NEW SYLLABUS FOR THE MASTER OF SCIENCE

IN

ZOOLOGY

TWO YEAR FULL-TIME PROGRAMME

DEPARTMENT OF ZOOLOGY

FACULTY OF SCIENCE
DEEN DAYAL UPADHYAYA, GORAKHPUR UNIVERSITY,
GORAKHPUR-273009

PROGRAME: M.Sc I Year ZOOLOGY

Year	Semester	Course Code	Course Title	Credit	Semester Credit
1	I	ZOO-501N	Biology of non-chordates	4+0	20
		ZOO-502 N	Use of Tools & Techniques in Biological Science	4+0	
		ZOO-503 N	Animal Physiology	4+0	
		ZOO-504 N	Biological Chemistry	4+0	
		ZOO-505 N	Practical based on ZOO-501N, ZOO-502N, ZOO-503N & ZOO-504N	0+4	
	II	ZOO-506 N	Chordates - Origin & Evolution	4+0	24
		ZOO-507 N	Systematics, Biodiversity and Evolution	4+0	
		ZOO-508 N	Genetics & Cytogenetic	4+0	
		ZOO-509N	Developmental Biology	4+0	
		ZOO-510N	Practical based on ZOO-506N, ZOO-507N, ZOO-508N &ZOO-509N	0+4	
		ZOO-511N	Integrated Pest management Open elective (Interdisciplinary)	4+0	

M. Sc II Year ZOOLOGY

2	III	ZOO-512N	Principles of Ecology	4+0	24
		ZOO-513N	Computational Biology and Biostatistics	4+0	
		Discipline Specific Elective I (Any One)			
		ZOO-514N	Biology of Parasitism	4+0	
		ZOO-515N	Applied Zoology	4+0	
		ZOO-516N	Epigenetic & Chromatin Biology	4+0	
		Discipline Specific Elective II (Any One)			
		ZOO-517N	Structure and Function of Genes	4+0	
		ZOO-518N	Animal Behavior	4+0	
		ZOO-519N	Molecular Endocrinology	4+0	
		ZOO520-N	Practical based on ZOO512, ZOO513, DSEI & DSEII	0+4	
		ZOO-521N	Industrial Training/Survey/Research Project	0+4	

	IV	**SPECIALIZATION BASED ELECTIVE (SBE)** *(Any one option to be chosen from SBE I, SBE II or SBE III)*			
		SBE I: ENTOMOLOGY			
		ZOO-522N	Economic Entomology	4+0	20
		ZOO-523N	Insect Morphology, Physiology and Development	4+0	
		ZOO-524N	Ecology, Evolution and Taxonomy	4+0	
		ZOO-525N	Insect Pest Management	4+0	
		ZOO-526N	Practical based on ZOO523N, ZOO524N, ZOO525N & ZOO526N	0+4	
		SBE II: FISH BIOLOGY			
		ZOO-527N	Taxonomy and Morphology of Fishes	4+0	20
		ZOO-528N	Ecology of Fishes And Conservation	4+0	
		ZOO-529N	Physiology and Development of Fishes	4+0	
		ZOO530N	Applied Ichthyology	4+0	
		ZOO-531N	Practical based on ZOO527N, ZOO528N, ZOO529N & ZOO530N	0+4	
		SBE III: CELL BIOLOGY			
		ZOO-532N	Cytological Techniques	4+0	20
		ZOO-533N	Cellular Organization & Fundamental Processes: Cell Structure	4+0	
		ZOO-534N	Gene Regulation, Cell Communication and Differentiation	4+0	
		ZOO-535N	Immunology and Cancer	4+0	
		ZOO-536N	Practical based on ZOO532N, ZOO533N, ZOO534N & ZOO535N	0+4	
		FOR ALL STUDENTS OF SEMESTER IV			
		ZOO-537 N	Industrial Training/Survey/Research Project	0+4	4

ZOO-501 N: NON- CHORDATA
CREDIT:4+0

Unit-1 Nutrition and reproduction in protozoa; Origin of Metazoa; Organization and Affinities of Porifera; Polymorphism and Colony formation in Cnidaria; Coral reefs.

Unit-2 Life cycle patterns in Helminthe parasaties; Ecology of soil Nematodes; Segmental organs in Annelida; Adaptive Radiation in Annelida.

Unit-3 Organization and Affinities of Onychophora; Larval forms in Crustacea; Parasitism in molluscs, Torsion its effect and significance in Gastropods.

Unit-4 Larval forms in Echinodermata; Affinities of Echinodermata and Hemichordata; Brief outlines of the structure and affinities of minor phyla with special reference to Ctenophore, Rotifera, Acanthocephala, Sipunculoidea and Echiuroidea

Suggested Literature:

1. A life of invertebrates by W.D. Russel-Hunter, MacMillan Publishing Co. inc., New York.
2. Advances in invertebrates' reproduction by K.G. Adiyodi and R.G. Adiyodi, Peralam-Kenoth Kerivellur, Kerala.
3. Biology of the invertebrates by Jan Pechenik, William C. Brown Publishers, Dubuque, Iowa.
4. Invertebrate Zoology by A. Kaestner, Interscience Publishers.
5. Invertebrate Zoology by Alfred Kaestner, H. W. Levi& L. R. Levi, John Wiley & Sons Inc.
6. Invertebrates (Protozoa to Echinodermata) by Ashok Verma, Narosa Publishing House, New Delhi.
7. Invertebrate Learning by W. C. Corning and J. A. Dayal.
8. Invertebrate Structure and Function by E. J. W. Barrington, The Camolet Press, Great Britain.
9. Invertebrate Zoology by P. A. Meglitsch& F.R. Schram; Oxford University Press.
10. Invertebrate Zoology by R. D. Barnes, V Edition. Holt Saunders International edition.
11. Principles of Comparative Anatomy of Invertebrates by W. N. Bekiemishev, University of Chicago Press.
12. Principles of Comparative Anatomy of Invertebrates by Dr J. M. Mac Lennon; Z. Kabata, Oliver and Boyd Edinburgh.
13. Textbook of Invertebrate Zoology by G. S. Sandher; H. Bhaskar, Campus Book International.
14. The Invertebrate by L. H. Hymen, McGraw-Hill Book Company.
15. The Invertebrate: A New Synthesis by R.S.K Barnes, P. Calow, P. J. W. Olive, D. W. Golding, and Spicer, J. I, III Edition, Blackwell Science.

Course Outcomes:

- The course will provide the basic concepts of Non Chordata, their morphology, origin and affinities.
- Students will be able to understand Larval forms in Echinodermata; Affinities of Echinodermata and Hemichordata; Brief outlines of the structure and affinities of minor phyla.
- Students will get benefit of this course in various competitive examinations.

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ZOO-502N: TOOL & TECHNIQUES IN BIOLOGICAL SCIENCE
CREDIT:4+0

Unit-1 Principles and uses of analytical Instruments; Balances, Flame Photometer, Spectrophotometer, Spectrofluro-photometer, Atomic Absorption Spectrophotometer.

Unit-2 Microbial technique: Media preparation and Sterilization, Inoculation and Growth Monitoring, Use of microbes in Fermentation, Microbial Assays.

Unit-3 Separation and Identification of Bio-molecules by Chromatography: Paper and thin layer Chromatography, Gel exclusion Chromatography, High performance Liquid Chromatography (HPLC), Affinity Chromatography.

Unit-4 Electrophoresis techniques: General principles, Support media; Electrophoresis of proteins and nucleic acid; Capillary Electrophoresis, Principles of Differential and Density centrifugation.

Suggested Literature:

1. Essential Laboratory Techniques by S.R. Gallagher, E.A. Wiley.
2. An introduction to Practical Biochemistry by D.T. Plummer.
3. Techniques in Live Sciences by D.B. Tembhare.
4. Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition by Keith Wilson and John Walker, Cambridge University Press.
5. Light Microscopy in Biology: A practical Approach, 2nd Edition by Alan J. Lacey, Oxford University Press.
6. Electron Microscopy: Principles and Techniques of Biologist by John J. Bozzola, Lonnie D. Russell, Jones &Bartiett Publ.
7. Tools and Techniques of Biotechnology by Mousumi Debnath, Pointer Publishers.

Course outcomes:

- This course will give students provide student basic knowledge of Microbiology.
- By the end of course they will have idea of the media preparations and sterilization, Inoculation and growth monitoring, use of microbes in fermentation, microbial assays.
- The will also develop the knowledge of instruments and techniques used for and separation and identification of bimolecules that will help them to plan their career in biological research and teaching.
- This course will be useful in various competitive exams like CSIR-NET etc.

ZOO-503N: COMPARATIVE ANIMAL PHYSIOLOGY CREDIT:4+0

Unit-1 Modes of nutrition, types of digestion and absorption of food; Neurons, Neuroglial cells, irritability, axonal and synaptic transmission, mechanism of conduction and transmission of nerve impulses; Sodium-Potassium ATPase pump, ion channels; Nernst equation, ionic basis of resting and spike potential, electrical potential, types of synapse and neurotransmitters.

Unit-2 Osmotic conformity and role of membranes in ionic regulation: Stenohaline, Euryhaline animals, Hypo and Hyper environment and terrestrial life; General characteristics of stimulus and response reaction: Chemoreceptors, photoreceptors, phonoreceptors, mechanoreceptors, equilibrium reception; Respiration: Oxygen and Carbon dioxide transport, factors affecting oxygen dissociation: Respiratory adaptation to low oxygen tension, regulatory process in respiration.

Unit-3 Thermoregulation in animals: Temperature relationship in poiklotherms, homeotherms, endotherms and heterotherms, thermal acclimatization; Circulation: Types of circulation, physiological categories of heart, conduction system, cardiac cycle, electrocardiogram; Body fluids, blood coagulation; hematological abnormalities, effectors organs; Types of muscles, its composition, mechanism of muscle contraction.

Unit-4 Pattern of nitrogen excretion in different animals: Types of excretory products, Pattern of excretion, excretory devices in invertebrates and vertebrates; Biosynthesis of urea and uric acids; Comparative study of endocrines organs and their hormonal secretion in non chordates and chordates

Suggested Literature:

1. Animal Physiology by M.Brown, Apple Academic Press.
2. Animal Physiology by R.C. Sobte, Narosa Publishing House.
3. Animal Physiology by F.R. Haninsworth
4. Comparative Animal Physiology by C.L. Prosser, W.B. Saunders Company.
5. Comparative Physiology of Animal by R.W.Hill; P.D. Sturke.
6. Environmental Physiology of Animals by P. Willmer; G. Stone, Blackwell Science Ltd.
7. General and Comparative Physiology by W.S. Hoar, Prentice Hall of India Pvt. Ltd.
8. Marshall's Physiology of Reproduction by G.E. Lamming, Churchill Liungstone.
9. Neural and Integrative Animal Physiology by C.L. Prosser, Wiley India Pvt. Ltd.
10. Principles of Animal Physiology by J.A. Wilson.

Course outcomes:

- This course will help a student to study the osmotic conformity and role of membranes in ionic regulation: Stenohaline, Euryhaline animals, Hypo and Hyper environment and terrestrial life.
- The student will acquire knowledge of comparative physiology of the animals belonging to different classes. This will help a student to understand evolution of the systems from simpler forms to complex ones.
- After the course the students will be able to participate in various national and international competitive examinations.

ZOO-504N: BIOLOGICAL CHEMISTRY **CREDIT:4+0**

Unit-1 Chemical equilibrium, Law of Mass action; Elementary thermodynamic system; Calculation of free energy change during biological Redox Reactions, Acid base Amphoteric, Zwitter ions.

Unit-2 Kinetics of enzyme of reaction; Kinetic of Enzyme– Catalyzed reactions, Order of enzyme reaction, Rate equations, Two substrate reactions; Temperature Coefficient, Activation Energy; Enzyme Inhibition, Competitive and Non competitive inhibitors ; Applications of Enzyme Inhibition Techniques in pest control, Allosteric Enzyme.

Unit-3 Structure and function of vitamins and coenzymes; aerobic and anaerobic energy production from carbohydrates, lipids and amino acids,(Glycolysis, HMP Shunt, Beta oxidation of fatty acids, deaminations, and trans animation of amino acids (Phenyl alanine, Tryptophan, Aspartate, Proline and Threonine)

Unit-4 Biosynthesis of Amino Acids (Phenylalanine, Tryptophan, Aspartate, Proline and Threonine), Nucleotides, Glycogen and Urea; Immoblized enzymes and their Applications.

Suggested Literature

1. Biochemistry by J.M berg J.L.Tymoczko, W.H.FreedmanPlagraueMacmillon
2. Biochemistry by Zubey; Styrer
3. Self physiology and Biochemistry by W.D. McElory , Prentice Hall of INDIA Pvt. LTD
4. Comparative biochemistry by K.A Munday, Pergmon Press Oxford London
5. Essentials of Biochemistry by Srivastva; Lal; N.Singh, Rekha Publications
6. Essentials of Biological chemistry by Fairley Kilgour, Affiliated east -west Press
7. Harper's Biochemistry by R.K. Murray, D.K Granner, A long medical book.
8. Introduction to biochemistry by J. Awapra, Printice Hall of INDIA Pvt. LTD
9. Lehninger Principles of biochemistry D.L Nelson, M.M .Cox W.H. Freedman Company

Course outcomes:

- The course will enable student to study the enzyme kinetics, order of enzyme reaction, rate equations, two substrate reactions; Temperature Coefficient, Activation Energy; Enzyme Inhibition, Competitive and non competitive inhibitors; Applications of enzyme inhibition techniques in pest control, Allosteric Enzyme.
- Student will be able to understand all the metabolic processes of a living organism.
- This course is useful in various competitive exams.

ZOO-505N: PRACTICAL BASED ON ZOO-501N, ZOO-502N, ZOO-503N & ZOO-504N
CREDIT:0+4

Exercise

Technique/ Instrumentations
Biochemistry Exercise
Physiology Exercise
Spotting (10 spots)
Viva voce
Total Mark

ZOO-501N: General characters and classification of the non- chordates phyla (Protozoa to Echinodermata) with the help of museum specimens and slides.

Protozoa: Vital staining and staining preparation of *Paramecium;* Study of cyclosis and trichocysts in *Paramecium;* Permanent preparation of *Ceratium, Noctiluca,Paramecium, Vorticella,* Study of prepared slides: *Balantidium, Nyctotherus, Opalina. Paramecium* conjugation/binary fission, *Entamoeba histolytica, Giardia, Trypanosoma, Leishmania, Trichomona.*

Porifera: Permanent preparation of gemmules, sponging fibres and different kinds of spicules, Study of museum specimens specimens/models; *Lecuosolania , Sycon , Grantia, Euplectella, Hyalonema, Oscarella, Chondrilla, Chliona, Chalina, Spongilla, Spongia, Hippospongia.*

Cnidaria and Ctenophora: Study of nematocycsts of *Hydra,* Permanent preparation of *Hydra; Obelia and* other hydrozoan colonies and *Obelia* Medusa ; Study of museum specimens/ models : *Tubularia , Bougainvillia, Pennaria, Hydractinia, Sertularia, Campanularia, Millepora, Stylaster, Physalia, Porpita, Valella, Aurelia, Rhizostoma, Tubipora, Alcyonium, Gorgonia, Corallium, Pennatula, Zoanthus, Metridium, Adamsia, Cerianthus, Fungia, Madrepora, Cestum* .

Helminths: Permanent preparation of selected soil and plant nematodes , cestode and trematode parasites of cattle and poultry , and different larval stages of liver fluke, Study of museum specimens/ whole mounts: *Convoluta, Dugesia, Bipalium, Fasciola , Paramphistomum, Schistosoma, Taenia, Moniezia , Echinococcus, Trichuris, Trichinella, Heterodera, Enterobius, Ascaris, Ancylostoma, Dracunculus, Wuchereria; study of prepared slides: Scolex of tape worm ,mature and gravid proglottid of tape worm; Study of cysticercus larva, hydatid cyst, larval stage of Fasciola* .

Annelida: Study of museum specimens*/models: Aphrodite, Tomopteris, Glycera, Chaetopterus, Arenicola ,Sabella, Amphitrite, Serpula, Tubifex, Branchiobdella, Eisenia, Metaphire, Placobdella, Pontobdella, Branchellion, Polygordius,* Study of prepared slides*:* T.S. of body of leech passing through various places.

Arthropoda: Study of museum specimen: *Limulus, Palamnaeus, Lycosa, Apus, Argulus,Balanus, Sacculina, Mysis, Gmmarus, Squilla*, Prawn, Lobster, true crab, hermit crab, *Julus, Scolopendra, Scutigerella, Lepisma, Mantis*, stick insect, grass hopper, *termites ,Forficula, Pediculus, Ranatra, Dysdercus, Musca* ,Lady bird beetle, butterfly, wasp, *Xenopsylla,* life history of honey bee, lac insect and silk moth; Study of prepared slides: Mouth parts of mosquitoes, house fly, honey bee, butterfly , *Sarcoptes, Ixodes, Cimex, Daphnia, Cypris, Cyclops, Pediculus, Pthirus.*

Mollusca : Study of museum specimen/models : *Chiton, Dentaliun, Pila, Aplysia, Baccinum, Doris, Lymnaea, Mytilus, Patella, Pecten, Limax,* pearl oyster, *Teredo, Nautilus, Loligo, Sepia, Octopus.* Study of prepared slide: Radula, T.S of shell of *Unio,* T.S of gill lamina *of Unio,* T.S of body of *Unio* passing through middle region; Larvae of molluscs.

Echinodermata: Study of museums specimen/ models: *Astropecten, Asterias, Ophio*thrix, *Opiura, Echinus, Clypeaster, Echinocardium, Thyone, Holothuria, Antedon*; Study of prepared slides: Larvae of echinoderms: Aristotle's lantern.

Hemichordata : Study of museum specimens: *Balanoglossus, Cephalodiscus: Tornaria* larva,

Minor phyla: Representative specimens of Onychophora (*Peripatus*), Sipunculida*(Sipunculus*), Echiurida (*Bonelia)*

ZOO-502N: Basic principles and Application of: Microtome, Spectro-photometer, Flame photometer, Atomic absorption, Spectroflouro-photometer, Paper and thin layer chromatography, Centrifuge.

ZOO-503N: Comparative study of total count of erythrocyte and leukocytes of fish bird, and rat. Comparative study of different leukocyte count (DLC) of fish, bird and rat, Colorimetric estimation of heamoglobin content of the blood, Colour index and mean corpuscular haemoglobin in fish, bird and rat, Determination of haemetocrit in fish, bird and rat, Determination of respiratory rate of rat in relations to size and sex; Respiration rate in fish at different temperatures.

ZOO-504N: Isolation and colorimetric determination of glycogen content of rat liver; Demonstration of effect of epinephrine on the glycogen yield from the liver; Estimation of nucleic acids in testis of rat. Comparative estimation of the protein content and total lipid in fat body of cockroach, liver of fish and rat. Quantitative estimation of total free amino acid in tissues of cockroach and paper chromatographic separation of these amino acids; Kinetic essay of salivary amylase and to study the effects of time, temperature and pH on its activity; Study of effect of substrate concentration on the activity of urease enzyme; Inhibition of cholinesterase activity in the brain of rat organophosphate.

ZOO-506N: CHORDATA: ORIGIN, EVOLUTION AND COMPARATIVE ANATOMY **CREDIT:4+0**

Unit-1 Origin of chordates: Characteristic of Ostractoderms (Cephalaspida ,Anaspida , Pteraspida , Coelolepida) and Placodermi (Rhenanida , Acanthothoraci , Petalichthyida , Arthrodira , Ptyctodontida, Phyllolepida , Antiarchi , Brindabellaspida); Inter-relationship among Ostracoderms and Placodermis.

Unit-2 General organization (external characters, endoskeleton alimentary canal , respiratory organ, blood vascular system, sense organs, urinogenital system) of Holocephali; Affinities of Holocephali, Dipnoi and Crosspterygii; origin of paired fins in teleosts; origin of tetrapoda from Lung fishes , Bichirs and Crosspterygians).

Unit-3 Rhynchocephalia, Origin and Evolution of Reptiles (Seymouria, Cotylosaurs, Captorhinomorphs , *Diadetomorphs plesiosaurs* and Ichthyosaurs , Archosaurs , Saurischia, Bronotosaurs and Diplodocus , Ornithischia) and Birds (Jurassic birds, Cretaceous birds , Cenozoic birds); Aerodynamics in Birds (modification in skeleton and musculature aspects ratio, take off, gliding and soaring flapping flight, slow and fast flight , perching mechanism, hovering; landing); origin and evolution of mammals; Diagnostic characters of mammals and reptiles with mammalian features (Seymouriamorph, Captorhynomrph, Theromorphs) Cynognathus, conversion stage of reptiles in mammals; first , mammals, adaptive radiation in Eutheria .

Unit-4 Comparative study of heart in different classes of vertebrates , e.g. fish, amphibians reptiles, birds and mammals; arterial and venous channel in different vertebrate group; comparative study of urinogenital system in different groups, e.g Amphibians, Reptiles, Birds and Mammals .

Suggested Literature:

1. Comparative Anatomy of vertebrates by Herbert W. Rand , Harverd University Press
2. Comparative Anatomy of Vertebrates by M. D. L. Srivastava
3. Evolution of the vertebrates, E. H. Colbert.
4. Introduction to vertebrates by T. C. Majupuria , s. Nagin Company
5. Text book of Comparative Anatomy of Vertebrate by Saurav Singh , Centrum Press
6. Text book of Zoology: Vertebrates by T. J. Parker &W. Haswell, modified by A. J. Marshal.
7. The life of vertebrates: J. Z .Young.
8. The origin of vertebrates by N. J. Berrill , Oxford at The clarendon Press
9. The vertebrates Body, A.S. Romer.
10. Vertebrate life by McFaland; Pough ; code ; Heiser, Macmillian and Collier Publisher
11. Vertebrate Palenotology . A. S. Romer.

Course outcomes;

- After the course the students will be able to understand the comparative anatomy of animals of different classes.
- This course will provide insight to the modification of the organs and system of the body in order to adapt in different habitats.
- The course will benefit students for various national and international competitive examinations

ZOO-507N: SYSTEMATICS, BIODIVERSITY & EVOLUTION **CREDIT:4+0**

Unit-1 Definition and basics concept of biosystematics & Taxonomy: Historical resume of systematic and its importance and application in biology; Trends in biosystematics: Concepts of different conventional and newer aspects– Chemotaxonomy, Cytotaxonomy, Ethotaxonomy, Molecular taxonomy, DNA fingerprinting & Molecular markers for detection and evaluation of polymorphism, RFLP, RAPD, Numerical taxonomy.

Unit-2 Dimensions of Speciation and Taxonomic Characters: Types of lineage changes, Production of additional lineage, Species concepts and its categories, Subspecies and infra-specific categories, Theories of biological classification, Hierarchy of categories, Taxonomic and non- taxanomic characters.

Unit-3 Procedure in taxonomy: Collection, Preservation, Identification, Different kinds of taxonomic keys, their merits and demerits, Different kinds of Systematic publications, Type of concept – different zoological types, Zoological Nomenclature, formation of scientific names of various taxa, International Code of Zoological Nomenclature (ICZN) –its operative principles, Interpretation and Application of important rules

Unit-4 Lamarckian theories, Neo- Lamarkism, Darwin's theory of natural selection : merits and demerits, Darwinian and pre-darwinian concepts of evolution: Birth of concept of organic evolution; Post–Darwinain concepts of evolution: Neo-darwinian concepts and sources of variation: Gradualistic vs. Non-gradualistic theories, Mayr's Founder Principle, Gould's punctuated equilibrium theory, Kimura's neutral theory, Neo–Darwinism's synthetic theory of evolution. Isolation and speciation; Genes in population; Hardy-Weinberg Law, Sewall Wright Effect, Micro evolution, Macro evolution and Mega evolution, Evolution in action

Suggested Literature:

1. Biology Systematics by A. Mielli, Chapmon and Hall
2. Evolution by Hall and Hallgrimsson ,johnsn and Bartlett publisher
3. Evolution by mark ridley . Blackwell science
4. Evolution by bartonn.Hbriggs, D.E.G., Eisen J.A., Goldstein , A.E. Ptel , N.H., cold spring Harbor Laboratory press new York , U.S.A.
5. Evolution by futuyma , D.J. , sinauer associates inc., sunderland , USA
6. Evolution by Hall , B.K. and Hallgrimsson , B..Jones and Bartlett publisher, Sudbury, USA
7. Evolution analysis by Freeman and Herron , Person /prentice hall
8. Methods and principle of systematic Zoology by E.Mayer , E.G.Linsley , R.L. vsinger, McGraw – Hill Book Company , ICN
9. Numerical Taxonomy by joseph felsentein , springer – verlag Berlin Heidelberg New York
10. Procedure in Taxonomy by E.T.Schenk and J.H.Mc.Masters , Standford University Press Standford , California
11. Taxonomy ; A text and reference book by r.e,blackwelder , john wiley and sons , INC
12. What evolution is by mayr E. Basic Books , new York , USA

Course outcomes:

- The study of the DNA fingerprinting & Molecular markers for detection evaluation of polymorphism, RFLP, PAPD etc and numerical taxonomy will be useful to student for research in different topics.
- This will enable students to categorize and systematically place animals with respect to their evolutionary lineage.
- This course will be useful in various competitive exams like CSIR-NET etc.

ZOO-508N: GENETICS & CYTOGENETIC **CREDIT:4+0**

Unit-1 Mendel's Law and their chromosomal basis; Extension of Mendel's principles; Allelic variations and gene function, Incomplete dominance and co- dominance, Gene mutation for allelism, Gene action– from genotype to phenotype – Penetrance and Expressivity, Gene interaction, Epistasis Pleiotropy; Interaction of gene.

Unit-2 Chromosomes and gene, Cytoplasmic inheritance, Environment and Heredity: Lethal genes; sex–linked inheritance; Pedigree Analysis, Chromosomal Mapping, Elements of Eugenics, Imprinting of genes, Gene Therapy

Unit-3 Sex chromosome, Sex determination, Multiple allelism, Numerical and Structural chromosome aberrations and their significance; DNA replication, Transposable elements in Prokaryotes and Eukaryotes, Role of transposable elements in genetic regulation

Unit-4 Microbial Genetics: Bacterial transformation, transduction, conjugation, Bacterial chromosome, Bacteriophages, Molecular Cytogenetic Techniques (FISH, GISH, DNA Fingerprinting, Flow cytometry and Chromosome painting)

Suggested literature:

1. Development genetics of higher organisms by George M. Malacinski ,Maxmillan
2. Embryology by M.P.Arora , Himalaya publishing house
3. Fundamantal of human genetics by sanjaymadsal , new central book agency , landon
4. Fundaments of genetics by G.S.Migalani , norsa publishing house
5. Genetics by P.K gupta , Rastogi publication
6. Genetics by E. Conrad , apple academics press
7. Grenetics by ursilagoodenough ,hotl-saumders international edition
8. Genetics by j. Russwll , Benjamin- cummings publishing company , san Francisco , colifornia.
9. Modern genetics analysis : intergrating genes and genome , by Griffiths J.F.,Gelbart ,M., Lewontin,c,and miller , w.h freeman and company , new York , USA
10. Molecular genetics by guther s. Stent Richard colendar .cbs publication and distributors
11. Principles of genetics by snustad and simmons (4^{th} ED.2005), john wiley& sons. USA

Course outcomes:

- Students will be able to understand gene flow, sex chromosome, sex determination, multiple allelism, Numerical and structure chromosome aberrations and their significance, DNA replication, Transposable elements in prokaryotes and eukaryotes ; Role of transposable elements in genetic regulation.
- They will also get an idea of microbial genetics, Imprinting of genes, chromosomes and gene and gene therapy.
- The course will help students in planning their research in the field of genetics and cytogenetics.
- Students will be benefitted during various competitive examinations.

ZOO-509N: DEVELOPMENTAL BIOLOGY **CREDIT:4+0**

Unit-1 Basic concepts of Development Biology – Cellular Differentiation, Signaling, Role of genes in Embryonic Development of *Drosophila*, Mutant screening in *Drosphila*, Pattern Regulation in Insect- Imaginal Discs; Development Pattern in Zebra fish; chicken and rat, Determination of polarity and symmetry.

Unit-2 Early Embryonic Development of Vertebrates and Invertebrates; Gametogensis , Structure of the gametes – the sperm and eggs , its types; function of Vitellogenins, Yolk and Egg membranes; Hormonal control of ovulation; fertilization, mechanism and types, capacitation, acrosome formation, fertilizin and anti-fertilizin reactions, amphimixis, patterns and planes of cleavages in different types of animals eggs, Role Yolk in egg organization, morulation and blastulation, types of blastula.

Unit-3 Fate maps and cell lineages; Gastrulation; axes and germs layers; morphogenesis, morphogenetic movement; cell adhesion, neural tube formation, cell migration, tubulation, exogastrulation delamination, fate of germinal layers, notogenesis and mesogenesis; axis specification in Drosophila; Anterior –Posterior and Dorsal –Ventral patterning – Role of maternal genes ; Growth and Differentiation its regulation at the level of chromosome ;

Unit-4 Introduction and organizer concept; Stem cell types and its biomedical application, tetraogensis, neoplasia, tumerogenesis, allometric growth, nucleocytoplasmic interaction, Regulation of tissue regeneration and gradients in development system in Hydra and an amphibian , transplantation, ageing, theories and age related changes at molecular level, biological ageing effect of various nutrients and hormones on ageing, cell death, transgenic animals: methods of formation, gene targeting, production and biomedical application of transgenic animals, mosaics, chimeras and knock out animals, Metamorphosis in Insect and Amphibians.

Suggested Literature:

1. A survey of embryology by F.G. Gilchirst , McGraw –Hill Bokk company
2. An introduction to embryology by B. L. Balansky , CBS college publishing
3. An introduction to embryology by B.L. Balinsky; Dr. Biol.Sci , sunders college publishing
4. Analysis of biology development by Kathoff , McGraw –Hill science , New delhi , India.
5. Altas of development embryology by Emil . S. Szebenyi , Faireigh Dickinson university press
6. Development biology by N.J.Berrill , tata McGraw – Hill publication
7. Development biology by scott F. Gillbert ,siauer Associated INC publication
8. Developmental biology by Gillbert ,Sinauer Associates Inc, Massachusetts, USA
9. Experiment embryology by Robert rogh , burgess publishing company
10. Foundation of embryology by Bradley M.Bopdwmer ,Holt Rinerhart and Winston , INC
11. Modern embryology by Charles w. Bopdwner, holt Rinehart and Winston, INC
12. Principle of development by Wolpert, Beddington, Brockes, Jessell, Lawrence , Meyerowitz.(3rd ED., 2006), oxford University press, new delhi , india
13. Regeneration in vertebrate by C.S Thornton, the university of Chicago press

Course outcomes:

- After studying this course the student will be able to understand the basic of development of an animal from a single cell to complex multicellular organism.
- This course will develop ability to think and come up with new ideas as it will introduce a student to organizer concept; stems cells types its biomedical application, tetraogensis, neoplasia, tumerogrnesis , allometric growth ; nucleocytoplasmic interaction.
- Development of transgenic animals and their uses will enhance the student's knowledge regarding development of living organisms for production of bio-molecules like insulin.

ZOO510: PRACTICAL BASED ON ZOO-506N, ZOO-507N, ZOO-508N & ZOO-509N **CREDIT:0+4**

Exercise

Cytogenetics exercise
Embryology exercise
Spotting (10 spots)
Viva-voce

Total marks

ZOO-507N, ZOO-508N: General character and Classification of chordate phyla.

Urochordata : Study of museum specimens/ whole mount *: Oikopleura, Herdmania , Ascidia, Pyrosoma, Doliolum, Salpa.*

Cephalochordata: Study of museum specimens/ models: Branchiostoma .

Cyclostomata : Study of museum specimens /models : *Petromyzon ,Myxine; Ammocoete* larva.

Pisces: Study of museum specimens/ models : *Sphyrna(hammer – headed shark), Trygon,(string –rays), Pristis , Raja (skate), Torpedo (electric–rays), Chimaera, Polypterus, Acipener, Polydon, Amia, Lepidosteus, Hilsa, Harppodon, Notopterus, Labeo, Catla, Cyprinus, Cirrhina, Heteropneustes, Clarias, Wallago, Mystus, Anguilla, Exocoteus, Hippocampus, Channa, Amphipinous, Anabas, Synaptura, Echeneis, Neoceratodus, Protopterus, Lepidosiren;* Study of disarticulated bones of carp.

Amphibia: Study of museum specimen/models*: Ichthyophis, Uraeotyphlus, Cryptobrunchus, Ambystoma, Axolotl larva, Salamandra, Amphiuma, Triturus, Proteus, Necturus , Siren, Alytes, Bufo, Hyla, Rhacophorus*, Study of disarticulated bones of Frog

Reptilia*:* Study of museum specimen/models Chelone, *Kachua, Sphenodon, Hemidactylus, Calotes, Draco, Phrynosoma, Iguana, Heloderma, Varanus, Ophiosarus, Typhlops, Python, Natrix, Ptyas, Dendrophis, Bungarus, Naja, Russlle's viper, Pit viper, Hydrophis, Cerotalus, Crocodilus, Alligator , Gavialis, Ichthyosarus, Dimentron, Brontosarus, Tyranosarus, Stegosarus*, Study of disarticulated bones of varanus

Aves: Study of museum specimens*/models: Arhaeopterys, Milvus(kite), Gyps(vulture), Pavo (peacock), Columba (pigeon), Eudynamys (koel) , Psittacula (parrot), Bubo (owl), Coracias (nilkanth), Dinopium (woodpecker), House sparrow, Corvus (crow) ;* Study of disarticulated bones of fowl .

Mammalians : Study of museum specimens / models : Echidna , Ornithorhynchus , Macropus , Erinaceus, Shrew, Pteropus, Bat, Loris, Manis, Hystrix, Funambulus, Rattus, Oryctologus or Lepus, Herpestes, Lutra, (otter), Civet cat , Macaca , Study of disarticulated bones of rabbit , Skull of dog .

ZOO-509N: Study of mitosis in onion root tip and meiosis in testis of grasshopper or any other insect with the acetocarmine squash method, Study of the salivary gland chromosomes of *Drosophila* and C*hironomus.*

ZOO-510N: Experiments on artificial ovulation, insemination in study of the post embryonic stages of frog and insects, mounting of egg and embryos of snail, study of hormonal control of amphibian metamorphosis, incubation and mounting of chick embryos, study of prepared slides of the embryology of frog, chick and mammals & mammalian placenta, Application of window techniques for in –situ study of chick embryo with special reference to morphogenetic movements, Determination of the effect of temperature on the embryonic development of chick, Study of the development of selected organs through preserved specimen and prepared slides, Experiments on regeneration in Hydra, Earthworm and Lizard.

ZOO-511N: INDUSTRIAL TRAINING/SURVEY/RESEARCH PROJECT **CREDIT:0+4**

ZOO-512N: PRINCIPLES OF ECOLOGY **CREDIT:4+0**

Unit-1 History and Scope of ecology, Autecology and Synecology, Environment: Meaning, Definition and Environmental perception in Vedic literature (air, fire, Earth, Water, Sun in Vedas), Environmental Ethics and Global Imperatives, Climate of India and Indian monsoons

Unit-2 Structure and Composition of atmosphere, hydrosphere, lithosphere and biosphere; Environmental factors (Abiotic factors): Medium, Substrate, Water and Humidity, Light, Temperature, Current and Pressure, Atmospheric gases (O_2, CO_2, and N_2), pH, Nutrients and their importance, Environmental (biotic factors; population and community ecology, parasitism and prey-predator relationship); Ecosystem: definition, type, structural components of different ecosystems, Terrestrial and aquatic (fresh water and marine) habitat; Autotrophs and Heterotrophs (Producer, Consumers, Decomposers and Transformers); Ecological pyramids of numbers, biomass and Energy, Concept of productivity and standing crops, ecotone, ecotype, Ecological indicators, Edge effect

Unit-3 Biogeochemical cycles, concept of stress and strain, Acclimation & acclimatization, adaptation, ecological habitats and niche, concept of limiting factors, Liebig's law of the minimum; Shelford law of tolerance, ecological succession; Concept of Homeostasis and feedback, Concept of model and ecosystem modeling, Conservation of natural resources; Wetlands

Unit-4 Ecological succession, Energy flow in ecosystem: Laws of thermodynamics, Primary and secondary productivity, Demography: Population size and density, life table, generation time, reproductive rate, dispersion, age, structure, survivorship, Population growth: natality, mortality, biotic potential, population interaction, Life history structures, evolution of sex and mating System, Concept of *r* and *k* selection.

Suggested Literature:

1. Basic concepts of Ecology by Clifford B. Knight, The Macmillan Company, New York
2. Basic Ecology by E.P. Odum, Oxford and IBN Publishing Co., New Delhi
3. Ecological Modeling by Grant, W.E. and Swannack, T..,(2008) , Blackwell.
4. Ecology and Applied Environmental Science by Kimonadjibros, cro Press.
5. Ecology and Margaret Brown, Apple Academic
6. Environmental Law by Gurkirat kaur, Shree Publishers and Distributors, New Delhi
7. Field Biology and Ecology by Benton and Werner, McGraw-Hill Book Company
8. Field Sampling: Principles and Practices in Environmental Analysis by Conklin A.R. Jr(2004), CRC Press
9. Fundamental processes in Ecology: An Earth system Approach by Wilkinson, D.M.;(2007),Oxford University PRESS , UK,
10. Fundamentals of Ecology by E.P. Odum,
11. Principles and standards for Measuring Primary Production by Fahey, T.J .and Knapp,A.K., (2007),Oxford University press, UK.

Course outcomes:

- Course will provide an understanding of ecological relationships between organisms and their environment.
- It will provide an overview of diversity of life forms in an ecosystem, explain and identify the role of the organism in energy transfers, habitat ecology and resource ecology.
- It will help to understand the Environmental Pollution and its management.
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ZOO-513N: COMPUTATIONAL BIOLOGY AND BIOSTATISTICS CREDIT:4+0

Unit-1 Basic Components of Computer- Hardware (CPU, input, output, storage devices), Software (operating systems), Application software: Introduction to Microsoft EXCEL : use of worksheet to enter data, edit data, copy data, move data, use of inbuilt statistical functions for computation of mean, S.D., correlation, regression coefficients, etc, use of bar diagrams, histogram, scatter plots etc. graphical tools in excel for presentation of data, Introduction to MSWORD word processor: editing, copying, moving, formatting, table insertion, drawing flowcharts, etc ; Introduction to PowerPoint: image and data handling.

Unit-2 Sampling technique: methods of sampling, sampling and non-sampling errors, tabulation and graphic representation of data, bar diagram, histogram, pie diagram, Measures of dispersion: interquartile ranges, variance and standard variation, coefficient of variation, measures of skewness, coefficient of skewness, kurtosis, standard error of a statistic, estimation theory, Null and alternative hypothesis, confidence limit testing of hypothesis, degree of freedom, Probability: theorems on probability, application of permutation and combination, (a) binominal distribution : mean, variance, conditions for application, Pascal's triangle, characteristics of binominal distribution; (b) Poisson distribution: (c) normal distribution : properties and applications

Unit-3 Probit analysis, correlation covariance, correlation analysis, correlation of coefficient, spearman's rank, correlation coefficient, regression; regression analysis, regression coefficient and its properties, coefficient of determination; test of significance of mean (large sample), two means (large sample); students' t-test: assumption, properties and application of t-test, Chi-square test: Properties and uses of chi-square, analysis of variance– one way and two of classification, f-test; types of non-parametric tests, its advantage/disadvantage and use, sign-test for paired data, Mann-Whitney U-tests, Spearman's rank correlation test; experimental design: basic concepts and principles

Unit-4 Introduction to Bioinformatics, Sources: WWW, HTML, URLs, Google Scholar, PUBMED, GenBank, Databases: nucleic acids, genomes, protein sequences, and structures, Sequence analysis (homology): pair wise and multiple, sequence alignments, BLAST, CLUSTALW, Phylogenetic analysis and detection of open reading frames

Suggested literature:

1.Biostatics by P N Arora and P.K Malhan, Himalaya publishing house
2. Principles of Biostatistics by Pagano M. Gauvreau, K (2000), Duxbury press, USA
3. Fundamental of Biostatics by I A Khan and A Khanam, Ukaaz publication, Hyderabad

Course Outcomes:

- Introduction to basic components of computers, Software (operating systems) and application software used in biological and statistical studies.
- An overview of databank search data mining, data management and interpretation.
- An introduction and learning of Probit Log Analysis for interpretation of toxicity data.
- The course will also introduce students to bioinformatics and help students in further studies.

ZOO-514N: BIOLOGY OF PARASITISM **CREDIT:4+0**

Unit-1 Introduction to Parasitology; animal associations and host– parasite relationship, distribution of diseases and Zoonosis caused by animal parasites, morphology, life-cycle, mode of infection of *Plasmodium*, molecular biology of *Plasmodium* – drug targets, mechanism of drug resistance, vaccine strategies and proteomic approaches.

Unit-2 Morphology, life-cycle and mode of infection of *Leishmania*, molecular biology of *Leishmania* – drug targets, drug resistance and vaccine strategies; Morphology, biology, life-cycle and mode of infection of *Entamoeba* and *Giardia*; Morphology, biology, life-cycle and mode of infection of gastro-intestinal nematodes (*Ascaris lumbricoides*, *Ancylostoma duodenale*, *Enterobius vermicularis*) and *Wuchereria bancrofti.*

Unit-3 Morphology, biology, life-cycles and modes of entry of *Fasciola, Taenia* and *Schistosoma*; molecular biology of nematodes, cestodes and trematodes, and vaccine strategies.

Unit-4 Pathology of Helminth infections; Immune response and self-defence mechanisms, immune evasion and biochemical adaptations of parasites; parasites of veterinary importance; Parasites of insects and their significance, host parasite interactions.

Suggested Literature:

1. *Ecology of Parasites* by A. P. Diwan; A. K. Arora, Anmol Publications, New Delhi
2. *Foundations of Parasitology* by Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA.
3. *Modern Parasitology: A Textbook of Parasitology* by F.E.G. Cox., Wiley-Blackwell, U. K.

Course outcome:

- This course will provide students an insight to Parasitology.
- It will help them to learn life cycles of various parasites, immune response to parasite and self-defense mechanisms and their control methods.
- Students will learn biochemical adaptations of parasites and parasites of insects and their significance, nematode parasites of plants and host parasite interaction.
- This course will help them is useful in various competitive exams.

ZOO-515N: APPLIED ZOOLOGY **CREDIT:4+0**

Unit-1 Aquaculture: marine, reverine and lacustrine fishes; Spme food fishes of India: *Wallago, Anquilla, Harpodon, Notopterus, Stromateous, Channa, Clarias, Labeo, Catla, Cirrhinus, Barbus*; Fish Culture in India; Indian Aquaculture: culture of carps, culture methods, prawn culture, exotic fishes; Importance of pearl culture; Methods of pearl culture; Status of pearl industry in India.

Unit-2 Domestic Animals – Animal Husbandry and Poultry: important breeds of cattle in India, exotic breeds, cattle breeding, artificial insemination, feeding and management of dairy stock, dairy products and chemistry of milk; Position of goat/pig production industry in India, breeds of goats/pig; Common cattle diseases; Poultry industry in India, important poultry breeds, poultry farming, diseases of fowl.

Unit-3 Apiculture : Importance of bee keeping, apiculture**,** *Apis* species**,** bee hive, social life of honey bee, properties of honey; Lac culture : Lac insect and its biology, rearing of lac insect, collection and processing of the lac; Sericulture : Mulberry and non-mulberry sericulture (tasar, munga and eri sericulture); Life cycle of silk moth; Physical and chemical properties of silk

Unit-4 Vermiculture : Introduction, ecology and distribution of earthworms; Vermiculture and vermicomposting methods; Chemical composition of waste based vermicompost; Economics of vermiculture and vermicomposting; Species of earthworms for vermicomposting; In situ application of vermiculture and crop productivity; Use of earthworms in land improvement and reclamation.

Suggested Literature:

1. Beekeeping in India by A.M. Wadhwani,
2. Poultry Husbandry by Morley A. Jull,
3. Domestic Water Buffalo by M. Fahimuddin
4. Live Stock & Poultry Production by Harbans Singh & E. N. Moore,
5. Text Book of Dairy Chemistry by M.P. Mathur, D.D. Roy, P. Dinaker

Course Outcomes:

- The course will provide an understanding of concept of fisheries, fishing tools and site selection for aquaculture.
- It will introduce students to basic concepts of Aqua culture systems, induced breeding techniques, post harvesting techniques, various concepts in lac cultivation, economic importance of lac cultivation, sericulture and apiculture.
- It will help students to learn about methods of Vermiculture and Vermi-composting and economic value of vermiculture and vermi-composting and use of earthworm in land improvement and reclamation.

ZOO-516N: EPIGENETICS AND CHROMATIN BIOLOGY **CREDIT:4+0**

Unit-1 Chromatin structure- basic organization of a eukaryotic genome; histone- structure and function; nucleosome as the fundamental particle; 30 nm chromatin fibers, higher order structure of chromatin, chromatin-territories; intra-nuclear spatial organization of chromatin: MARs and SARs and their importance.

Unit-2 Epigenetics- from phenomenon to field, a brief history of epigenetics- overview and concepts; chromatin modifications and their mechanism of action, concept of 'histone-code' hypothesis, epigenetics in *Saccharomyces cerevisiae,* position effect variegation, heterochromatin formation, and gene silencing in *Drosophila,* fungal models for epigenetic research: *Schizosaccharomyces pombe* and *Neurospora crassa*; epigenetics of ciliates; RNAi and heterochromatin assembly, role of noncoding RNAs; epigenetic regulation in plants.

Unit-3 Chromatin structure and epigenetics marks - transcriptional silencing by polycomb group proteins, transcriptional regulation by trithorax group proteins, histone variants and epigenetics, epigenetic regulation of chromosome inheritance, epigenetic regulation of the X chromosomes in *Caenorhabditis elegans*, dosage compensation in *Drosophila,* dosage compensation in mammals; types mechanism of chromatin remodeling.

Unit-4 Epigenetics and genome imprinting - DNA methylation in mammals, genomic imprinting in mammals, germ line and pluripotent stem cells, epigenetic control of lymphopoiesis, nuclear transplantation and the reprogramming of the genome. epigenetics and human disease, epigenetic determinants of cancer.

Suggested Literature:

1. Epigenetics by C. David Allis and Thomas Jenuwein, (2007) Cold Spring Harbor Laboratory Press, New York, USA
2. Molecular Biology of Gene by Watson et al. (5th Ed. 2004), Pearson Education, Delhi, INDIA

Course outcome:

- Course will give a detailed understanding of chromatin structure and different levels of its organization.
- Awareness of brief history of epigenetics and key concepts.
- Detailed knowledge chromatin modifications and their mechanism of action, concept of 'histone code' hypothesis in the phenomenon of epigenetics.
- Developing skill in describing chromatin structure and epigenetics marks, dosage compensation and mechanism of chromatin remodeling.
- Learning of epigenetics and genome imprinting and the reprogramming of the genome.

ZOO-517N: STRUCTURE AND FUNCTION OF GENES **CREDIT:4+0**

Unit-1 Structure of nucleic acids, folding motifs, conformation flexibilities, denaturation, renaturation, kinetics of hybridization, super-coiling of DNA, packaging of DNA in the nucleus, structure of chromatin, chromatin territories. Genetic material and its evolution-structure and function relationships, evolution of genetic material, genes and genomes.

Unit-2 DNA replication, recombination and repair mechanism, nucleic acid polymerization, accuracy during flow of genetic information, DNA polymerases, proof-reading activity, errors and damage in the DNA, mechanism of DNA repair; genome instability; transcriptional control of gene expression- positive and negative regulations, RNA polymerases, promoters and regulatory sequences, activators and repressors of transcription, transcription initiation by RNA polymerases, regulation of transcription-factor activity, elongation and termination of transcription.

Unit-3 Post-transcriptional gene control and nuclear transport- types of introns and their splicing, evolution of introns, catalytic RNA, alternative splicing and proteome diversity, regulation of Pre-mRNA Processing, micro RNA and other non-coding RNAs, degradation of RNA.

Unit-4 Transport across the nuclear envelope and stability of RNA- structure of nuclear membrane and nuclear pore complexes, processes of nuclear import and export and their regulation, degradation of RNA. Translational machinery and translational control -energetics of amino acid polymerization, tRNAs and their modifications, aminoacyl tRNA synthetases, accuracy during aminoacylation of tRNA, regulation of initiation of translation in eukaryotes, elongation and its control, inhibitors of translations.

Suggested Literature:

1. Genes by Lewin, (9^{th} Edition 2008), Jones and Bartlett Publishers, Boston, USA
2. Genetics (Analysis of Genes and Genomes) by Denial L. Hartl, Jones and Bartlett Publishers
3. Molecular Biology of The Cell by Bruce Alberts, Garland Science Taylorand Francis Group
4. Molecular Biology of the Gene by Watson et al. (5th Ed. 2004), Pearson Education, Delhi, INDIA
5. The Cell : A Molecular Approach by Geoffrey M. Cooper, Sinauer Associates, INC

Course outcome:

- The course will introduce students to structure of nucleic acids, folding motifs, conformation flexibilities, denaturation, renaturation, kinetics of hybridization, super-coiling of DNA, packaging of DNA in the nucleus, structure of chromatin, chromatin territories.
- Regulation of Pre-mRNA Processing, micro RNA and other non-coding RNAs, degradation of RNA.
- Description of transport across the nuclear envelope and stability of RNA, processes of nuclear import and export and their regulation, degradation of RNA.
- This course will be useful in various competitive exams like CSIR-NET etc.

ZOO-518N: ANIMAL BEHAVIOUR **CREDIT:4+0**

Unit-1 Introduction - definition, historical out line, patterns, objective and mechanism of behaviour, asking questions; Reflexes: reflex action, types of reflexes, reflex arch, characteristics of reflexes and complex behaviour; Orientation: primary and secondary orientation; Sun-compass orientation, dorsal -light reaction. kinesis –orthokinesis and klinokinesis, taxis – different kinds of taxis

Unit-2 Eusociality, social organization in honey bee, polyphenism and its neural control, flower recognition, displacement and translocation experiment, various type of communications, production of new queen and hive, swarming, honey bee as super organism**;** Fixed action pattern: mechanism, deprivation experiment, controversies, FAP-characteristics and evolutionary features; Learning and instincts: conditioning, habituation, sensitization, reasoning.

Unit-3 Innate releasing mechanisms: key stimuli, stimulus filtering, supernormal stimuli, open and closed IRM, mimetic releaser, code breakers, Homeostasis and behaviour: motivational system, physiological basis of motivation, control of hunger drive in blow fly and thirst drive in goat, role of hormone, motivational conflict and decision making, displacement activity, models of motivation, measuring motivation, Hormones and pheromones influencing animal behaviour.

Unit-4 Patterns of communication (chemical, visual, light, audio, species specificity of songs, evolution of language with respect to primates); Social behaviour with reference to insects and primates; Sexual behaviour: Courtship, sexual selection, mating patterns, parental care, migratory behaviour of fishes and birds; Territorial behaviour; Behavioural genetics.

Suggested Literature:

1. An Introduction to Animal Behaviour by A. Manning and M.S Dawkins, Cambridge University Press, UK
2. Animal Behaviour an Evalutionary Approach by V. S. Lamoureux, Apple Academic Press
3. Animal Behaviour by John Alcock, Sinauer Association, INC
4. Animal Behaviour in The Laboboratory by P. Silverman, London, Chapman and Hall
5. Animal Behaviour by David McFarland, Pitman Publishing Limited, London, UK
6. Animal Behaviour, John Alcock, Sinauer Associate Inc., USA
7. Exploring Animal Behaviour by Paul W. Sherman & John Alcock, Sinauer Associate Inc., Massachusetts, USA
8. Hearing and Sound Cmmunication in Fishes by Tavolga, Popper and Fay, Springer-Verlag, New York
9. Introduction to Animal Behaviour by Rishikesh and Niraj, Campus Books
10. Mechanism of Animal Behaviour by Peter Marler and J. Hamilton; John Wiley & Sons, USA
11. Perspective in Chemoreceptors and Behaviour by Chapman; Bernays; Stafflano, Springer verlag
12. Perspective on Animal Behaviour by Goodenough, McGuire and Wallace, John Wiley & Sons, USA
13. Principles of Animal Behaviour by Lee Alan Dugatkin, W. W. Norten and Co., New York
14. Principles of Behavioral Analysis by J.R. Millenson, The Macmillan Company, New York
15. Prosomian Behaviour by R. D. Martin, Duckworth
16. Reading in Animal Behaviour by T. E. McGill, Holt, Rinehart and Winston
17. Text Book of Animal Behaviour by F. B. Manal, PHI Learning Pvt.
18. The Orientation of Animal by Gotffried and Donald, Dover Publication, INC, New York

Course outcome:

- This course will provide an insight to different types of behavior in animals.
- The student after this course will exhibit critical and integrative thinking skills.
- Demonstrate ability to communicate scientific information in both oral and written formats.
- Demonstrate knowledge of key concepts in animal behavior.
- Exhibit quantitative research skills (or demonstrate ability to perform all parts of the scientific method).
- Demonstrate ability to think flexibly and apply knowledge to new problems.

ZOO-519N: MOLECULAR ENDOCRINOLOGY **CREDIT:4+0**

Unit-1 Discovery of hormones as chemical signals for control and regulation of physiological processes; Nature of hormonal actions; Major questions in biology of hormones; Techniques for quantization of hormones; Design and development of hormonal assays.

Unit-2 Structure of peptide and protein hormones; Purification and characterization of hormones; Structure-Function relationships in different hormones; Phylogenic analysis of hormonal structures and functions; Biosynthesis of protein hormones; Storage and secretion of hormones: molecular mechanisms of regulation; Transcriptional and post-transcriptional mechanisms of hormone biosynthesis and secretion; Regulation of biosynthesis and secretion; Inhibitors of hormone biosynthesis and their use.

Unit-3 Nature of hormonal effects and actions; Discovery of receptors in target tissues; Mechanisms of hormone action and signal attenuation; Signal discrimination, signal transduction and signal amplification in hormone regulated physiological processes; Structural requirements for successful hormone-receptor interactions; Receptor antagonists and their applications; Metabolism of hormones by target and non-target tissues; Pharmacokinetics of hormones; Hormones and behaviour- cellular and molecular actions of semiochemicals.

Unit-4 Hormones as therapeutic agents; Current developments in design and production of hormonal contraceptives; Recombinant protein hormones-production and application in regulation of fertility in farm animals and humans; Evolution of chemical communication in animal systems; Unsolved problems in hormonal biology.

Suggested Literature:

1. Molecular Biology of Steroid and Nuclear Hormone receptors by L.P. Freedman, Birkhauser, Boston, USA
2. Biochemical Actions of Hormones, by ed. G. Litwack, Academic press, New York, USA
3. Comparative Vertebrate Endocrinology by P. J. Bentlay

Course outcome:

- The student after this course will exhibit critical and integrative thinking skills
- Understanding the nature of hormonal action and its experimental methods of evaluation elucidation of biosynthesis of protein hormones and molecular mechanisms of regulation.
- Knowledge of signal discrimination, signal transduction and signal amplification in hormone regulated physiological processes.
- To Developing knowhow of pharmacokinetics of hormones and behavior.

ZOO-520N: PRACTICAL BASED ON ZOO-512N, ZOO-513N, DSEI & DSEII **CREDIT:0+4**

Ecology exercise	
Statistical exercise	
Exercise for Parasitism	Any one
Exercise for Applied Zoology	
Exercise for Epigenetics and Chromatin Biology	
Exercise for Structure and Function of Gene	Any one
Exercise for Animal Behaviour	
Exercise for Molecular Endocrinology	
Viva-voce	
Total	

ZOO-512N: Study of different structural adaptations of animals to ecological conditions; Study of the micro and macro fauna of soil by froth floatation method; Comparative estimate of physico-chemical ecofactor in different localities; Temperature, pH, carbonate, sulphate, nitrate and turbidity in freshwater sample; Moisture content in soil sample; Study of seasonal variation in plankton population; Demonstration of parallax vision and height perception; Analysis of plant community and biodiversity and biomass; Study of seasonal variation in plankton population both qualitative and quantitative.

ZOO-513N: Use of excel sheet for data processing; Designing simple experiments for testing mean differences, test of significance (chi-square test), etc.

ZOO-514N: Study of prepared slides and museum specimens of selected parasites of representative groups of protozoans, helminths and arthropods; Demonstration of *in vitro* and *in vivo*, infection of *Fasciola* in snail and mammals by histopathology and immune reactions; Culturing insect parasitic nematode and their life cycle; Culturing an insect parasitoid and studying their infection on an insect host; Survey of vector born diseases in local and adjoining areas.

ZOO-515N: Field Study at different Government/Non-Government farm houses/apiaries/ dairies/poultries/sericulture in local area and a project has to be submitted.

ZOO-516N: Isolation of nuclei (as a source for studies on structure of chromatin) from rat/mouse liver by discontinuous sucrose-density gradient centrifugation; Isolation of total histones, and resolution on SDS-PAGE; Studies on modifications of histones (such as acetylation, methylation etc;) by western-blotting using modification-specific antibodies; Expression and purification of recombinant histones; Isolation and characterization of total nuclear proteins; Digestion of nuclei by MNase and calculation of 'repeat-length' of nucleosomes; Digestion of nuclei by DNase-I, and studies of DNA superhelicity in the nucleosomes; Preparation and characterization of soluble-chromatin (10 and 30 nm chromatin-fibers); Purification of and characterization of mononucleosomes; Reconstitution of nucleosome-core and PCR-amplified synthetic DNA; Chromatin-immunoprecipitation (ChIP).

ZOO-517N: Familiarization with sterile-handling techniques for growth of bacteria, such as sterilization, growth media, types of culture etc; Isolations of genomic DNA from bacteria and mouse/rat liver; Measurement of absorption-spectrum of DNA, RNA, and nucleotides; Studies on denaturation of DNA and determination of Tm and calculation of G: C content; Studies on stability of DNA and RNA towards alkali; Studies on growth curve of *E.coli* in synthetic medium and calculation of log-phase for metabolic

experiments; Studies on induction of *lac*-operon; Studies on catabolite repression of *lac*-operon and role of cAMP; Generation and selection of mutants for *lac*-operon, calculation of mutation-frequency.

ZOO-518N: Study of Taxis; Kinesis; Habituation; Trial and error learning; Visual discrimination; Feeding behavior; Pheromonal communication with reference to sexual/special behavior; To study the responses of woodlice to hygrostimuli; To study the geotaxis behaviour of earthworm; To study the orientation responses of first instar noctuid larvae to photo stimuli; To study the median threshold concentration of sucrose solution in eliciting feeding responses of housefly; To study the orientation responses of larvae to volatile and visual stimuli.

ZOO-519N: Isolation of protein hormone and demonstration of bio- activity in an in vivo bio- assay (e;g; FSH); Immunocytochemical localization of a pituitary hormone using light or electron microscopy (e;g; Prolactin); In vivo bio- assay for estrogen; In vivo bio- assay for testosterone; In vivo bio- assay for luteinizing hormone; In vitro biochemical assay for a hormone (LH or PRL); Effect of hCG on poly A rich RNA content in ovary; Quantification of specific transcript (mRNA) after ovarian stimulation by hCG or FSH; Affinity purification of ovine/bubaline pituitary TSH; Preparation and characterization of hormone- enzyme conjugate; ELISA for any one hormone and estimation of plasma level; Estimation of cAMP in a rat tissue (e;g; adipose) with and without hormone stimulation; Streptozotocin administered rat model for diabetes; Demonstration of phospholipase C action; Molecular cloning of a protein hormone (e;g; buffalo prolactin); Expression of recombinant buffalo prolactin in *E. coli.*

ZOO-521N: INDUSTRIAL TRAINING/SURVEY/RESEARCH PROJECT CREDIT:0+4

SBE I: ENTOMOLOGY

ZOO-522N: ECONOMIC ENTOMOLOGY **CREDIT:4+0**

Unit-1 Beneficial insects: Biology of beneficial insects (*Apis, Bombyx, Kerria*), Insect products, use of insects in medicines, insects in Biological Research, Pollination by insects, insects as consumers, Scavengers and as food, Forensic entomology.

Unit-2 Harmful insects: life history, damage caused, and control measures of following insects pests: household insects: insect injurious to man (*Aedes, Anopheles, Culex, Phlebotomus, Cimex, Xenopsylla, Pediculus*) and life stock (*Simulium, Tabanus, Hypoderma, Cochliomyia, Hippobasca*), insects transmitting viral diseases in plants: pests of cotton (*Apis gossypii*, *Earias* spp., *Pectinophora Gossypiella*, *Dysdercus koenigii*, *Myllocerus undecimpustulants*, *Amrasca biguttula biguttula*), pests of sugarcane (*Scirpophaga excerptalis, Chilo infuscatellus, Emmalocera depressella, Pyrilla perpusilla, Aleurolobus borodenis).*

Unit-3 Life history, damage caused, and control measures of following insects pests, pest of cereals crops *(Leptocorisa acuta, Scirpophaga incertulas, Chilo suppressalis, Hieroglyphus banian, Dicaladispa armigera, Sesamia inferens, Nephotettix spp*); pest of pulses (*Helicoverpa armigera*), pests of vegetables (*Aulacophora indica, Leucinodes orbanalis, Bactrocera cucurbitae, Henosepilachna* spp., *Phthorimaea operculetta, Pieris brassicae*); pests of oilseeds (*Amsacta albistriga* and *Amsacta moorei*, *Athalia lugens proxima, Lipaphis erysimi, Bagrada hilaris).*

Unit-4 Pests of fruits and fruit trees *(Quadraspidiotus permiciosus, Eriosoma lanigerum, Oryctes rhinoceros, Papilio demoleus, Amritodus atkinsoni*); pests of stored commodities: *Trogoderma granarium, Tribolium spp., Callosobruchus chinensis, Corcyra cephalonica, Sitophilus oryzae, Sitotroga cerealella*).

Suggested literature:

1. Elements of Entomology by Prof. Rajendra Singh, II-Edition. (2018). Rastogi Publications, Meerut.
2. A textbook of Agricultural entomology by Alford, D.V. (1990). Wiley- Blackwell.
3. Elements of economic entomology by David, B.V. (2000), Popular Book Depot, Chennai.
4. Applied Entomology, D.S.Reddy. New Vishal Publications, New Delhi.

Course outcome:

- To study about the beneficial and harmful insects, significance of their products, benefits of insects in agriculture sector, medicinal values of insects, pests of stored grains, crops, vegetables, oilseeds and plants.
- The student after this course will exhibit critical and integrative thinking skills.
- Demonstrate ability to communicate scientific information in both oral and written formats.
- Demonstrate ability to think flexibly and apply knowledge to new problems.

ZOO-523N: INSECT MORPHOLOGY, PHYSIOLOGY AND DEVELOPMENT **CREDIT:4+0**

Unit-1 The integumentary system: histology of the integument, physical property and chemical composition of cuticle, sclerotization, colouration and moulting, Morphology of the head, tentorium, antenna and mouth parts and their modification; thorax, tergites, legs and their modifications, wing structure and venation, their modifications coupling mechanism and abdomen, pregenital abdominal appendages, external genitalia

Unit-2 Nervous system: the neurons, central visceral and peripheral nervous system. Sensory mechanisms; mechanoreceptors (tango reception, proprioception, sound perception), chemoreception, thermoreception, hygroreception and photoreception (compound eyes, image formation, stemmata, ocelli); Bioluminescence and sound production.

Unit-3 Alimentary system : nutrition, feeding behavior, morphology of the gut and physiology of digestion and absorption, Circulatory system: dorsal vessel, accessory pulsating structures, sinuses and diaphragms mechanism of circulation, composition and function of haemolymph: respiratory system structure of trachea, tracheoles, air sacs, spiracles, physiology of respiration, respiratory adaptation of aquatic and parasitic insects; Excretory system: Malpighian tubules and its arrangements, physiology of excretion (nitrogenous excretion, salt and water balance)

Unit-4 Reproductive system: male and female: development, post embryonic development, metamorphosis, types of larvae and pupae. Exocrine glands: structure and function, pheromones, Endocrine glands: structure and function of non neural, neural and peptide hormones, regulation of general body function and metabolic activities, moulting, polymorphism and diapauses.

Suggested Literature:

1. A text Book of Entomology by R. Mathur, Campus books
2. A text book Entomology by Patnaik, D.D (2013), Dominant Pbl.
3. Biochemistry of insects Rockestein , M(1978), Academic Press, New York
4. College Entomology by Essig, E.O.(1942) Macmillan, New York
5. Comprehensive insect Physiology, Biochemistry and Pharmacology by kerkut, GA and B.I Gilbert (1985) volume 1-13, Pergamon press Oxford New York
6. Elements of Entomology by Singh, R(2015) Rastogi publ.MERRUT
7. Entomology Ecology and Biodiversity by Tyagi B.K.(2011), Scienctific Publishers (India)
8. Fundamentals of Entomology by Elzinga, R.J (2004) 6^{TH} edition. Publication. Prentice Hall
9. Fundamental s of insect physiology by Blum, M.S(1985) , Wile and sons , New York
10. General and applied Entomology by Nayar, K.K,.T.N.Ananthkrishnana& B.V. David (1979), Tata McGraw Hill publication Co Ltd., New Delhi
11. General Entomology by Mani, M.S(1982) Oxford and IBH publishing Co. Pvt. LTD. New Delhi
12. General text book of Entomology by KuzmanH.,Apple academics
13. Imm's General text book of Entomolgy By Richerds, O.W. and R.G Davis (1977) Vol I (structure, physiology, and development), 10^{th} Edition, Chapman & Hall, London, New York
14. Insect Biology A text Book of Entomology by Evans.H.E,. (1984) Addison Wisley publishing company, Reading EGKFOKY
15. Insect physiology and Anatomy by Pant, N.C and S.Ghai(1981), ICAR , New Delhi
16. Insect physiology by W.Hening, John Wiley and Sons
17. Insect plant Relationships by Van Emden, Hf (1972) Black Well, London
18. Introduction to comparative Entomology by Fox.R.M. and Fox.J.W. (1964), Van Nostrand Reinhold, New York
19. Pest control by van Emden , H.F.(1992) 2^{nd} Edition Cambridge University Press, New York

20. Principles of insect Morphology by Snod Grass, R.E (1935) , McGraw , Hill, New York
21. Text book on Agricultural Entomology by Pruthi, H.S (1969), ICAR New Delhi
22. The Insects : An Outline of Entomology by P.J. Gullan, Wiley-Blackwell
23. The Insects : An Outline of Entomology by P.J. Gullan and Cranston. P.(2010)4THEd.,Wiley-Blackwell Press.584 pp
24. The Insects Structure and Function by Chapman. R.F.(1998), 4th Edition, Cambridge University Press.
25. The Principles of Insect physiology by Wigglesworth.V.V (1982), Chapman & Hall, London
26. The Science of Entomology by Romoser,. W.S. and J.G. Stoffolano(1994), 3rd Edition, Wm.C.Brown Publisher, USA.

Course outcome:

- To the value of wildlife, field observations sign and foot prints, locomotory pattern in tetrapods.
- Understand the management practices required to achieve a healthy ecosystem for wildlife population along with emphasis on conservation and restoration.
- Sociobiology of wild animals, migratory and breeding behavior and their sociobiological importance.
- Description of reason for wild life depletion and wild life ecotourism management measures for wild life conservation.

ZOO-524N: ECOLOGY, EVOLUTION AND TAXONOMY **CREDIT:4+0**

Unit-1 Insects and the abiotic environment: effect of temperature, moisture and light on insect population; insect plant interaction; plant and insect herbivore relationship; primary and secondary metabolic plant products. Host selection by insects; chemical defense in plants; allocation of protective chemicals, primary role of toxic chemicals; response of insects to chemical defense; temporal avoidance of chemical semiochemicals.

Unit-2 Insect origin and evolution: Ancestry of insect origin and evolution of insects, relationship between entogonathous and ectogonathousapeterygotes, outline classification of insects: classification, characters, economic importance and examples of following: Entognatha (proturan, collembola, dipluran); Thysanura (Lepismatidae); Palaeoptera(Ephemeroptera, odonata) Orthoptera (schizodactylidae, tettigoniidai, gryllidae, gryllotalpidae, acrididae), phasmida (phasmidae, phyllidae); Dictyoptera (blattaria, Mantodea) Isoptera (kalotermitidae, Termitidae); Phthiraptera (Mallophaga, Anopluara- Haematopinidae, Pediculidae)

Unit-3 Classification, characters, economic importance, and examples of following : Hemiptera (Fulgoridae, Lophopidae, Cicadidae, Membracidae, Cicadellidae, Psyllidae, Aleyrodidate, Aphidadae, Margarodidae, Kerridae, Pseducoccidae, Coccidae, Diaspididae , Redividae, Cimicidae, Anthocoridae, Lygaeidae, Pyrrociridae, Coreidae, Scutelleridae, Pentatomidae,Gerridae, Notonectidae. Belostomatidae, Nepidae); Thysanoptera (Terebrantia—Thritidae, Tubulitera); Neuroptera (Chrysopidae); Coeoptera (Carabidae, Cicindellidae, Dytiscidae,Gyrinidae. Hydrophilidae, Lucanidae, Scaribaeide. Buprestidae, Elateridae,Lampyridae. Dermestidae.Coccinellidae, Tenebrionidae, Meloidae. Cerambycidae, Chrysomelidae,Bruchidae, Curculionidae.)

Unit-4 **S**iphonophera:(Pulicidae,Ceratophyllidae);Diptera(pschodidae,Culicidae,Simulidae,Chironomidae,Bibionidae,Myctophilidae,Cecidomyidae,Tabanidae,Asilidae,Bombyliidae,Syrphidae, Agromyzidae,Drosophilidae,Gasterophilidae,Muscidae,Calliphoridae,Hippoboscidae);Lepidoptera (tineidae, Psychidae, Plutellidae, Nymphalidae,Pieridae, Papilonidae, Geomrtridae, Bombycidae, Sphingigae, Arctiidae, Noctuidae); Gelechidae; Pyrialidae; Hymenoptera (tenthredinidae, ichnegumonidae, Braconidae,Evaniidae, Cynipidae, Chalacidae, Eulophidae, Trichogrammitidae, Scoliidae, Formicide Vespidae, Sphecide, Xylocopidae, Aphidae)

Suggested literature:

1. Elements of Entomology by Singh.R, (2015), Rastogi Publ, Meerut.
2. Dynamics of Insect-Plant Interaction by Ananthkrishnana, T N & A Raman(1988). Oxford & IBH Publishing Co Pvt. Ltd., New Dehli.
3. Navel aspects of insect plant interaction by Barbosa. P.& D.K. Letoumeau (1988). John Wiley & Sons New York.
4. Arthropoda Phylogeny by Boudreaux, B.H (1997), with special reference to insects, Wiley and Sons , New York, pp. 320.
5. Evolution of the insects by Grimaldi . D &Engel .M.(2005), Cambridge University Press, New York and Cambridge, pp. 755.
6. Arthropoda Phylogeny by Gupta , A.P. (1979), Van Nostrand reinhold, New York.
7. Insect Ecology by Price, P.W 1984, 2nd edition, John Wiley & Sons, New York.

Course outcome:

- Student can learn biological evolution and understand that many of the organisms that inhabit the Earth today are different from those that inhabited it in the past.
- Explained adaptation, providing examples from several different fields of biology explained how the molecular record provides evidence for evolution, understand the Human origin and evolution.
- The student after this course will exhibit critical and integrative thinking skills.
- Demonstrate ability to communicate scientific information in both oral and written formats.
- Exhibit quantitative research skills (or demonstrate ability to perform all parts of the scientific method).
- Demonstrate ability to think flexibly and apply knowledge to new problems.

ZOO-525N: INSECT PEST MANAGEMENT **CREDIT:4+0**

Unit-1 Insect pest management: physical control measures (temperature, electromagnetic fields and ionizing radiations); mechanical control measures (handpicking of infested plants and their destruction, netting, bagging and dislodging insect pests, trenching, insect barriers, insect traps, destruction of crop residues, weeds and trash).

Unit-2 Cultural control measures (selected of quality seeds, clean cultivation, destruction/provision of alternative/traps plants, crop rotations, tillage operations, timing of planting/harvesting, nutrient/water management).

Unit-3 Chemical control measures: insecticides: classification, properties, synergistic, repellants, attractions: feeding deterrents: feeding deterrents; formulations, biopesticides; benefits and risks of chemical control; application; modes of action of insecticides, developments of insect resistance against insecticides; Biocontrol measures (organisms used in biocontrol, inoculation, augmentation and conservation of natural enemies- pathogens, predators and parasitoids; selected criteria of a promising natural enemy). Feasibility of biocontrol.

Unit-4 Genetic control measures (sterile- male techniques, artificial manipulation of gene composition of pest insects; breeding of insect-resistant host plants); Legal control measures (enactment and enforcement of quarantines); Concept of Integrated Pest Management (IPM) in agro-ecosystem; Ticks and Mites of Economic Importance.

Suggested literature:

1. Elements of Entomology by Prof. Rajendra Singh, II-Edition. (2018). Rastogi Publications, Meerut.
2. Integrated pest management by Abroi, D.P. (2014). Academic Press, U.S.A.
3. A textbook of Agricultural entomology by Alford, D.V. (1990). Wiley- Blackwell.
4. Agriculture pests of South Asia and their Management by Atwal, A.S. and Dhalwal, G.S. (1997), Kalyani Publishers, New Delhi.
5. Agricultural pests and their control by Awasthi, V.B. (2001), Scientific Publishers, New Delhi.
6. Elements of economic entomology by David, B.V. (2000), Popular Book Depot, Chennai.

Course outcome:

- To study the methods of pest management, physical control measures, mechanical control measures, selected quality seeds, clean cultivation, and destruction of alternative/trap plants, crop rotations, tillage operations, and timing of planting/harvesting, nutrient/water management.
- The student after this course will exhibit critical and integrative thinking skills.
- Exhibit quantitative research skills (or demonstrate ability to perform all parts of the scientific method).
- Demonstrate ability to think flexibly and apply knowledge to new problems.

ZOO-526N: PRACTICAL BASED ON ZOO-523N, ZOO-524N, ZOO-525N & ZOO-526N **CREDIT:0+4**

Exercise
Major Dissection
Minor Dissection
Taxonomy (identification of two insects)
Physiology Exercise
Spotting (10 spots)
Viva-voice
Total

1. Detailed study of the external features of grasshopper
2. Dissection of different systems of Gryllotalpa, Dysdercus, Housefly/Calliphora, Moth/butterfly/Catterpillars/Wasp, honey bee, Dung beetle, Water beetle.
3. Permanent preparation of testis of Coxkroach, salivary gland of dysdercus , ovary, spermatheca and accessory gland of house fly.
4. Sting apparatus of wasp/ honey bee.
5. Spiracles of the caterpillar and wing scales of a lepidopteran insect.
6. Legs of tresterrial and aquatic insects showing simple adaptation concerning locomotion.
7. Study of prepared slides of : T.S / L.S. of integument and the various region of gut, ovary, testis and brain.
8. Whole mounts of thoracic/ abdominal spiracles, different types of antennae, legs, moth parts , wings and sting apparatus of honey bee/ wasp.
9. Determination of pH of insects guts and haemolymph .
10. Qualitative assay of free amino acids and haemolymph and fat body.
11. Quantitative estimation of glycogen, protein and lipid.
12. Qualitative determination of uric acid from fat body/ Malpighian tubules.
13. Determination of the rate of passage of food through gut.
14. Collection of different kinds of larvae and pupae of insects.
15. Collection, preservation and identification of locaaly available insects.
16. Permanent preparation of mouth parts, antennae, wings, legs, Spiracles and external genitalia of insects from different groups.
17. Identification of various insects pests, their life -history and materials damaged by them.
18. Study of various groups of insecticides and equipment's used for insecticide application.
19. To study histology and to demonstrate the presence of lipid and glycogen in microtomy sections of suitable material.
20. Study of life -history of beneficial insects and their products.

SBE II: FISH BIOLOGY

ZOO-527N: TAXONOMY AND MORPHOLOGY OF FISHES CREDIT:4+0

Unit-1 Characteristics of fishes: classification by Berg, Romer, Bertin and Niambourg, and Greenwood; modern classification of fishes: detail taxonomic studies of following orders of fishes of U.P and Bihar up to families: clupeiformes, cypriniformes, beloniformes, cyprinidontiformes, mugiliformes, ophiocephaliformes, symbranchiformes, perciformes, mastacembaliformes and tetradontiformes.

Unit-2 Structure and function of ear-air bladder connection with Weberian apparatus in fishes; different types of caudal fins; Modification of caudal fin, origin of the paired fin.

Unit-3 Structure and function of specialized organs in fishes, electric organ, sound producing organs, light producing organs and poison glands in fishes.

Unit-4 Adaption to different modes of life with special reference in hill stream and deep sea fishes. Sense organs as Chemoreception and electroreception in fishes.

Suggested Literature:

1. Fish and fisheries by S.S Khanna
2. Fish and Fisheries by C.B.L Srivastava.
3. Handbook of fishery Technology by V.M. Novikov, A.M Erindublishng company.
4. Fish and fisheries of India by V.G. Jhingra, Hindustan publication corporation.
5. Fisheries Science by Rounsefell and Evarhart, international books and periodical supply service.
6. Khanna S.S. and H.R. Singh A Text book of Fish Biology & Fisheries Narendra Publication House, Delhi
7. Moorjani, M.N. Fish processing in India ICAR Publ. New Delhi

Course outcomes:

- Demonstrate and understand Taxonomical and Morphological study.
- An overview of diversity of life forms in fishes to study for help to prepare various competitive examinations.

ZOO-528N: ECOLOGY OF FISHES AND CONSERVATION **CREDIT:4+0**

Unit-1 Plankton, Definition, Occurrence and types of plankton, significance of plankton, Plankton in relation to fish production, Inter-relationship between fishes and their biotic environment.

Unit-2 Inter-relationship between fishes and abiotic environment; influence of following abiotic factors on life of fishes, e.g. density and pressure, temperature, salt content in water, light, sound, electric current, bottom deposits and particle suspended in water.

Unit-3 Influence of biotic factors on life of fishes; Interspecific and Intraspecific interrelationship among fishes with different other organisms- parasitism, commensalisms, mutualisms, predator and cannibalisms.

Unit-4 Culture of asexual or sterile fish, hybridization, gynogenesis and androgenesis, transgenic fish, fish conservation of threatened fresh water fishes (*in situ*, *ex situ*), techniques of Cryopreservation.

Suggested Literature:

1. Behavior of teleost fishes by Tony J. Picher, Champman and Hall.
2. Comparative Vertebrate Endocrinology by P.J. Bentlay
3. Ecology of fishes by G.V. Nikolsky, Academy press, London.
4. Ecology of fresh waters by Bria Mass, Willey Blackwell
5. Fish and fisheries by S.S Khanna
6. Fish and Fisheries by C.B.L Srivastava.
7. Khanna S.S. and H.R. Singh A Text book of Fish Biology & Fisheries Narendra Publication House, Delhi
8. Moorjani, M.N. Fish processing in India ICAR Publ. New Delhi

Course outcomes:

- Students will understand and develop knowledge about the influence of biotic factors on the life of fishes; interspecific and intraspecific interrelationship among fishes with different other organisms relation, the study for help to prepare various competitive examinations.

ZOO-529N: PHYSIOLOGY AND DEVELOPMENT OF FISHES **CREDIT:4+0**

Unit-1 Different types of feeding habits in fishes and their adaptation in elementary tract, Physiology of digestion, respiration and osmoregulation in freshwater and marine fishes.

Unit-2 Structure of Male and Female reproductive organs of Fishes and physiology of reproduction, Viviparity in Fishes, Structure of kidney of freshwater and marine fishes and physiology of excretion.

Unit-3 Embryogenesis, process of gastrulation, neuralation, organ formation, larval development and metamorphosis in freshwater fishes.

Unit-4 Structure of Pituitary gland, thyroid, adrenal glands, corpuscles of Stannius and Urophysis in fishes: hormones, secreted by theses glands and their physiological significance.

Suggested literature:

1. Behavior of teleost fishes by Tony J. Pitcher, Chapman and hall.
2. Ecology of freshwater by Bria mass , Willey Blackwell
3. Fish and fisheries by S.S Khanna.
4. Fish and Fishery by C.B. L. Srivastava
5. Fish life Environment and diversity by N.B. Marshal, Agrobios (India)
6. Fish physiology edited by W.S Hoar & D J Randall Vol I and II academic press INC.
7. Khanna S.S. and H.R. Singh A Text book of Fish Biology & Fisheries Narendra Publication House, Delhi

Course outcomes:

- The student will understand the applications of this course in different field of Science and technology think and develop new ideas in rearing and increasing the productivity of fishes.
- The course will benefit students by preparing them in various national and international competitive examinations for higher studies.

ZOO-530N: APPLIED ICHTHYOLOGY **CREDIT:4+0**

Unit-1 Marine, freshwater estuarine reservoir and cold water fisheries of India: fish culture-nutritional requirements of carps, siluroids and murrels , carp cultivation in India; spawning, collection, hatcheries, rearing, shocking, transport and mortality of fish fry.

Unit-2 Fertilization and management of fishery pond. Composite fish culture, cage culture and culture of exotic fishes; induced breeding: methods of fishing in India with particular reference to U.P. preservation, processing, transport and Marketing of fish. Food value and flavours of different fishes.

Unit-3 Larvivorus fishes and public health, common enemies and symptoms, etiology and treatment of diseases of food fishes; fish culture in paddy fields and reservoir ; integrated fish farming with prawn, pig, duck and poultry.

Unit-4 Sewage fed fisheries and its importance; pollution affecting fishery water with special reference to oil spills, domestic pollution, industrial water pollution, radio-active waste; bio-accumulation and bio-magnifications.

Suggested Literature:

1. Aquaculture and fisheries Biotechnology Genetic Approaches, Dunha, R.A, CABI publishing USA.
2. Handbook of fishery Technology by V.M. Novikov, A.M Erindublishng company.
3. Fish and fisheries of India by V.G. Jhingra, Hindustan publication corporation.
4. Fisheries Science by Rounsefell and Evarhart, international books and periodical supply service.
5. Aquaculture principles and practices, Pillay T.V.R.. Blackwell publicsing , USA
6. Khanna S.S. and H.R. Singh A Text book of Fish Biology & Fisheries Narendra Publication House, Delhi
7. Moorjani, M.N. Fish processing in India ICAR Publ. New Delhi
8. FAO (1972) Catalogue of Fishing gears design. Fishing News books, pp 155

Course outcomes:

- Learnt the general classification of fishes, economically important marine and freshwater fishes, migrations and fishery products.
- Described recent concepts in fisheries management, endangered species management and to know the various aquaculture systems.
- The course will provide an understanding about the type of hatchery, brood stock, larval production, feed management water quality and disease management in cultivable species, live feed production.

ZOO-531N: PRACTICAL BASED ON ZOO-527N, ZOO-528N, ZOO-529N & ZOO-530N **CREDIT:0+4**

Exercise
Major Dissection of edible/culturable fish
Taxonomy (identification of two fishes)
Physiology Exercise
Ecology excercise
Spotting (10 spots)
Viva-voice
Total

1. Study of organ system of Sc*oliodon, labeo* and *wallago*; study of accessory respiratory organs and their blood supply in *heteropneusus*. *Clarias, Channa* and Amphibians: Study of air bladder and ear connection in Notopterus and Gudusia or Hilsa; Morphology of olfactory organs and their innervations on teleosts:preparation of a skeleton and an alizarine mount of fish, Study of prepared microslides: Osteolosy of *Wallago*.
2. Quantitative estimation of liver glycogen and blood sugar; demonstration of color change.
3. Systematics of marine and freshwater fishes with special reference to identification of local forms; structural adaptations in fishes.
4. Qualitative and quantative study of freshwater plankton; estimation of Dissolved oxygen, free carbondioxide, alkanity in a local fish pond; oxygen consumption in local fish sin different habitats.
5. Study of food and structural modifications due to feeding habits, gills and gill-rackers, mouth eye alimentary canal, olfactory organs etc: Study of age and growth in fishes; Study of amphibians, exotic poisonous, venomous larvivorous and sound producing fishes.
6. Study of common aquatic vegetation and aquatic insects: study of fishing gears, with particular reference to UttarPradesh: soil factors; estimation of hydrobiogical parameters temperature, pH, conductivity, salinity, dissolved oxygen, primary productivity, ammonia, nitrite, nitrate, phosphate, biological oxygen demand,chemical oxygen demand, of nursery rearing, shocking and breeding ponds.
7. Estimation of ovarian egg counts: culture of live food organisms and assay of nutritional quality of live food; estimation of popular density of live food organisms; decapsulation and hatching of *Artemia* cysts for use in hatcheries; Demonstration of breeding pools and hatcheries. Induced breeding of Indian major carps and catfishes. Identification of eggs, spawn, fry and fingerings of cultivable fishes of india.
8. Collection and identification of aquatic weeds and aquatic insects: Study of feeding habits of fishes by gut content analysis, isolation and estimation of fish immunoglobulins; Molecular techniques in fish health management: Aquarium design and maintenance formulation and preparation of artificial fish food for Indian major carps and Prawns; Analysis of proximate composition of fish and processed products.
9. Visit to freshwater marine fish farm.

SBE III: CELL BIOLOGY

ZOO-532N: CYTOLOGY TECHNIQUES **CREDIT:4+0**

Unit-1 Microscopy : basic principles of light microscopy, magnification, numerical aperture, resolution, stereo microscopy, principles and instrumentation of phase contrast, interference, polarisation (bireferingant object, plane polarized light, Nicole prism), Fluorescence microscopy; principles and instrumentation of electron microscopy(transmission electron microscope (TEM), Scanning electron microscopy(SEM)); different fixation and staining techniques for electron microscope. Freeze -etch and freeze-fracture methods for EM; image processing methods in microscopy

Unit-2 Basic principles of freeze drying technique (Lyophilization) and their uses; X-ray diffraction; basic principle of X-ray diffraction methods and instrumentation uses of X-ray diffraction study in cell biology; Autoradiography: basic principles of Autoradiography and their uses in cell biology; detection and measurement of different types of radioisotopes used in biology; safety aspects; methods of cell culture and cell line establishment, media preparation.

Unit-3 Chemical basis of fixation of ethanol, methanol, acetone, acetic acid, trichloroacetic acid, picric acid, mercuric chloride, formaldehyde, chemistry of cytochemical localization of glycogen by periodic acid- Schiff method; protein by coupled tetrazonium reaction method; lipid by Sudan Black B method; nucleic acid by Feulgen and methyl green- pyronin; acid and alkaline phosphatase by method Gomori's lead phosphate and Azo-dye coupling method; oxidases by diphenyl amine and nathoquinone.

Unit-4 Purification and fractionation of nucleic acid, nucleic acid hybridisation, enzymatic replication of DNA by PCR- optimize reaction component, cycling parameters. DNA template, primers, bivalent and monovalent cations, cot analysis, taq and thermostable DNA Polymerases, enhancers; DNA micro- arrays, GISH and FISH.

Suggested Literature:

1. Cell and molecular biology, D. Roberties
2. Cell bilogy, Saunders
3. Molecular cell biology, Albert Brucee et al
4. The cell nad molecular approach, G.M Cooper
5. Cell biology, Gerald Karp.

Course outcomes:

- After the course the students will be able to understand the techniques used to study purification and fractionation of nucleic acid, nucleic acid hybridisation, enzymatic replication of DNA by PCR- optimize reaction component, cycling parameters.
- This course is useful in various competitive examinations and will also enable student to work in different research laboratories.

ZOO-533N: CELLULAR ORGANIZATION AND FUNDAMENTAL PROCESSES: CELL STRUCTURE **CREDIT:4+0**

Unit-1 The nucleus (the nuclear envelop and traffic between the nucleus and cytoplasm), internal organization of the nucleus, the nucleolus; plasma membrane structure and chemical composition; movements of substances across the membrane.

Unit-2 Protein shortening and transport endoplasmic reticulum (the endoplasmic reticulum and protein sectreation, the smooth ER and lipid synthesis, export of protein and lipids from the ER), The Golgi apparatus (organization of the Golgi, protein glycosylation within the Golgi Lipid and polysaccharide metabolism to the Golgi, protein sortening and export from the Golgi apparatus).

Unit-3 Lysosomes. Types, ultrasound and functions, lysosomal enzymes, endocytosis and lysosome formation, phagocytosis and autophagy; lysosomal storage disorders.

Unit-4 Bioenergetics and metabolism (mitochondria-organizaton and function, mechanisms of oxidative phosphorylation, peroxisomes- functions of peroxisomes); types of ribosomes, its ultrastructure; functions and biogenesis in eukaryotes and prokaryotes.

Suggested Literature:

1. Biochemistry of lipids and membranes by D.E Vance; J E Vance, the Benjamin/Cummimge Co.
2. Cell & Molecular biology, D Roberties.
3. Molecular cell biology, Albert Brucee et al
4. The cell and molecular approach, G.M Cooper
5. Cell biology, Gerald Karp.
6. Cell biology by Thomas D. Pollard, Saunders.

Course outcomes;

- Student will understand about the structure and functioning of all organelles in the cell.
- This course is useful to further study of the students in the field related to cellular functions.

ZOO-534N: GENE REGULATION, CELL COMMUNICATION AND DIFFERENTIATION **CREDIT:4+0**

Unit-1 Cell signaling: general principles of cell signaling, forms of signaling, classes of cell surface receptors protein, signaling of steroid and thyroid hormones through intracellular receptors, signaling via – G- protein linked cell surface receptors; interferon.

Unit-2 The cell division cycle; the general strategy of cell cycle, regulation of the cell cycle by cell growth an extra circular signals, cell cycle check points, regulation of cell cycle progression.

Unit-3 Circular mechanism of development: mechanisms of cell diversification in the early animal embryo, cell memory, cell determination and concept of positional values; differentiated cells and their maintenance: maintenance of the differentiated state, tissues with permanent cells, renewal by simple duplication. Renewal by stem cells, uses, progenitor, embryonic, adult and pluripotent stem cells, Apoptosis and natural cell death

Unit-4 Gene regulation in prokaryotes, operon model in bacteria, promoter and operator genes, working of genetic switches, transcriptional and translation control, Gene regulation in eukaryotes, hormone regulation or gene control, DNA binding motifs and gene regulatory proteins.

Suggested Literature:

1. Cell & Molecular biology, De Roberties.
2. Molecular cell biology, Albert Brucee et al
3. The Cell and molecular approach, G.M Cooper
4. Cell biology, Gerald Karp.
5. Cell biology by Thomas D. Pollard, Saunders.

Course outcomes:

- This course will help a student to learn the communication between the cells and help a student to unfold the molecular events involved in differentiation and division of cells in research programmes based on molecular biology.

ZOO-535N: IMMUNOLOGY AND CANCER **CREDIT:4+0**

Unit-1 Historical account of immunity, theories, recognition, kinds of immunity, immune responses, self and non self, diversity, innate or germ line immunity, adaptive or acquired immunity, Humoral & cell mediated immunity.

Unit-2 Organs and cells of immune system: Lymphoid organs of the body, thymus, bone marrow, lymphnodes spleen, GALT, MALT, CALT. Lymphokines, cytokine, complements, T-cell receptors, molecular and antigen presentation onto T cells, Cytotoxic T cells, Helper T Cells and T cells and T cell activation, Selection of the T cells repertoire HLA, Compliments: alternate/ classical pathways.

Unit-3 Fine structure of antibodies, types, function, production & synthesis of polyclonal and monoclonal antibodies. Antigen-antibody interactions, cross reactivity, avidity, precipitation reactions, agglutination reaction, ELISA.RIA

Unit-4 Biology of Cancer : causes and types of cancer, properties of cancer cells, Molecular genetics of cancer, diagnoses, prevention and treatment, hypersensitivity, autoimmune disorders, immunodeficiency diseases (AIDS)

Suggested Literature:

1. Janus Kuby 8th edition: Principles of Immunology
2. Connors & Smith: Essentials of Medical Genetics (1994), Blackwell
3. Jorde et al: Medical Genetics (2003), Elsevier

Course outcomes:

- Outline the key components of the innate and adaptive immune responses.
- To describe about cell types and organs which are involved in an immune response, described the Infectious diseases, hypersensitivity, autoimmune disorders, immunodeficiency diseases.
- Students will also learn the basics about cancer.

ZOO-536N: PRACTICAL BASED ON ZOO-532N, ZOO-533N, ZOO-534N & ZOO-535N **CREDIT:0+4**

Exercise
Cytochemical localization
Vital staining
Microtomy
Isolation of nucleic acid
Spotting (10 spots)
Viva-voice
Total

1. Handling and use of phase contrast microscope.
2. Quantitative estimation of DNA, RNA, alkaline phosphate.
3. Cytochemical localization of phosphatases, RNA,DNA, proteins, lipids and glycogen.
4. Study of chromosomal behavior during cell division, using squash preparations of animal (testes of rat and grasshopper; bone morrow of rat) tissues and plants (onion root tip) tissues.
5. Prepared slides of chromosomes behavior during cell division.
6. Study of salivary gland chromosomes of drosophila and/or Chironomus larvae.
7. Identification and study of mutant forms of drosophila.
8. Drosophila culture technique.
9. Cytochemical localization of golgi complex, mitocohondria, acids and alkaline phosphatases and glycogen.
10. Supravital staining of Nissl bodies, mitochondria and Cytoplasmic organells and inclusion.
11. Study of prepared slides of various cytoplasmic organells and inclusion.
12. Study of prepared slides of various stages during mitotic, and meiotic cell divisions. Bacterial culture techniques. Isolation of nucleic acids.

FOR ALL STUDENTS OF SEMESTER IV

ZOO-537N: INDUSTRIAL TRAINING/SURVEY/RESEARCH PROJECT CREDIT:0+4

ZOO-511N: INTEGRATED PEST MANAGEMENT (Minor) **CREDIT:4+0**

Unit I Introduction: Define pest, pest control and Integrated pest management, Brief History of pest control, Promise and perils of pesticide.

Unit II Pest management Tactics: Regulatory control (Qurantine, eradication, control districts, crop free period, certification of seeds and planting stock), Cultural control (Sanitation, Tillage, Crop rotation, Cropping systems) Use of attractants, repellents, pheromones, kairomones in pest management.

Unit III Pest management Tactics: Biological control (Ecological considerations, Biological control of Insects: parasites, parasitoides) Genetic Manipulation of pest population (Sterile insect release, delayed Sterility, Genetic Displacement)

Unit IV Pest management Tactics: Genetic manipulation of crop (Plant resistant to insects, Inheritance and expression of plant resistance, Deployment of resistant genes.

Suggested Readings:

1. H.H. Ross, C.A. Ross & J.R.P. Ross, 1982. A textbook of entomology. (John Wiley & Sons).
2. R.A. Arnett & R.L. Jacques, 1985. Insect life: A field entomological manual for the amateur naturalist (Prentice-Hall, Inc.)
3. D.B. Tembhare, 1997. Modern entomology. (Himalaya Publ. House).
4. Alford: A textbook of Agricultural Entomology, Blackwell 1999
5. Atwal: Agricultural pests of India and South-East Asia, Kalyani Publishers, 1986
6. Dent : Integrated Pest Management, CABI, 2000
7. Gillot: Entomology (2nd ed.) Plenum Press,1995
8. Gullan & Cranston: The Insects: An Outline of Entomology (5^{th} ed.) Wiley Blackwell, 2014.
9. Harborne: Introduction to Ecological Biochemistry (4th ed.), 1993
10. Imms: A General Text Book of Entomology (2 vols.), Asia Publishing House, 1997
11. Norris et al: Concepts in Integrated Pest Management, Prentice-Hall, 2002
12. Pedigo: Entomology and Pest Management (4th ed.), Prentice Hall, 2002
13. Schoonhoven et al.: Insect-plant Biology- from physiology to evolution (1st ed.) Chapman & Hall, 1998
14. Srivastava: A Text Book of Applied Entomology (Vol. I & II, 2nd ed.) Kalyani Publ.,2001
15. Srivastava & Dhaliwal: A Text Book of Applied Entomology (Vol. I & II.) Kalyani Publ., 2010
16. Thacker: An introduction to arthropod pest control, Cambridge University Press, 2002

Course Outcome:

- An understanding about integrated pest management will help students to spread awareness and plan research to manage pests, save crops in an eco-friendly way.
- They will be able to join different research institutions for further studies.