L	L	L	L
CO3	M	H	M	H	L	M	L	L
CO4	H	H	M	M	L	H	H	L
CO5	M	H	H	L	L	L	M	H

(H-High, M-Medium, L-Low)

CORE PRACTICAL – III - BIOCHEMISTRY & CELL AND MOLECULAR BIOLOGY

Semester	**II**
Course Type	**CORE PRACTICAL III**
Title of the Course	**BIOCHEMISTRY & CELL AND MOLECULAR BIOLOGY**
Course Code	**NZOL21**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOL21	**BIOCHEMISTRY & CELL AND MOLECULAR BIOLOGY**	**Credits: 2**	**Max. Marks: 100**

Course Prerequisites:
The students should know the basics of biochemistry & knowledge on the cell structure and functions of various organisms.

CODE: NZOL21	**BIOCHEMISTRY & CELL AND MOLECULAR BIOLOGY**	**L**	**T**	**P**	**C**
		0	**-**	**4**	**2**
Course Objectives	➢ To determine the biomolecules by qualitative and quantitative method. ➢ To separate compounds by chromatography and prepare buffers. ➢ To understand different types of cells and their structure ➢ To analyze the biochemical parameters of blood. ➢ To learn the karyotyping of organisms and understand the mitosis and meiosis process.				

List of Practical

BIOCHEMISTRY -36 Hours

- Preparation of Buffers: Phosphate and Citrate Buffer.
- Qualitative analysis of biomolecules (proteins, carbohydrates and lipids).
- Estimation of protein
- Estimation of lipids
- Estimation of carbohydrates
- Estimation of Glucose
- Estimation of Urea
- Estimation of Creatinine
- Determination of aminoacids in body fluids of cockroach using paper chromatography
- Determination of aminoacids through thin layer chromatography.

CELL AND MOLECULAR BIOLOGY - 36 Hours

- Separation of bioactive compound by Thin Layer Chromatography
- Electrophoresis (Demonstration) Principles and utility of microscopy
- Cell size determination
- Observation of distinguishing features of different eukaryotic cells.
- Preparation of blood smear and differential staining of blood cells.
- Identification of Blood group.

- Haemolymph Study of Cockroach
- Preparation of blood film (Thin and Thick)
- Haemocytometery of RBC and WBC of human blood.
- Determination of erythrocyte sedimentation rate (ESR)
- To study different phases of mitosis in Onion root tip.
- To study meiosis in Grasshopper testis.
- Human Buccal smear to show squamous epithelial cells
- To study the Barr body from the smear of buccal epithelial cells (FEMALE)
- Preparation of polytene chromosomes of Chironomous larva/Drosophila.

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Analyze the biomolecules in the tissue and blood samples.	K4
CO2	Separate aminoacids and bioactive compounds using chromatography technique and to estimate glucose, urea and creatinine	K2, K4, K5
CO3	Enable to handle different types of microscope used in biological research, understand the functional differentiation of eukaryotic and prokaryotic cells.	K1, K2
CO4	Acquire knowledge on the structure of blood components and blood biochemical parameters such as blood counting, grouping and ESR.	K3
CO5	Analyze the mechanism of mitosis, meiosis and enumerate the structure of polytene chromosome of chironomous larvae.	K4, K3

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	L	H	L	M	M	L	L	M
CO2	L	H	L	M	L	L	L	L
CO3	H	H	M	L	L	M	L	M
CO4	M	H	M	H	L	M	L	M
CO5	M	H	H	L	L	L	M	M

(H-High, M-Medium, L-Low)

CORE PRACTICAL – IV: DEVELOPMENTAL BIOLOGY & MICROBIOLOGY

Semester	**II Semester**
Course Type	**CORE PRACTICAL IV**
Title of the Course	**DEVELOPMENTAL BIOLOGY & MICROBIOLOGY**
Course Code	**NZOL22**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOL22	**DEVELOPMENTAL BIOLOGY & MICROBIOLOGY**	**Credits: 2**	**Max. Marks: 100**

Course Prerequisites:
The students should know the basics of biochemistry & knowledge on the cell structure and functions of various organisms.

CODE: NZOL22	**DEVELOPMENTAL BIOLOGY & MICROBIOLOGY**	**L**	**T**	**P**	**C**
		0	**-**	**4**	**2**
Course Objectives	➢ To impart knowledge on the growth and development of an organisms. ➢ To understand the growth and metamorphosis of organisms. ➢ To know the regenerating ability in amphibians. ➢ To understand the methods of cultivating bacteria. ➢ To identify, grow and determine the antibiotic sensitivity of bacteria.				

List of Practicals

DEVELOPMENTAL BIOLOGY - 36 Hours

- Structure of spermatozoa and egg
- Study on types of cleavage
- Vital staining and mounting of chick blastoderm
- Regeneration in Amphibians
- Study of insect metamorphosis

MICROBIOLOGY - 36 Hours

- Preparation of Non-Selective and Selective culture media.
- Enumeration of microorganisms through spread plate and pour plate method.
- Staining methods: Preparation of smears for staining – Simple staining, Negative staining, Gram staining.
- Identification of bacteria – Staining method – Gram positive and Gram negative bacteria.
- Measurement of bacteria through microscopy.
- Bacterial growth curve – Counting.
- Antibiotic susceptibility test.

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Study and understand the growth and development of organisms, to know the regenerating ability of amphibian.	K1, K2
CO2	Learn the metamorphosis of insects and staining of chick blastoderm.	K2
CO3	Isolate, enumerate and cultivate bacteria.	K3, K5
CO4	Identify bacteria through various staining methods and measure the size and determine the growth of bacteria.	K4
CO5	Perform antibiotic sensitivity pattern for pathogenic bacteria.	K4

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	H	M	L	L	L	L
CO2	H	H	H	M	L	L	L	L
CO3	L	H	L	L	L	L	M	L
CO4	L	H	L	L	L	L	M	L
CO5	L	H	L	L	L	L	L	L

(H-High, M-Medium, L-Low)

CORE PAPER IX: COMPARATIVE ANIMAL PHYSIOLOGY

Semester	**III**
Course Type	**CORE PAPER IX**
Title of the Course	**COMPARATIVE ANIMAL PHYSIOLOGY**
Course Code	**NZOC31**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

CODE: NZOC31	**COMPARATIVE ANIMAL PHYSIOLOGY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should have a basic knowledge on animal physiology of various animals.

CODE: NZOC31	**COMPARATIVE ANIMAL PHYSIOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**

Course Objectives

- To have a comprehensive knowledge and get familiar with the biological functions, structural arrangements of various organ in animal systems.
- To provide knowledge on vital physiological process, muscle and endocrine of animals
- To know the biological significance of hormones and acquire knowledge on the respiration, circulatory process and understand the biological clock mechanism of organisms

Unit I	**ADAPTATION**	**15 hours**

Levels of adaptation - Mechanism of adaptation - Significance of body size - Adaptation, acclimation and acclimatization - Concepts of homeostasis. Physiological adaptations of different environments – Marine - Shores and Estuaries – Freshwater - Extreme aquatic environments - Terrestrial life - Extreme terrestrial environments - Parasitic habitats.

Unit II	**DIGESTION AND PHYSIOLOGICAL MECHANISM**	**14 hours**

Digestion: Absorption, - Role of salivary glands, Pancreas and intestinal glands in digestion – Regulation of body temperature - Physiological adaptation to osmatic and ionic stress; - Osmoregulation in aquatic and terrestrial environments. Physiological response to oxygen deficient stress - Physiological response to body exercise - Meditation, Yoga and their effects.

Unit III	**RESPIRATORY PHYSIOLOGY**	**14 hours**

Structures – Respiratory gases – uptake – respiratory pigments – O_2 & CO_2 dissociation curves – transport of respiratory gases. Anatomy and Physiology of the respiratory tract- transport of oxygen and carbon dioxide - regulation of respiration.

Unit IV	**EXCRETORY PHYSIOLOGY**	**14 hours**

Excretory organs – mechanism of excretion – physiology – adaptations of excretion to environment – Excretory products: synthesis and elimination-Mammalian kidney - Urine formation- waste elimination - regulation of water balance - acid base balance.

Unit V	NEUROMUSCULAR AND ENDOCRINOLOGY	15 hours
Neurons – action potential – nerve impulse transmission – neurotransmitters – mechanism of neural transmission – Nerve conduction- synapse- Neurotransmitters- Neurons central and Peripheral Nervous system - Basic mechanisms of hormone action - endocrine glands in mammal – Pituitary, Thyroid, Adrenal and Islets of Langerhans - hormones and functions – hormonal disorders - Role of reproductive hormones.		

ReferenceBooks

- Jordan, E.L. and Verma, P.S. 1993.Chordate Zoology and Animal Physiology, S Chand and Company.
- Schiemdt Nielsen, K.1997. Animal Physiology: Adaptation and Environment. Cambridge University Press.
- Kay, I. 1998. Introduction to Animal Physiology, Kay(Ian), Bios Scientific Publishers.
- Verma, P.S. 2000. Physiology Edn.5 Part Ii, Verma (P.S) Etc, Aul. H Ed.Nch (James) Himalaya
- David Randall, Warren Burggren and Kathleen French, 2002. Eckert's Animal Physiology Mechanisms and Adaptations, 2002. W.H. Freeman & Co. Ltd.
- Berry, A.K. 1993. Textbook of Animal Physiology and Endocrinology, Emkey Publications.
- Berry, A.K. 2002. Textbook of Animal Physiology With Related Biochemistry For B.Sc., and M.Sc., Students Of Zoology of All Indian Universities, Emkey Publications.
- Rastogi, S.C., 2008. Essentials of Animal Physiology, The New Age International.

Web Source:	➢ https://onlinecourses.nptel.ac.in/noc20_bt42/preview ➢ https://onlinecourses.swayam2.ac.in/cec20_bt19/preview ➢ https://www.classcentral.com/course/edx-respiration-in-the-human-body-3050 ➢ https://onlinecourses.nptel.ac.in/noc20_hs33/preview ➢ https://www.classcentral.com/course/edx-comprendre-la-respiration-10242

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1:	Know the mechanism of adaptation and significance of body size, Concepts of homeostasis. Understand the adaptations of different environments and biology of Parasitic habitats.	**K1, K2**
CO2:	Be familiar with the Physiology Animal digestion and absorption and Role of salivary glands, importance of intestinal glands and regulation of body temperature. Know the physiological adaptation to and osmoregulation in aquatic and terrestrial environments.	**K1,K2**
CO3:	Know the Structure and function of respiratory system of different animal and transport of respiratory gases. Understand the Anatomy and Physiology of the respiratory tract- transport and regulation of respiration.	**K1,K2**
CO4:	Be aware of mechanism of excretion, physiology and adaptations of excretion to environment and know about excretory products. Understand the structure of mammalian kidney formation of urine, waste elimination, regulation of water and acid balance.	**K1, K2**
CO5:	Understand the function of neurons, nerve impulse, central	**K1, K2**

	and Peripheral Nervous system. Know the Basic mechanisms of hormone action and endocrine glands in mammal.	

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	M	L	L	H	L	L	L	L
CO2	M	L	L	H	L	L	M	L
CO3	L	L	L	H	L	L	L	L
CO4	M	L	L	H	L	L	L	L
CO5	L	L	L	H	L	L	L	L

(H-High, M-Medium, L-Low)

CORE PAPER X: IMMUNOLOGY

Semester	**III**
Course Type	**CORE PAPER X**
Title of the Course	**IMMUNOLOGY**
Course Code	**NZOC32**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC32	**IMMUNOLOGY**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
Have knowledge of the Microbiology and Biochemistry of Cell.

CODE: NZOC32	**IMMUNOLOGY**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To make students understand the types lymphoid organs lymphoid cells ➢ To make students learn the types of immunoglobulins, antigen antibody responses. ➢ To give a understanding on the Histocompatibility organs transplantation, ➢ To give knowledge on hypersensitivity, Complement system ➢ To make students learn the immunological diagnostic techniques				
Unit I	**TYPES OF IMMUNITY & CELLS AND ORGANS OF IMMUNOLOGY**				**13 hours**
Types of Immunity Innate and Acquired immunity – Lymphoid-system: Primary and secondary lymphoid organs, tissues. Cells of immune-system: lymphoid lineage, myeloid lineage. Molecules-complement, acute phase proteins, interferon, lymphokines and cytokines.					
Unit II	**ANTIGENS ANTIBODY RESPONSES**				**13 hours**
Chemical nature of antigens- epitope and paratope- - essential factors for antigenicity & pathogenicity- cross reacting antigen, heterophile antigens, Forssman antigens, haptens, adjuvants. Antibodies and immunoglobulin - Structure of immunoglobulin, Types of Immunoglobulin, Structure and biological properties of immunoglobulin G, M, A, D and E - Monoclonal and polyclonal antibodies - Hybridoma technology- Monoclonal antibody production and designer monoclonal antibodies.-Antigen - Antibody reactions-- precipitation - single radial immunodiffusion –double immunodiffusion –immunoelectrophoresis – rocket immune electrophoresis- Immunofluorescence. Agglutination: haemagglutination- bacterial agglutination- passive agglutination- agglutination inhibition test - Binder- Ligand assays: RIA, ELISA, EMIT.					
Unit III	**IMMUNE RESPONSE AND HYPERSENSITIVITY REACTIONS**				**16 hours**
Humoral immune response - Primary and secondary humoral immune response, importance of B-cells in humoral immune response (antibody formation), factors influencing antibody formation. Cell mediated immune response – cells involved in the cell mediated immune response, cytokines and their actions- Complement System Classical pathway, Alternate pathway, MBL pathway Types of hyper sensitivity – Type I, II, III, IV and V hyper sensitivity reactions.					

Unit IV	AUTO IMMUNITY & TRANSPLATATION IMMUNOLOGY	15 hours
Autoimmunity – causes of autoimmune diseases - Type-1Diabetes- Addison's disease and Graves, disease. Immunostimulation and Immunosuppression organ specific and systemic auto immune diseases – diagnosis and treatment Autoimmune disease detection: Rheumatoid arthritis, Transplantation immunology - types of grafts - Histocompatibility Complex (MHC)-Mechanism of graft rejection - graft versus host reaction –immune suppression - prevention of graft rejection.- Histocompatibility testing: HLA typing- RFLP method, PCR method: Immunodeficiency-inherited and acquired.		
Unit V	**VACCINES AND DIAGNOSTIC IMMUNOLOGY**	**15 hours**
Vaccine – types – whole organism/live vaccines, inactivated killed / attenuated vaccines- synthetic peptide vaccine, multivalent subunit-anti idotype vaccine, designer vaccine, edible vaccine, DNA vaccine, recombinant vector vaccine; Abzymes:Detection methods of antigens and antibodies: Immunodiffusion: Ouchterlony analysis-Double immunodiffusion. Immunoelectrophoresis. Radio immunoassay– Isoelectric focussing Binder- Ligand assays: RIA, ELISA, EMIT.- Hepatitis – B virus test-Immune complex detection: Rossette Forming Assay, Plaque Forming Assay, complement fixation test.		

ReferenceBooks

- Roitt, Ivan, M., Brostoff, Jonathan, Male, David, K., 1998. Immunology, London, Philadelphia.
- Rastogi. S.C, 2010. Elements of Immunology, CBS Publishers and Distributors.
- Janis Kuby, 2018. Immunology W.H.Freeman and Company, New York.
- Coleman, R.M., Lomb, M.F. and R.E.S. Cord, 1999. Fundamental Immunology 2nd Edn. W.C. Brown Publishers U.S.A.
- Darla J. Wise., Gordonr Carter, 2010. Immunology, Wiley-Blackwell.
- Roitt, 2017. Essential Immunology, Delves, Wiley-Blackwell.
- Julius M Cruse; Robert E Lewis, 2013. Immunology Guidebook, Academic Press.
- Angela, H., 2010. Immunology, Oxford University Press.
- Talwar .G.P. and S.K. Gupta, 2012. A hand book Practical immunology, Second edition, CBS publisher.
- Pinchuk, G. 2004. Schum's Outlines Immunology, Tata McGraw –Hill.

Web Source:	https://nptel.ac.in/courses/102106035 Immunology : https://www.classcentral.com/course/swayam-immunology-14117 Immunology : https://swayam.gov.in/nd2_cec20_bt05/preview https://www.classcentral.com/course/immunologyfundamentalsimmunitybcells-12724 https://www.coursera.org/lecture/immunologyfundamentalsimmunitybcells/monoclonal-antibodies-KxBvo -

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	The students will know the types of Immunity– Lymphoid-system: Primary and secondary lymphoid organs, tissues. Cells of immune-system	K1, K2
CO2	The students will know the types of antigens- Types of antibodies and properties and antigen antibody interactions	K1,K2
CO3	The students will know the Primary and secondary humoral immune response- Complement System Classical pathway, Alternate pathway- Types of hyper sensitivity.	K1,K2
CO4	The students will know the autoimmunity diagnosis and treatment Autoimmune disease- Transplantation immunology	K1, K2
CO5	The students will know the Vaccine – types Detection methods of antigens and antibodies	K1,K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	L	H	L	L	L	L
CO2	H	H	L	H	L	M	L	L
CO3	M	H	L	H	L	L	L	L
CO4	H	M	M	H	L	L	L	L
CO5	M	H	L	H	L	L	L	L

(H-High, M-Medium, L-Low)

CORE PAPER XI: GENETICS

Semester	**III**
Course Type	**CORE PAPER XI**
Title of the Course	**GENETICS**
Course Code	**NZOC33**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC33	**GENETICS**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
Know the basic mechanism of transmission of hereditary characters in organisms.

CODE: NZOC33	**GENETICS**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ Understand the transmission of hereditary characters in populations. ➢ Know the phenotypic and genotypic expression of gene. ➢ Learn the structure and function of genome of organisms. ➢ Enable to know the mutagenic substance and their biological impacts. ➢ Realize the structural and numerical aberrations ofchromosomes. ➢ Understand the concept sex determination pattern of organisms. ➢ Know the gene expression for protein synthesis and post transcriptional modifications of protein products				
Unit I	**MENDELIAN GENETICS**				**15 hours**
Fundamental of Mendelian genetics: Principles of segregation- Rediscovery of Mendel's work-Mendelian inheritance in Human- Extension and Application of Mendelian genetics-Geneic Interaction: Types of genic interaction -Linkage and crossing over, sex linkage, sex limited and sex influenced characters.					
Unit II	**GENE CLONING AND GENE MAPPING**				**15 hours**
Gene cloning-Role of restriction Endonucleases-Vectors- Identifying a specific clone with a specific probe-cDNA cloning-Methods of Expressing cloned genes-Manipulation of cloned genes-Protein engineering with cloned genes-Using cloned genes as probe-Analyse the base sequence of a gene-DNA sequencing-Genetic mapping-physical map- Application of gene cloning and advanced gene mapping: -use cloned genes in Medicine and Agriculture, human genetic diseases-Human gene therapy-Protein products from transgenic organism-mapping the human genome: tools for mapping large genome.					
Unit III	**GENE EXPRESSION**				**15 hours**
Gene regulation in eukaryotes, Gene clustering**,** Mechanism of positive and negative control of gene expression. Translational and transcriptional control of regulatory mechanism of expression, Environmental effects on gene regulation. Gene silencing, and Epigenetics					
Unit IV	**MUTATION**				**15 hours**

Mutagens-mutagenesis, Types of mutation-Chromosomal mutation: Changes in structure (types-deletion-duplication, inversion-translocation-variation in chromosome morphology-Changes in chromosome number (Ploidy-Euploidy-polyploidy-auto, allo and synthesized allopolyploidy)-monosomy-nullisomy-trisomy-tetrasomy). Gene mutation: Morphological mutation, nutritional mutation,lethal mutation-conditional mutation- mutator genes- Mutation affect the Genetic material-Missense and non-sense mutation-spontaneous mutation-silent mutation-reversion-DNA REPAIR:DNA damage-Excision repair-mismatch repair- sickle-cell anemia, forward and reverse mutation, frame shift mutation, site directed mutagenesis. Transposonssable elements-evolutionary significance.		
Unit V	**POPULATION GENETICS**	**12hours**
Introduction- Types of genetic variation-measuring genetic variation-Hardy –Weinberg Principle-Inbreeding-self fertilization-inbreeding coefficient-calculating the inbreeding coefficient-Factors influencing Hardy-Weinberg equilibrium- Extension and application of population genetics.		
Reference Book ➢ Lewin's, Jocelyn E. Krebs, EJijott S. Goldstein, Stephen T. Kilpatrick GENES XI.2016.Weaver and Hedrick. Genetics. Third edition-McGraw Hill Education Pvt. ltd ➢ Verma, P.S. and Agarwal, V.K.2009. Genetics. S.Chand & Company PVt.Ltd.new Delhi. ➢ Verma, P.S. and Agarwal, V.K.2004. Cell Biology, Genetics, Molecular Biology, Evolution & Ecology. S.Chand & Company PVt.Ltd.new Delhi. ➢ Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., 2013. Molecular Biology of the Gene, 7th Edition, Pearson Publishers. ➢ Rastogi, V.B., 2019. Genetics, 4th Edition, MedTech. ➢ Pragya Khanna, 2020. Essentials of Genetics, Wiley Blackwell. ➢ Singh, B.D. 2022. Fundamentals of Genetics, MedTech Science Press.		
Web Source:	https://nptel.ac.in/noc22_bt07/preview https://nios.ac.in/media/documents/SrSec314NewE/Lesson-22.pdf https://sites.ualberta.ca/~enoch/Resources/Genetics.pdf	

Course Outcomes(COs):

Course Outcome	After the Completion of the Course, the student will be able to–	Cognitive Level
CO1	Understand the mechanism of Mendelian inheritance in Human, Geneic Interaction:, Linkage and crossing over.	K1, K2
CO2	Learn the gene cloning methods and their application in agriculture, medicine and disease therapy.	K1,K2
CO3	Describe the mechanism of gene expression, protein synthesis, translation and transcription.	K1,K2
CO4	Knowledge on the aware of mutagenic agents and their impact on human.	K1, K2
CO5	Gain knowledge on the inbreeding/out breeding , factors altering the gene pool and gene frequency of organisms.	K1,K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	L	M	L	L	L	L
CO2	M	H	L	L	L	L	L	L
CO3	H	L	L	M	L	L	L	L
CO4	H	H	L	L	L	L	L	L
CO5	M	H	L	L	L	L	L	L

(H-High, M-Medium, L-Low)

CORE PAPER XII: BIOINSTRUMENTATION

Semester	**III**
Course Type	**CORE PAPER XII**
Title of the Course	**BIOINSTRUMENTATION**
Course Code	**NZOC34**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC34	**BIOINSTRUMENTATION**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should possess basic knowledge on the fundamentals of analytical techniques.

CODE: NZOC34	**BIOINSTRUMENTATION**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To know the basic principle of instruments used in biology. ➢ To separate, purify and analyze various biological macromolecules using advanced biological techniques. ➢ Acquire knowledge on the applications of radioisotopes in medicine.				
Unit I	**MICROSCOPIC TECHNIQUES**				**14 hours**
Principles and application of light, phase contrast, fluorescence microscopy, confocal – Scanning and Transmission Electron Microscopy. Preparation of animal and microbial samples for microscopy – pH meter – Centrifuge – Types of centrifuge.					
Unit II	**CHROMATOGRAPHY**				**15 hours**
Principles and applications of Chromatography-Thin layer (TLC) - Ion exchange and affinity chromatography –High performance liquid chromatography (HPLC), Gas chromatography (GC), Liquid chromatography – Mass spectrometry (LC-MS) and Fast protein liquid chromatography (FPLC).					
Unit III	**ELECTROPHORESIS**				**13 hours**
General principles – Electrophoresis of proteins: SDS – PAGE, Native gels, Two dimensional gel Elecrophoresis – Isoelectro focusing – Detection and estimation of proteins – Western Blotting – Electrophoresis of nucleic acids: Agarose gel electrophoresis of DNA, PCR - DNA sequencing – NGS.					
Unit IV	**PRINCIPLES AND APPLICATIONS OF SPECTROSCOPY**				**15 hours**
UV and Visible spectroscopy – Raman spectroscopy – Flourescence spectroscopy, Atomic absorption spectroscopy – Nuclear Magnetic Resonance Spectroscopy – Turbidometry – Nephlometry					
Unit V	**RADIOISOTOPES**				**15 hours**
Introduction– Radioactive decay – Types and measurement – Principles and applications of Geiger – Muller (GM) counter – Solid and Liquid Scintillation Counter – Autoradiography – Radioimmunoassay – Radiation Dosimetry					

ReferenceBooks

- Clifford D. Ferris, 1979. Introduction to Bioinstrumentation: With Biological, Environmental and Medical Applications, Humana Press.
- Alonso, A. and Arrondo, J.L.R., 2006. Advanced Techniques in Biophysics, Springer, UK.
- Pranab Kumar Banerjee, 2010. Introduction to Biophysisc, S. Chand & Company.
- Sabari Ghosal and A.K. Srivastava, 2010. Bioanalytical Techniques and Instrumentation, PHI Learning Private Ltd. New Delhi.
- Kothari, C.R. 2004. Research methodology: Methods and Techniques, New Age International (P) Ltd. Publishers, New Delhi.
- Abhilasha Shourie and S.S.Chapadgaonkar, 2015. Bioanlaytical Techniques, The Energy and Resources Institute.
- Sabari Ghosal and Anupama Sharma Avasthi, 2018. Fundamentals of Bioanalytical techniques and instrumentation, PHI Learning Private Ltd. New Delhi.
- Hofmann A 2018. Wilson and Walkers Principles and Techniques of Biochemistry andd Molecular Biology, Cambridge University.

Web Source:	https://www.pdfdrive.com/nptel-bioanalytical-techniques- https://microbenotes.com/category/instrumentation/

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Understand various types of microscopes and its application in the field of biology.	K1, K2
CO2	Know how to separate, purify and identify bioactive metabolites/proteins using chromatographic techniques.	K1, K4
CO3	Know the techniques involved in determining the molecular weight of proteins and nucleic acids.	K4
CO4	Quantify various biological micro- and macromolecules using spectroscopy techniques.	K4
CO5	Know different methods to determine radioactivity and its application in medicine.	K2, K3, K4

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	M	M	L	L	L	L
CO2	L	H	L	H	L	L	L	M
CO3	L	H	H	L	L	H	L	L
CO4	L	H	M	M	L	M	L	L
CO5	L	L	M	L	L	L	H	L

(H-High, M-Medium, L-Low)

CORE PRACTICAL – V - COMPARATIVE ANIMAL PHYSIOLOGY & IMMUNOLOGY

Semester	**III**
Course Type	**CORE PRACTICAL V**
Title of the Course	**COMPARATIVE ANIMAL PHYSIOLOGY & IMMUNOLOGY**
Course Code	**NZOL31**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

CODE: NZOL31	**COMPARATIVE ANIMAL PHYSIOLOGY & IMMUNOLOGY**	**Credits: 2**	**Max. Marks: 100**

Course Prerequisites: The students should have basic knowledge on evolution and biostatistics.

CODE: NZOL31	**COMPARATIVE ANIMAL PHYSIOLOGY & IMMUNOLOGY**	**L**	**T**	**P**	**C**
		0	**-**	**4**	**2**

Course Objectives

- To know the vital physiological function of organism
- To acquire knowledge on the osmoregulation of organism
- To impart knowledge on Immunological technique for identifying blood group, counting of blood components and estimation of ESR
- To understand the function of immune system

COMPARATIVE ANIMAL PHYSIOLOGY — 36 Hours

- Influence of temperature on Oxygen consumption of a fish
- Influence of salinity on oxygen consumption of a fish
- Estimation of salt gain by a fish
- Estimation of salt loss by a fish
- Estimation of Haemoglobin in frog's blood
- Influence of temperature on enzyme activity and measurement of activation energy
- Influence of pH on amylase activity
- Influence of substrate concentration on amylase activity
- Preparation of urate crystals of cockroach
- Preparation of haemin crystals
- Assay of acid/alkaline phosphatase enzyme
- Calculation of Body mass index.

IMMUNOLOGY — 36 hours

- Haemagglutination - Qualitative analysis "ABO" blood group.
- Haemagglutination - Qualitative analysis - haemaggultination titration.
- Estimation of differential leucocyte counting
- Blood cell counting –Total RBC and WBC counting
- Preparation of blood film
- Preparation of Haemin crystals of man, rat and rrabit/guineapig.
- Preparation of Antigen - RBC - Demonstration.
- Pregnancy test kit
- Ouchterlony technique - Demonstration.
- Immunoelectrophoresis - Demonstration.

- Histology of Lymphoid organs - Thymus, Spleen, Bone marrow, Lymph node.
- Enumeration of lymphocytes and cells of Immune system - Human blood.
- ELISA –Demonstration
- SDS-PAGE- To determine protein molecular weight
- Isolation of Plasmid DNA-Agarose Gel Electrophoresis
- Isolation of Chromosomal DNA from human blood.

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to–	Cognitive Level
CO1	Know the impact of Oxygen, temperature and salinity on living organism and estimate the RQ value of organism.	K1, K2
CO2	Acquire knowledge on enzymatic activity with aid of digestion process of an organism.	K2, K4
CO3	Learn the calculation of body mass index and correlate the energy level.	K1, K2
CO4	Understand the antibody-antigen interaction and involved the determination of blood group.	K2, K4
CO5	Describe the various immunological technique.	K1, K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	L	M	L	L	H	L	L
CO2	H	L	M	L	M	H	L	L
CO3	H	L	M	L	L	H	L	L
CO4	H	L	M	L	M	H	L	L
CO5	H	L	M	L	L	H	L	L

(H-High, M-Medium, L-Low)

CORE PRACTICAL – VI: GENETICS AND BIOINSTRUMENTATION

Semester	**III**
Course Type	**CORE PRACTICAL VI**
Title of the Course	**GENETICS AND BIOINSTRUMENTATION**
Course Code	**NZOL32**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

CODE: NZOL32	**GENETICS AND BIOINSTRUMENTATION**	**Credits: 2**	**Max. Marks: 100**

Course Prerequisites: The students should have basic knowledge on mechanism of genetic interaction and basic principle of instrumentation.

CODE: NZOL32	**GENETICS AND BIOINSTRUMENTATION**	**L**	**T**	**P**	**C**
		0	**-**	**4**	**2**
Course Objectives	➢ To know the transmission of hereditary traits among individual in a family ➢ To acquire knowledge on gene pool and gene frequency ➢ To know the methods to quantify biological macromolecules by spectroscopy. ➢ To impart knowledge on separation of aminoacids and pigments using chromatography. ➢ To understand how to determine the molecular weight of proteins by electrophoresis.				

GENETICS — **36 Hours**

- Mendelian experiments: Monohybrid cross, Dihybrid cross and Trihybrid cross by using coloured beads.
- Analyze Hardy-Weinberg equilibrium with partial selection on recessive allele.
- Analyze Hardy-Weinberg equilibrium with complete selection on recessive allele
- Concept of Genetic drift in a small population.
- Analyze the quantitative inheritance (Height and Weight of human beings and Serration of neem leaves)
- Analysis the finger print of class population
- Pedigree Analysis:
  - Transmission of autosomal recessive trait
  - Transmission of autosomal dominant trait
  - Transmission of sex linked recessive trait
  - Transmission of Y linked dominant trait
  - Muscular distrophy
- Preparation of human karyotype.
- Identification of syndromes (Down, Klinefelter and Turner) from karyotype photographs showing clinical features of each syndrome case.
- Mounting of salivary glands of Drosophila larvae / Chironomous larva. Analysis of banding pattern.
- Localization of Barr body in the Buccal smear - squamous epithelial cells of female.

- Preparation of culture media. Culture of Drosophila - Methods of maintenance.
- Sex identification of at least four mutants.
- Serial homology in appendages of Prawn.

BIOINSTRUMENTATION	36 hours

- Quantitative estimation of protein, lipid and carbohydrate from animal tissues.
- Separation of aminoacids by paper chromatography.
- Separation of lipids by Thin layer chromatography.
- SDS-PAGE analysis.
- Isolation of casein from milk.
- Counting of viable and dead cells using haemocytometer.
- Theories and principles of AAS, HPLC and ELISA

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to–	Cognitive Level
CO1	Know the preparation of karyotypes of metaphase chromosome of human and identify the disease causing gene by karyotyping.	K1, K2
CO2	Acquire knowledge on genetic drift or bottle neck principle operating on a small population.	K2, K4
CO3	Construct the family chart for the sex linked inheritance	K1, K2
CO4	Estimate proteins, lipids and carbohydrates in the tissue samples, Count viable and dead cells using haemocytometer.	K2, K4
CO5	Separate aminoacids by paper chromatography and proteins by electrophoresis	K1, K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	L	M	L	L	H	L	L
CO2	H	L	M	L	M	H	L	L
CO3	H	L	M	L	L	H	L	L
CO4	H	L	M	L	M	H	L	L
CO5	H	L	M	L	L	H	L	L

(H-High, M-Medium, L-Low)

ELECTIVE II: 1. ESSENTIALS OF BIOLOGICAL RESEARCH

Semester	**III**
Course Type	**ELECTIVE II**
Title of the Course	**ESSENTIALS OF BIOLOGICAL RESEARCH**
Course Code	**NZOEE**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

NZOEE	**ESSENTIALS OF BIOLOGICAL RESEARCH**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
The learner should have the understanding of the basic concepts and experimental techniques in biological science.

CODE: NZOEE	**ESSENTIALS OF BIOLOGICAL RESEARCH**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	➢ Teach methods of research, designing research and data collection ➢ To teach the methods of references and significance of plagiarism ➢ To impart knowledge on project report preparation ➢ To know the personnel safety, experimental animal safety and hazardous material handling methods ➢ Know the methods and important of safe guarding intellectual properly				

Unit I	**DESIGNING RESEARCH TITLE**	**8 hours**
– Types of Research – Research methods – Designing Research – Data Collection – Data analysis.		
Unit II	**LITERATURE CITATION AND PLAGIARISM**	**12 hours**
Introduction – Different systems of citing References – Name – Year system – Citation in the text – List of References – Format of Reference section – Alphabetical and chronological arrangement of references – Alphabet to number system – references without article – Journal abbreviation – Plagiarism and its significance.		
Unit III	**RESEARCH PROJECT AND REPORT WRITING**	**8 hours**
Title – Author and address – Abstract – Summary – Synopsis – Keywords – Review of Literature – Materials & methods – Result – Discussion – Acknowledgement – Appendixes – References.		
Unit IV	**LABORATORY SAFETY AND BIOTEHICS**	**12 hours**
Biohazard agents – Risk groups and Biosafety levels – Lab acquired infections – Safety measures – Additional Hazards – Safety in Genetic Engineering – Safety of Laboratory animals – Biological model system – Animal welfare – CPCSEA guidelines for Laboratory Animal Facility.		
Unit V	**INTELLECTUAL PROPERTY RIGHTS**	**14 hours**

Introduction – Protection of IPR in India – Terminology associated with IPR – Patent – Copy right – Trademark – Geographical Indexing – Plant variety and farmers right protection – Trade secret – Copy left - Traditional knowledge – Biodivrsity - Biopiracy
ReferenceBooks ➢ Nicholas H. Steneck. 2007. Introduction to the Responsible Conduct of Research. Office of Research Integrity. Available at: https://ori.hhs.gov/sites/default/files/rcrintro.pdf ➢ The Student's Guide to Research Ethics By Paul Oliver Open University Press, 2003. ➢ Adil E. Shamoo, David B. Resnik. 2003. Responsible Conduct of Research By Oxford University Press. ➢ Anderson B.H., Dursaton, Poole M. 1997.Thesis and assignment writing, Wiley Eastern. ➢ Bijorn Gustavii, 2006. How to write and illustrate scientific papers? Cambridge University Press. ➢ Bordens K.S. and Abbott, B. 2008. Research Design and Methods, Mc Graw Hill. ➢ Graziano, A., M., and Raulin, M.L., 2007. Research Methods – A Process of Inquiry, Sixth Edition, Pearson.

Web Source:	https://www.researchgate.net/publication/316976812_ https://nptel.ac.in/courses/102103083 https://nptel.ac.in/courses/102107028

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Know the Types of Research, methods of Research, designing Research – Data Collection and analysis	K1, K2
CO2	Different systems of citing References -References without article – Journal abbreviation – Plagiarism and its significance	K1,K2,K3
CO3	Title – Author and address – Abstract – Summary – Synopsis – Keywords – Review of Literature – Materials & methods – Result – Discussion – Acknowledgement – Appendixes – References	K1,K2,K3
CO4	Bio safety levels in Lab acquired infections – Safety measures – Additional Hazards – Safety in Genetic Engineering – Safety of Laboratory animals – Biological model system – CPCSEA guidelines for Laboratory Animal Facility	K1, K2,K3
CO5	Protection of IPR- Patent – Copy right – Trademark – Geographical Indexing – Plant variety and farmers right protection – Trade secret – Copy left - Traditional knowledge – Bio-diversity – Bio-piracy	K1,K2,K3, K6

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	L	L	M	M	H	H	M	H
CO2	L	L	M	M	H	H	M	H
CO3	L	L	M	H	H	H	M	H
CO4	L	M	M	H	H	H	M	H
CO5	L	M	M	H	H	H	M	H

(H-High, M-Medium, L-Low)

ELECTIVE II: 2. APPLIED ENTOMOLOGY

Semester	**III**
Course Type	**ELECTIVE II**
Title of the Course	**APPLIED ENTOMOLOGY**
Course Code	**NZOEF**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

NZOEF	**APPLIED ENTOMOLOGY**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
Know the basic mechanism of transmission of hereditary characters in organisms.

CODE: NZOEF	**APPLIED ENTOMOLOGY**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	➢ Understand the general classification and structure of insects ➢ Know the importance and scope of sericulture industry, bee keeping and economic value of insects ➢ Knowledge on the pests management in various field crops ➢ Understand the application of insects for tissue culture and medicinal value				
Unit- I	**PRINCIPLES OF APPLIED ENTOMOLOGY AND PEST MANAGEMENT**				**12 hours**
Insect origin and evolution, biodiversity, Insects of economic importance. Pests -Definition, categories, causes for outbreak, general equilibrium position, economic damage, economic injury level, economic threshold level, losses caused by pests. Pest monitoring- pest surveillance, forecasting, survey and sampling techniques, crop loss estimation. Biological control- History, concepts, classical examples, natural and biological control, predators, parasitoids, entomopathogenic microorganisms, entomophagous nematodes, biopesticides, exotic biocontrol agents, augmentative and conservation biocontrol, advantages and disadvantages of biological control. Integrated pest management (IPM)-Definition, concepts, goals and strategies of IPM, key components of IPM, IPM program development and models					
UnitII	**INSECT-PLANT INTERACTIONS, CHEMICAL ECOLOGY AND INSECT RESISTANCE**				**12hours**
Host plant-insect interactions- Plant nutrition and secondary metabolites, host plant resistance mechanisms- ecological and genetic resistance, genetically modified resistant plants, sequestration and detoxification in insects. Pheromones- Types, chemical characteristics, pheromone olfaction mechanisms, biosynthesis of pheromones, pheromone application in pest management, pheromone traps and lures. Insecticides- Nomenclature, types (systemic insecticides, organochlorines, organophoshates, carbamates, pyrethroids, inorganics, botanicals, synergists, fumigants, insect growth regulators), formulations, toxicity parameters- LD50, LC50, LT50, KD50, ED50/EC50, mode of action, safety measures, advantages and disadvantages of pesticides. Insect resistance- History of resistance, cross and multiple resistance, resistance development, resistance mechanisms and management.					
Unit-III	**PRODUCTIVE INSECTS AND PESTS OF ECONOMIC IMPORTANCE**				**12 hours**

Honey bees-Honey bee species, role of bees in pollination, bee keeping and management practices, bee products, pests and diseases of honey bees and their management. **Silkworm**-Silkworm species, silkworm rearing and management practices, pests and diseases of silkworms/host plants and their management. **Household pests**-House fly, cockroaches, bed bugs, and ants –biology, economic importance and management. **Pests of stored products**- Rice weevil, Pulse beetle, and Rice moth –biology, damage and management. **Pests of crops**- Rice, vegetables, mango, coffee, coconut, cotton and sugarcane-biology, damage and management of major pests.		
Unit-IV	**Medical entomology and parasitic diseases**:	**12 hours**
Vector biology and human parasites- Malaria, filariasis and leishmaniasis-distribution and biology of vectors and parasites, host-parasite interactions and co-evolution, defense mechanisms, epidemiology and control. **Arboviral diseases**- Yellow fever, dengue, and Japanese encephalitis-epidemiology, vector biology and management. V**enomous insects and Forensic entomology** - Venomous insects and allergic reactions. Forensic entomology of human and wildlife.		
Unit V	**INSECT BIOTECHNOLOGY**	**6 hours**
Insect biotechnology-. General introduction to insect biotechnology.-. Use of insects in tissue culture and genetic studies as model animals.-Importance of insects in medicine and cosmetics with respect to biotechnology		
Reference Books ➢ Chapman RF. 1998. The Insects: Structure and Function. Cambridge Univ. Press, Cambridge. ➢ David BV & Ananthkrishnan TN. 2004. General and Applied Entomology. Tata-McGraw Hill, New Delhi. ➢ Duntson PA. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi. ➢ Evans JW. 2004. Outlines of Agricultural Entomology. Asiatic Publ., New Delhi. Richards OW & Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman & Hall, London. ➢ Saxena RC & Srivastava RC. 2007. Entomology: At a Glance. Agrotech Publ. Academy, Jodhpur. ➢ Snodgross RE. 1993. Principles of Insect Morphology. Cornell Univ. Press, Ithaca.		
Web Source:	https://sites.google.com/a/uasd.in/ecourse/agricultural-entomology https://onlinecourses.swayam2.ac.in/cec20_bt02/preview	

Course Outcomes(COs):

Course Outcome	After the Completion of the Course, the student will be able to–	Cognitive Level
CO1	Describe the bee keeping technique and their management.	K1, K2
CO2	Learn the biology and rearing aspects of silkworm.	K1,K2
CO3	Learn the economic importance of various insects	K1,K2
CO4	Construct the package of pests management practices of agricultural crops	K1, K2
CO5	Learn the biotechnological application of insects.	K1,K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	L	M	L	L	L	L
CO2	M	H	L	L	L	L	L	L
CO3	H	L	L	M	L	L	L	L
CO4	H	H	L	L	L	L	L	L
CO5	M	H	L	L	L	L	L	L

(H-High, M-Medium, L-Low)

ELECTIVE II: 3. BIOFOULING AND BIOREMEDIATION

Semester	**III**
Course Type	**ELECTIVE II**
Title of the Course	**BIOFOULING AND BIOREMEDIATION**
Course Code	**NZOEG**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

CODE: NZOEG	**BIOFOULING AND BIOREMEDIATION**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
The student should have basic knowledge on marine ecosystem and its biological importance.

CODE: NZOEG	**BIOFOULING AND BIOREMEDIATION**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	➢ Study the pattern of biofouling process and its impact in the marine environment. ➢ Acquire knowledge on various antifouling methods to combat biofoulers. ➢ To know about the impact of marine pollution and application of bioremediation to control pollution.				

Unit I	**BIOFOULING PROCESS**	**10 hours**

Conditional film formation – Primary, Secondary and Tertiary colonizers – Boring organisms - Composition – Diversity – Factors influencing settlement of marine foulers and borers in tropical sea – Microbiologically influenced corrosion (MIC)

Unit II	**IMPACTS OF BIOFOULING**	**10 hours**

Introduction to fouling organisms - Geographical distribution and problems of fouling organisms – in the power stations – Navigation and other coastal installations – Aquaculture (cages and pens) – Invasive Aquatic species - Global economic loss.

Unit III	**ANTIFOULING**	**12 hours**

History and Development of antifouling – Toxic antifoulants (Copper and Tin) – Booster biocide - Toxicity on Non targeted and non-targeted marine organisms – Sex reversal– Antifouling methods – IMO regulation – Natural product antifoulants: Antifouling compounds from marine organisms (corals, sponges, gorgonians and ascidians), marine plants (seaweeds, seagrass and mangroves) and marine microorganisms (Bacteria, actinomycetes and fungi).

Unit IV	**MARINE POLLUTION**	**11 hours**

Sources of marine pollution – transport path – dynamics – composition of domestic, industrial, agricultural and aquaculture discharges – their composition and impact in the marine environment – Oil pollution: sources and fate of oil, composition and toxicity of oil, biological effects - Waste dumping, mining and dredging operations and their impacts in marine organisms.

Unit V	**BIOREMEDIATION**	**11 hours**

Bioremediation – Types (Biostimulation, Bioaugmentation and Intrinsic bioremediation) – Xenobiotics, Heavy metals - Phytoremediation – Biotransformation – Biodegradation: Pesticides and Hydrocarbons - Microbially Enhanced Oil Recovery – Bioethanol and Biogas Production - Wastewater treatment - Domestic sewage and Industrial wastewater
ReferenceBooks ➢ Ronald M. Atlas and Richard Bartha, 1997. Microbial Ecology, Benjam Cummings Publishing Company, USA. ➢ Fingerman, M., Nagabhusanam, R. and Thompson, M. F., 1997. Recent advances in Marine Biotechnology, Oxford and IBH Publishers. ➢ Landis, W.G. and W.G. Yu., 2004. Introduction to Environmental Toxicology, Lewis Publishers, A CRC company. ➢ Singh, D.P. and S. K. Dwivedi, 2005. Environmental microbiology and Biotechnology, 1st Edition, New Age International Private Ltd., New Delhi. ➢ Kumar, A. 2008. Aquatic Environment and Toxicology, Daya Publishing House, ISBN-13: 9788170353126. ➢ Jeffrey Peirce, J., Ruth, F., Weiner, P. and A. Vesilind., 2015. Environmental Pollution and Control (4th Edition), Elsevier. ➢ Ram Chandra, 2015. Advances in Biodeterioration and Bioremediation of Industrial waste, CRC Press. ➢ Surajit Das and Hirak Desh, 2021. Microbial biodegradation and Bioremediation, Elsevier.

Web Source:	https://microbenotes.com/bioremediation/ https://www.imo.org/en/OurWork/Environment/Pages/Biofouling.aspx

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Understand the stages and factors influencing the process of biofouling in the marine environment.	K1, K2
CO2	Know the distribution of fouling organisms, impacts and economic loss pertained to biofouling.	K2
CO3	Learn about the toxicity of antifouling biocide on marine organisms and natural product antifoulants.	K4, K5
CO4	Acquire knowledge on the sources, composition and toxicity of various pollutants on marine biota.	K2
CO5	Understand the process of utilizing promising microbes to clean up the environmental pollutants.	K3, K4

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	L	L	L	H	H	L
CO2	H	H	L	L	M	L	H	L
CO3	L	L	L	L	H	M	H	L
CO4	L	L	L	M	L	L	H	L
CO5	H	M	L	L	M	L	H	L

(H-High, M-Medium, L-Low)

ELECTIVE II: 4. FISH PROCESSING TECHNIQUES

Semester	**III**
Course Type	**ELECTIVE II**
Title of the Course	**FISH PROCESSING TECHNIQUES**
Course Code	**NZOEH**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

CODE: NZOEH	**FISH PROCESSING TECHNIQUES**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites: The student should have a basic knowledge on fish biology.

CODE: NZOEH	**FISH PROCESSING TECHNIQUES**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	➢ To learn the scope and importance of fish processing techniques ➢ To give detailed insight into various aspects of freezing of fish. ➢ To provide understanding on chemical, bacterial and sensory changes during freezing and storage techniques.				
Unit I	**FUNCTIONAL PROPERTIES OF SEAFOODS**				**10 hours**
Functional properties of seafood proteins: Solubility, emulsification, viscosity, water holding, stability- Sarcoplasmic proteins: Heme proteins, Myoglobin, Hemocyanins, parvalbumins, antifreeze proteins, pigments, enzymes- hydrolases, oxidoreductases- Collagen in fish muscle-skin characteristics of seafood collagen.					
Unit II	**FREEZING TECHNIQUES**				**10 hours**
Technological aspects of freezing: Slow and rapid freezing, Methods of freezing, comparison of various freezing methods, selection of a freezing method, product processing, packaging and different types of freezers-Determination of freezing points from time- temperature plots- preparation of fish for freezing.					
Unit III	**FISH CANNING AND SPOILAGE**				**10 hours**
Introduction to canning and its historical developments-Advantages of canning in relation to other preservation methods- Raw materials and sub materials, their characteristics and suitability for canning- Spoilage of canned foods - types, causes and preventive measures-hygiene and sanitation and waste disposal.					
Unit IV	**PACKAGING AND TRANSPORTATION**				**12 hours**
Introduction to packaging-Importance of packaging in fish processing, functions, objectives and requirements- Properties of packaging materials- Types of packaging materials for canned foods, metal containers (Tin Plate, TFS, Aluminium cans) and retortable pouches- Safety and legislation aspects of packing- Labelling and bar coding- Principles of packaging fresh produce handling and transportation- Transportation of frozen fish-Packaging for retail sale and storage.					
Unit V	**FISH BY PRODUCTS AND WASTE UTILIZATION**				**12 hours**

Fish meal: Dry reduction and wet reduction methods specification of storage-Fish oil body oil liver oil extraction purification preservation storage application-Fish silage acid silage fermented silage application-Fish maws, fish glue, fish gelatin, isinglass, pearl essence- Shrimp wastes chitin, chitosan-production uses-Biochemical and pharmaceutical products.
Reference Books ➢ Clucas IJ. 1981. Fish Handling, Preservation and Processing in theTropics. Parts I, II. FAO. ➢ Andrew CC. 1990. Food Refrigeration Processes. Elsevier. ➢ Regenssein JM & Regenssein CE. 1991. Introduction to Fish Technology. Van Nostrand Reinhold. ➢ Hall GM. (Ed). 1992. Fish Processing Technology. Blackie. ➢ KK. 2001. Post-harvest Technology of Fish and Fish Products. Daya Publ. House.Balachandran KK. 2001. Post-harvest Technology of Fish and FishProducts. Daya Publ. House. ➢ Gopakumar K. (Ed.). 2002. Text Book of Fish Processing Technology.ICAR. ➢ Nambudiri DD. 2006. Technology of Fishery Products. Fishing Chimes.

Web Source:	➢ https://www.youtube.com/watch?v=e9kZmwRZHas ➢ https://www.youtube.com/watch?v=At4dDZQbnoA

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1:	Understand the functional properties of seafood proteins and know the pigments, enzymes, hydrolases, oxidoreductases, collagen and skin characteristics of seafood.	K1, K2
CO2:	Be familiar with the technological aspects of freezing, processing, packaging - Determination of freezing points from time- temperature plots- preparation of fish for freezing.	K1,K2
CO3:	To know the advantages of canning in relation to other preservation methods and understand the soil age of canned foods - types, causes and preventive measures-hygiene and sanitation and waste disposal.	K1,K2
CO4:	Understand the Importance of packaging in fish processing, - Properties of packaging materials, Labelling and bar coding - methods of transportation of frozen fish.	K1, K2
CO5:	Know the procedure on fish liver oil extraction, purification, preservation, storage application. Usage of shrimp wastes chitin, chitosan-production and its pharmaceutical importance.	K1, K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	L	L	L	L	L	L	L	H
CO2	L	L	L	L	L	L	L	H
CO3	L	L	L	L	L	L	L	H
CO4	L	L	L	L	L	L	L	H
CO5	L	L	L	L	L	L	L	H

(H-High, M-Medium, L-Low)

CORE PAPER XIII: EVOLUTION

Semester	**IV**
Course Type	**CORE PAPER XIII**
Title of the Course	**EVOLUTION**
Course Code	**NZOC41**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

NZOC41	**EVOLUTION**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites:
The student should possess basic knowledge on the animal evolution.

CODE: NZOC41	**EVOLUTION**	**L**	**T**	**P**	**C**
		4	**-**	**-**	**4**
Course Objectives	➢ To understand the basic concepts on evolution. ➢ To know mechanism of evolutionary changes in living system. ➢ To study the evolutionary patterns of animals at molecular level.				

Unit I	**THEORIES OF EVOLUTION**	**15 hours**

Emergence of evolutionary theories Lamarck – Neo-Lamarckism – Darwin – Neo-Darwinism – Biological species concepts – evolutionary synthesis – evolutionary time scale – eras – periods – epoch. Human evolution: Stages of primate evolution including *Homo*. Behavioral Evolution: Altruism and evolution – Group selection and kin selection – Cultural evolution of Human.

Unit II	**MOLECULAR EVOLUTION**	**14 hours**

Role of gene in evolution - Evolution of gene families, Molecular drive - Assessment of molecular variation - Origin of higher categories - Phylogenetic gradualism and punctuated equilibrium - Micro- and Macro-evolution – speciation.

Unit III	**PHYLOGENETIC METHODS TO ESTIMATE EVOLUTION**	**14 hours**

How to construct phylogenetic tress? - Phylogenetic inference –Distance methods ,parsimony methods, maximum likelihood method - Immunological techniques – Regulatory genes and their evolutionary consequences – Molecular clock.

Unit IV	**DNA BARCODING**	**15 hours**

Amino acid sequences and phylogeny - Nucleic acid phylogeny-DNA-DNA hybridizations, Restriction Enzyme sites, Nucleotide sequence comparisons and homologies – DNA barcoding in molecular evolutionary study.

Unit V	**EVOLUTIONARY ECOLOGY**	**14 hours**

Metapopulations - Monitoring natural populations - Why small populations become extinct? - Loss of genetic variations - Conservation of genetic resources in diverse taxa – Artificial evolution (*in vitro*) – Application of Artificial Intelligence in Animal Ecology.

ReferenceBooks

- Chiarelli, A.B. 1973. Evolution of Primates, Academic Press.
- Daniel L. Hartl, 1980. Principles of population Genetics, Sinauer Associates, Inc., Publishers, USA.
- Berry, R.J., Crawford, T.J., Hewitt, G.M., 1992. Genes in Ecology, Cambridge University Press.
- Dan Graur and Wen-Hsiung Li, 2000. Fundamentals of molecular evolution (2nd Edition), Sinauer Associates, Inc., Publishers, USA.
- Yadav, B.N. and Kumar, D., 2000. Vertebrate zoology and evolution. Daya Publishing Co.
- Andrew Cockburn, 2001. An introduction to evolutionary ecology (2nd Edition), Wiley Blackwell.
- Cain, A.J., 2016. Animal species and their evolution. Princeton University Press.
- Pandian, T.J., 2021. Evolution and speciation in Animals, CRC Press, NY.

Web Source:	https://www.biologyonline.com/dictionary/phylogeny https://bio.libretexts.org/Courses/Butte_College/BC%3A_BIOL_2_-_Introduction_to_Human_Biology_(Grewal)/Text/09%3A_Biological_Evolution/9.2%3A_Darwin%2C_Wallace%2C_and_the_Theory_of_Evolution_by_Natural_Selection

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Understand the history and theories of evolution.	K1, K2
CO2	Study the evolutionary changes of an organism at molecular level.	K3, K4
CO3	Acquire knowledge on analyzing the evolutionary relationship between the organisms using different phylogentic methods.	K4
CO4	Know the method to identify a species through DNA barcoding.	K2, K4
CO5	Know the genetic variation among organisms and application of artificial intelligence in animal ecology.	K3, K4, K5

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	M	L	L	H	L	L
CO2	H	M	L	L	M	H	L	L
CO3	H	L	L	L	M	L	L	L
CO4	H	L	L	L	M	H	L	L
CO5	H	L	M	L	M	M	L	L

(H-High, M-Medium, L-Low)

CORE PAPER XIV: BIOSTATISTICS & COMPUTER APPLICATION

Semester	**IV**
Course Type	**CORE XIV**
Title of the Course	**BIOSTATISTICS & COMPUTER APPLICATION**
Course Code	**NZOC42**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

CODE: NZOC42	**BIOSTATISTICS & COMPUTER APPLICATION**	**Credits: 4**	**Max. Marks: 100**

Course Prerequisites: The student should have a basic knowledge on Computational biology and statistics

BIOSTATISTICS & COMPUTER APPLICATION	**L**	**T**	**P**	**C**
	4	**-**	**-**	**4**

Course Objectives

- To impart knowledge on the application of statistical tool in research and other surveillance programme.
- To know the sampling pattern, collection, maintenance and analysis of data.
- To acquire the knowledge on computer operations and database management by using statistical and bioinformatics software packages.

Unit I	**POPULATION AND SAMPLE**	**13 hours**

Samples and population-variables-Types of variable-accuracy and precision, derived variables-Graphical representation of data using simple statistics-Sampling methods-Diagrams and graphs: types of diagrams, graphs frequency distribution- continuous frequency distribution-cumulative frequency distributions-handling of data.

Unit II	**STATISTICAL METHODS**	**14 hours**

Measures of central tendency and Average: objectives and types of average- Probability- types of probability-Probability distributions (Binomial, Poisson and normal) - Sampling distribution - - Confidence Interval – Errors - Levels of significance- Chi square test: Procedure and application of Chi square test.

Unit III	**TEST OF SIGNIFICANCE**	**14 hours**

Student's t- test-Regression and Correlation – Karl pearson's coefficient of correlation-Analysis of frequencies t-test - Analysis of variance – Principle and Types of ANOVA (One and Two way analysis of variance) – Applications of ANOVA.

Unit IV	**SOFTWARE TOOLS AND PACKAGES**	**16 hours**

Dynamic programming: ORIGIN PRO-SPSS:Introduction-Data file-Statistical Analysis-Charts and graphs. One way ANOVA with SPSS-Multible comparison test with SPSS- BLAST and FASTA-Application of Blast tool.

Unit V	**OPERATING SYSTEMS AND APPLICATIONS**	**15 hours**

Classification of computers - Hardware components - Input devices – Output devices - Memory devices –Industrial application- Digital information processing- Database management - Internet and its applications. Statistical software packages- Operating system – Windows - Computer applications - Office automation- Library Information System.

Reference Books

- Zar, J.H. 1984. Biostatistical analysis. (2nd Edn.), Prentice Hall International Inc.
- Hunt, R. and J. Shelley.1988. Computers and common sense. Prentice-hall of India Pvt. Ltd. New Delhi.
- Bailey, N.T.J. 1997. Statistical Methods in Biology, III Ed., Cambridge University Press, New York.
- Milton, J.S. 1992. Statistical methods in Biological and Health Sciences. Mc Graw Hill Inc., New York.
- Claverie, J.M. and Notredame C. 2003 Bioinformatics for Dummies. Wiley Editor.
- Setubal, J. and Meidanis, J. 1996 Introduction to Computational Molecular Biology. PWS Publishing Co., Boston.
- Letovsky, S.I. 1999 Bioinformatics. Kluwer Academic Publishers.
- Baldi, P. and Brunak, S. 2001 Bioinformatics: The machine learning approach, The MIT Press.
- Rajathi. A. and P.Chandran.2010. SPSS for you. MJP Publishers, Chennai 600005.

Web Source:	➢ http://genome.ucsc.edu ➢ https://www.youtube.com/watch?v=2zLn-RngMU4

Course Outcomes (COs):

Course Outcome	**After the Completion of the Course, the student will be able to –**	**CognitiveLevel**
CO1:	Know the variables, sample value and population, types of variable. Understand the graphical representation of data using simple statistics. Analysis the Sampling methods and types of diagrams, graphs, frequency distribution.	K1, K2,K3,K5
CO2:	Know the measures of central tendency and average, objectives and types of average. Understand the types of probability, Sampling distribution, confidence Interval and Levels of significance, and application of Chi square test.	K1,K2,K5
CO3:	Familiar with the awareness of student's t- test, Regression and Correlation,Karl pearson's coefficient of correlation-Analysis of frequencies t-test, Analysis of variance Principle of ANOVA and Applications of ANOVA.	K1,K2,K3
CO4:	Perceive the dynamic programming of BLAST, FASTA and Application of BLAST tool in phylogenetic analysis. Be aware of ORIGIN PRO, SPSS and One way ANOVA with SPSS in multible comparison test.	K1, K2, K6
CO5:	Understand the classification and hardware components of computers and application of Industrial and digital information processing. Understand the Database management and statistical software packages also, know the operating library Information System.	K1, K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	L	L	L	L	M	L	L	L
CO2	L	L	L	L	M	L	L	L
CO3	L	L	L	L	M	L	L	L
CO4	L	L	L	L	M	M	L	L
CO5	L	L	L	L	M	L	L	L

(H-High, M-Medium, L-Low)

ELECTIVE II - COMPUTATIONAL BIOLOGY (E-PATHSALA-2)

Semester	**IV**
Course Type	**ELECTIVE II**
Title of the Course	**COMPUTATIONAL BIOLOGY (E-PATHSALA-2)**
Course Code	**NZOEPB**
Teaching Hours	**54 Hours/ Semester : 3 Hours/ week**

NZOEPB	**COMPUTATIONAL BIOLOGY (E-PATHSALA-2)**	**Credits: 3**	**Max. Marks: 100**

Course Prerequisites:
Have knowledge of the Microbiology and Biochemistry of Cell.

CODE: NZOEPB	**COMPUTATIONAL BIOLOGY (E-PATHSALA-2)**	**L**	**T**	**P**	**C**
		3	**-**	**-**	**3**
Course Objectives	➢ To make students understand the types lymphoid organs lymphoid cells ➢ To make students learn the types of immunoglobulins, antigen ➢				
Unit I	**BIOLOGICAL DATABASES**				**7 hours**
Introduction to Biological Databases - Primary and Secondary databases-Sequence related data, GoalDriven Databases, Data Format-Data Generation & Associated Organization-Structural Database-Chemical Databases-Case studies					
Unit II	**SEQUENCE ANALYSIS**				**12 hours**
Pairwise sequence alignment:- Sequence Comparison (Nucleic Acid/Protein sequences) and interpretation of results: Pairwise sequence alignment-Edit Operations and Edit Distance-Implementation of the Global Alignment Algorithm-Implementation of the Local Alignment Algorithm-Gap penalties-Accuracy of Multiple Sequence Alignments-Sequence Comparison(Nucleic Acid/Protein sequences) and interpretation of results: Multiple Alignments-Multiple Sequence Alignment Algorithms- Multiple Alignments based on Sum of Pairs (SP) Score- Progressive Alignment-Scoring Matrices for Sequence Alignment -Case studies					
Unit III	**DATABASE SEARCHING-PATTEN RECOGNITION**				**10 hours**
abase Searching -Sequence-based Database Searches - Text Search and BLAST-the BLAST and FASTA family of program- Pattern Recognition Methods in Sequence Analysis.- Introduction to Chemoinformatics & Chemical databases-Graph Theory Based Approach to chemicals and functional descriptors- Chemical Descriptors-Relationships between chemical structure and biological activity (QSAR & QSPR) --Case studies.					
Unit IV	**PHARMACOPHORE GENERATION**				**10 hours**
Drug Discovery Cycle-Introduction to Ligand Based design- Ligand based design: pharmacophore generation-pharmacophore based 3DSearching Database, Virtual Screening-Three dimensional approaches to Chemical Database Searching- Molecular Docking- Types of QSAR methods – 2D, 3D, 4D, 5D and 6D QSAR methodologies - 3D QSAR & Data driven Predictions- Prediction of					

ADME & Toxicity -Case studies. .

Unit V	MOLECULAR MODELLING	15 hours

modeling in Protein Structure Prediction, Advantages and Disadvantages, Prediction of 2D & 3D Structure of Proteins-I: Secondary Structure Prediction-Tertiary structure prediction- Refinement of Predicted Model, Introduction to Molecular Dynamics, Origin of Force Fields-Introduction to Structure based Designing- Interaction of Active site-Structure Based Design of Compounds-Structure Based Docking- Scoring Functions-Potential Energy Surface-Molecular Simulation & Flexibility of proteins-Effect of solvation and electrostatics in molecular simulation-Application of Solvation model in Molecular design Free Energy & Entropy of Biomolecules- Inferring Function from Structure - Introduction to Omics & Genomics, High throughput gene annotation/ Genomics/GWAS, Proteomics, Transcriptomics and Metabolomics, metabolic modeling in biology--Case studies.

ReferenceBooks

- Lesk, A.M. 2014. Introduction to Bioinformatics; Oxford University Press, UK, Fourth edition.
- Gretchen Kenney, 2016. "Bioinformatics: Principles and Analysis"; Syrawood Publishing House USA.
- Scott Markel, 2003. Sequence Analysis in a Nutshell – A Guide to Common Tools & Databases"; O′Reilly; I edition, ISBN-13: 978-0596004941.
- David Mount, 2004, "Bioinformatics: Sequence and Genome Analysis"; Cold Spring harbor laboratory Press, US Revised Edition.
- Ole Lund, Nielsen, M., Lundegaard, C. Kesmir, C. and Brnak, S., 2005. Immunological Bioinformatics"; The MIT press.
- Jean-Michel, Cand Notredame, C. 2006. "Bioinformatics for Dummies"; John Wiley& Sons, Second Edition.
- Kindreas D Batevanis, 2006. "Bioinformatics: A Practical Guide to the Analysis of Gene and Protein"; Wiley Inter Science, Singapore, 3rd Edition.
- Andrew R. Leach & Valerie J. Gillet, 2007. "An Introduction to Chemoinformatics"; Springer, Revised Edition.
- David Edward, 2007. "Plant Bioinformatics": Methods and Protocol, Humana Press.
- Baxevanis, A.D. and Francis Ouellellette, B.F. 2011. "Bioinformatics –a practical guide to the analysis of Genes and Proteins"; John Wiley & Sons, UK, Third Edition.
- Hossein G. Gilani, Katia G. Samper, Reza Khodaparast Haghi, 2012. "Chemoinformatics: Advanced Control and Computational Techniques"; Apple Academic Press, First edition.
- Caroline St Clair, Jonathan E. Visick, 2013. "Exploring Bioinformatics"; Jones and Bartlett Publishers, Inc; 2nd Edition, ISBN-13: 978-1284034240.

Web Source:	https://nptel.ac.in/courses/102106035 https://epgp.inflibnet.ac.in/ahl.php?csrno=3-

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to –	CognitiveLevel
CO1	Know the various Databases in Biology- Data Format-Data Generation & Associated Organization-Structural Database-Chemical Databases.	K1, K2
CO2	Shall know the Two sequence alignment:- Sequence Comparison-Multiple Sequence Alignments-Sequence Comparison- and Matrices for Sequence Alignment	K1,K2
CO3	Database Searching -Text Search and BLAST-the BLAST family of program- Pattern Recognition Methods in Sequence Analysis.- Introduction to Chemoinformatics& Chemical databases-Graph Theory Based Approach to chemicals and functional descriptors- Chemical Descriptors-Relationships between chemical structure and biological activity (QSAR & QSPR)	K1,K2
CO4	Introduction to Ligand Based design- Ligand based design: pharmacophore generation-pharmacophore based 3DSearching Database,-Three dimensional approaches to Chemical Database Searching- 3D QSAR & Data driven Predictions- Prediction of ADME & Toxicity	K1, K2
CO5	Prediction of 2D & 3D Structure of Proteins-I: Secondary Structure Prediction-Tertiary structure prediction-High throughput gene annotation/ Genomics/GWAS,Proteomics, Transcriptomics and Metabolomics, metabolic modeling in biology-Metabolic modeling in biology	K1,K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	L	M	L	L	L	L
CO2	M	H	L	L	L	L	L	L
CO3	H	L	L	M	L	L	L	L
CO4	H	H	L	L	L	L	L	L
CO5	M	H	L	L	L	L	L	L

(H-High, M-Medium, L-Low)

CORE PRACTICAL – VII – EVOLUTION & BIOSTATISTICS AND COMPUTER APPLICATIONS

Semester	**IV**
Course Type	**CORE PRACTICAL VII**
Title of the Course	**EVOLUTION & BIOSTATISTICS AND COMPUTER APPLICATIONS**
Course Code	**NZOL41**
Teaching Hours	**72 Hours/ Semester : 4 Hours/ week**

CODE: NZOL41	**EVOLUTION & BIOSTATISTICS AND COMPUTER APPLICATIONS**	**Credits: 2**	**Max. Marks: 100**

Course Prerequisites:
The students should have basic knowledge on evolution and biostatistics.

CODE: NZOL41	**EVOLUTION & BIOSTATISTICS AND COMPUTER APPLICATIONS**	**L**	**T**	**P**	**C**
		-	**-**	**4**	**2**
Course Objectives	➢ To know the application of biostatics in biological research ➢ Enable to handle the computer aided statistical software ➢ To impart knowledge on evolutionary significance of organism ➢ To understand how to evolve the new species and pattern of evolution.				

EVOLUTION — **36 hours**

- Geological time scale
- Evolutionary Experiment : Chemical origin of life -Urey Miller experiment
- Speciation
  - Allopatric, parapatric, sympatric
  - Darwin finches, HMS Beagle
- Evolution of man, reptiles, birds, horse, elephant, dinosaur
- Connecting link
  - Annelida – Arthropoda
  - Birds – reptiles
- Evidence of evolution
  - Homologous and Analogous
  - Fossil evidence
  - Living fossil – Limulus
- Phylogenetic tree
- Molecular clock

BIOSTATISTICS AND COMPUTER APPLICATION — **36 hours**

- Binomial distribution using two coins
- Binomial distribution using three coins
- Measurement of central tendency: mean , median and mode
- Test of significance: t-test, Chi-Square test

- Standard deviation and standard error of mean
- ANOVA; One way ANOVA and two way ANOVA
- Correlation Coefficient
- Rank Correlation Coefficient
- Regression Analysis; height and weight relationship of students and Length and weigh relation of fish.
- Structuring data for use in SPSS
- Different types of graph using ORIGIN software

Presentation of data in the form of diagram Pie chart, Bar diagram, Histogram, Pictogram, Cartogram, Line graph, Scatter plot, Frequency curve, Polycon

Course Outcomes (COs):

Course Outcome	After the Completion of the Course, the student will be able to–	Cognitive Level
CO1	Know the evolutionary history of living system and understand the connecting link between the phyla.	K1, K2
CO2	Acquire knowledge on the construction of phylogenetic tree to understand the evolutionary history.	K2, K4
CO3	Apply the statistical tools in the biological research	K1, K2
CO4	Understand the variation among the sample by statistical method.	K2, K4
CO5	Learn the test of significance of variable, goodness of fits, ANOVA, regression and correlation coefficient between the variables.	K1, K2

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

Mapping with PSO:

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	L	M	L	L	H	L	L
CO2	H	L	M	L	M	H	L	L
CO3	H	L	M	L	L	H	L	L
CO4	H	L	M	L	M	H	L	L
CO5	H	L	M	L	L	H	L	L

(H-High, M-Medium, L-Low)