ಮಂಗಳೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ
**MANGALORE UNIVERSITY**
**(Accredited by NAAC with 'A' Grade)**

ಕ್ರಮಾಂಕ/ No. : MU/ACC/CR 56/2020-21/A2

ಕುಲಸಚಿವರ ಕಛೇರಿ
ಮಂಗಳಗಂಗೋತ್ರಿ – 574 199
Office of the Registrar
Mangalagangothri – 574 199
ದಿನಾಂಕ/Date:01.02.2021

## NOTIFICATION

Sub: Revised syllabus of M.Sc. Zoology programme.
Ref: Academic Council approval vide agenda
No.: ಎ.ಸಿ.ಸಿ:ಶೈ.ಸಾ.ಸ.2:21(2020–21) dtd 23.12.2020.

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The revised syllabus of M.Sc. Zoology programme which is approved by the Academic Council at its meeting held on 23.12.2020 is hereby notified for implementation with effect from the academic year 2021-22.

Copy of the Syllabus shall be downloaded from the University Website (www.mangaloreuniversity.ac.in)

**REGISTRAR**

To,

1. The Chairman, Dept. of Applied Zoology, Mangalore University, Mangalagangothri
2. The Chairman, P.G. Board of Studies in Applied Zoology, Mangalore University.
3. The Registrar (Evaluation), Mangalore University.
4. The Principal of the College concerned.
5. The Superintendent (ACC), O/o the Registrar, Mangalore University.
6. The Asst. Registrar (ACC), O/o the Registrar, Mangalore University.
7. Guard File.

# Mangalore University

## Department of Applied Zoology

## M.Sc. Zoology
## Choice Based Credit System
## (CBCS)

## SYLLABUS

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**2020**

# Contents

# PREAMBLE

In an attempt to make the post graduate courses competitive and on par with the global standards, University Grants Commission had directed implementation of Choice-Based Credit System. The syllabi of various courses are being updated by Mangalore University. In keeping with the current style and developments in Animal Sciences the course content is being modified and designed to make it skill based so as to provide an opportunity to the student to opt for various courses customised for his/her inclination, choice is provided through soft-core courses and open elective courses. A solid grounding in a subject is provided through hard-core courses which are mandatory. There will thus, be a component of hard-core, soft-core and open-elective courses. Open-elective courses are to be opted during 2nd and 3rd Semester.

The present syllabus designed by the Board of studies spans over IV semesters. It will have a total of 92 credits, of which 46 credits (50%) form the hard-core, 40 credits (44%) form the soft-core and open electives account for 6 credits. The scheme of examinations and internal assessment is also provided. The calculation of credits and CGPA will be as per the guidelines of the University

Chairman
Board of Studies

# M.Sc. ZOOLOGY

## CHOICEBASED CREDIT SYSTEM (CBCS)
## SEMESTER PATTERN

**Scheme of Examinations and Evaluation;**

The theory and practical component of a course shall be evaluated as below;

| ***Theory*** | **Marks** |
|---|---|
| Internal assessment | 30 |
| Final examination | 70 |

***Practical***

| | |
|---|---|
| Internal assessment | 15 |
| Final examination | 35 |
| Total | 150 |

**Internal assessment shall be as below:**

**Theory**

a. 2 tests for a total of 30 marks.
b. The marks obtained shall be reduced to 30
c. Assignment/Seminar may be given in lieu of an objective test as decided by the departmental council.

**Practical/laboratory**

a. Continuous assessment or a practical test ordinarily during 14$^{th}$ week for 10 marks.
b. Records to be valued for 5 marks. The total maximum shall be 15 marks.

**Project work (field/ laboratory work)**

Project work consists of field/laboratory work. Internal assessment shall be based on

| | **Marks** |
|---|---|
| a) Evaluation of Project report/ dissertation | 10 |
| b) One viva voce | 20 |
| **Total** | **30** |

Final examination shall carry 70 marks and the dissertation shall be sent for central valuation. A dissertation/project report shall be evaluated by 2 examiners one external and one internal from out of the panel of examiners prepared by the B.O.S. and approved by the University.

**Pattern of Question Paper**

***Theory Examination:***

One question (question I) with five subdivisions (a-e) representing all units with each subdivision carrying 2 marks. Five questions (question II to VI) of 12 mark each. One question from each unit of the syllabus. A question may have not more than 3 subdivisions (Example. II a, b, c) all carrying equal marks.

Q I. a-e : Short questions one from each unit. 5 x 2 = 10

QII to QVI : Each question for 12 marks (One question of 12 marks or two questions of 6 marks each or three questions of 4 marks each) representing unit 1 to 5 with internal choice.

***Internal assessment:***

Q I. a-d : Multiple choice question 4 x 1 = 04

QII a-c : Short questions 3 x 2 = 06

QIII to QIV : Each question for 10 marks or two questions of 5 marks each with internal choice

***Practical***

The final practical examination (3 Hrs.) is evaluated for 35 marks and may have one or two major (10 to 12 marks) and one or two minor (5 – 8 marks) questions with 5 marks for viva voce. The final pattern can be arrived at by the departmental council.

## List of Hard core, Soft-core and Open Elective courses

| Semester | Code Number | Hard core courses |
|---|---|---|
| **I** | **ZOH 401** | Animal Taxonomy and Evolution |
| **I** | **ZOH 402** | Biological Chemistry |
| **II** | **ZOH 451** | Animal Cell Biotechnology |
| **II** | **ZOH 452** | Toxicology and Cancer Biology |
| **III** | **ZOH 501** | Genetics and Quantitative Biology |
| **III** | **ZOH 502** | Nutrition and Metabolism |
| **IV** | **ZOH 551** | Biology of Immune System |
| | | |
| | | **Soft core courses** |
| **I** | **ZOS 403** | Comparative Anatomy |
| **I** | **ZOS 404** | Tools and Techniques in Biology |
| **I** | **ZOS 405** | Entomology |
| **II** | **ZOS 453** | Molecular Cell Biology |
| **II** | **ZOS 454** | Comparative Physiology |
| **II** | **ZOS 455** | Adaptation Biology |
| **III** | **ZOS 503** | Fisheries and Aquatic Biology |
| **III** | **ZOS 504** | Animal Breeding |
| **III** | **ZOS 505** | Environmental Biology |
| **IV** | **ZOS 553** | Wildlife Conservation and Management |
| **IV** | **ZOS 554** | Neurobiology and Behaviour |
| **IV** | **ZOS 555** | Statistics and Bioinformatics |
| | | |
| | | |
| | | **Open Elective courses** |
| **II** | **ZOE 456** | Human genetics |
| **II** | **ZOE 457** | Ornamental Fish Production and Management |
| **III** | **ZOE 506** | Infectious Diseases |
| **III** | **ZOE 507** | Vermitechnology |

## Overview and Schematic Syllabus

### I Semester

| Course Code | Hard/Soft core courses | Teaching Hrs/Week | Exam Hrs. | Credit | Marks | | Max. Marks |
|---|---|---|---|---|---|---|---|
| | | | | | IA* | Exam | |
| ZOH401 | Animal Taxonomy and Evolution | 4 | 3 | 4 | 30 | 70 | 100 |
| ZOH402 | Biological Chemistry | 4 | 3 | 4 | 30 | 70 | 100 |
| ZOS403 | Comparative Anatomy | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOS404 | Tools and Techniques in Biology | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOS405 | Entomology | 3 | 3 | 3 | 30 | 70 | 100 |
| | | | | | | | |
| ZOP 406 | Animal Taxonomy and Evolution | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 407 | Biological Chemistry | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 408 | Comparative Anatomy | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 409 | Tools & Techniques in Biology | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 410 | Entomology | 4 | 3 | 2 | 15 | 35 | 50 |
| | | | | 22 | | | 600 |

Any one of the soft core courses to be opted/offered.

### II Semester

| Course Code | Hard/Soft/Open elective courses | Teaching Hrs/Week | Exam Hrs. | Credit | Marks | | Max Marks |
|---|---|---|---|---|---|---|---|
| | | | | | IA* | Exam | |
| ZOH451 | Animal Cell Biotechnology | 4 | 3 | 4 | 30 | 70 | 100 |
| ZOH452 | Toxicology and Cancer Biology | 4 | 3 | 4 | 30 | 70 | 100 |
| ZOS453 | Molecular Cell Biology | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOS454 | Comparative Physiology | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOS455 | Adaptation Biology | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOE456 | Human Genetics | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOE457 | Ornamental Fish Production and Management | 3 | 3 | 3 | 30 | 70 | 100 |
| | | | | | | | |
| ZOP459 | Animal Cell Biotechnology | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP460 | Toxicology and Cancer Biology | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP461 | Molecular Cell Biology | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP462 | Comparative Physiology | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP463 | Adaptation Biology | 4 | 3 | 2 | 15 | 35 | 50 |
| | | | | | | | |
| | | | | 25 | | | 700 |

Any two of the soft core courses to be opted/offered. Any one of the open elective will be offered.

**III Semester**

| Course Code | Hard/Soft/Open elective courses | Teaching Hrs/Week | Exam Hrs. | Credit | Marks | | Max Marks |
|---|---|---|---|---|---|---|---|
| | | | | | IA* | Mark | |
| ZOH501 | Genetics and Quantitative Biology | 4 | 3 | 4 | 30 | 70 | 100 |
| ZOH502 | Nutrition and Metabolism | 4 | 3 | 4 | 30 | 70 | 100 |
| ZOS503 | Fisheries and Aquatic Biology | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOS504 | Animal Breeding | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOS505 | Environmental Biology | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOS506 | Infectious diseases | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOE507 | Vermitechnology | 3 | 3 | 3 | 30 | 70 | 100 |
| | | | | | | | |
| ZOP 508 | Genetics and Quantitative Biology | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 509 | Nutrition and Metabolism | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 510 | Fisheries & Aquatic Biology | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 511 | Animal Breeding | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 512 | Environmental Biology | 4 | 3 | 2 | 15 | 35 | 50 |
| | | | | 25 | | | 700 |

Any two of the soft core courses to be opted/offered. Any one of the open elective will be offered.

**IV Semester**

| Course Code | Hard/Soft/Open elective courses | Teaching Hrs/Week | Exam Hrs. | Credit | Marks | | Max Marks |
|---|---|---|---|---|---|---|---|
| | | | | | IA* | Mark | |
| ZOH551 | Biology of Immune System | 4 | 3 | 4 | 30 | 70 | 100 |
| ZOP552 | Project work (Field\ lab work) | | | 4 | 30 | 70 | 100 |
| ZOS553 | Wildlife Conservation and Management | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOS554 | Neurobiology and behavior | 3 | 3 | 3 | 30 | 70 | 100 |
| ZOS555 | Statistics and Bioinformatics | 3 | 3 | 3 | 30 | 70 | 100 |
| | | | | | | | |
| ZOP 556 | Biology of Immune System | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 557 | Wildlife Conservation and Management | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 558 | Neurobiology and behavior | 4 | 3 | 2 | 15 | 35 | 50 |
| ZOP 559 | Statistics & Bioinformatics | 4 | 3 | 2 | 15 | 35 | 50 |
| | | | | 20 | | | 550 |

Any two of the soft core courses to be opted/offered.

**Grand Total of Maximum Marks 2550**

**Credits distribution**

| | Credits | Percentage (%) |
|---|---|---|
| Total | 92 | - |
| Hard core | 46 | 50 |
| Soft core | 40 | 44 |
| Open elective | 06 | 06 |

***LEARNING OBJECTIVES:***

1. To foster pristine ambiance to the students with plethora of opportunities to gain mastery in distinct facets of Zoology.
2. To enrich proficiency in animal studies and handling, breeding and conservation of animals.
3. To cultivate professional integrity and righteousness through mentoring by connoisseur of subject experts
4. To adept skills required for teaching and research in animal sciences.

***LEARNING OUTCOME***:

1. With Master's Degree in Zoology you will learn how animals are grouped, their anatomy, physiology, nutrition, metabolism and adaptations. You will acquire an understanding of genetics and its importance in breeding of animals. You will also gain insight into toxic substances their effects, cell and molecular biology, cancer and its epidemiology, functioning of immune system, radiation and its effects and applications in biological systems. You will acquire competence with Wildlife conservation and management, Fisheries and aquatic biology and animal tissue culture and biotechnology.
2. To nurture oral and written skills to communicate effectively with scientific fraternity.
3. Retrieve, explore and exploit information, to pen scientific articles and present papers.
4. Well-designed syllabus facilitates students to excel in various competitive exams.

***OUTCOME OF THE PROGRAMME***:

Students on completion of M Sc. Zoology will acquire the knowledge of:

1. Different branches of animal sciences such as Animal systematics, evolution and anatomy, cell and molecular biology, modifications and adaptations of animals to different environments.
2. They will practice ethical, responsible, professional handling of animals and will be well trained in Animal physiology, immunology, neurobiology, nutrition and metabolism.
3. Applied aspects like toxicology, cancer biology, animal cell biotechnology,
4. Genetics and animal breeding, Aquatic and fishery biology, Aspects of wildlife conservation and management, vermin-technology.
5. Comply with all applicable regulations and requirements regarding biological effects of radiation and applications of radiation.

***SPECIFIC OUTCOME OF THE PROGRAMME*:**

Students of M Sc. Zoology will acquire the skills and ability to:

1. Teach zoology at UG/PG level and biology at pre degree level.
2. Do research in basic and applied aspects of animal sciences.

3. Take up positions as lab technician/ forensic experts in toxicology / drug testing laboratories.
4. Take up a profession in animal breeding programs/museum curator/ zookeeper/Wildlife biologist/Scientist post in different laboratories and in industries.

# I Semester

# ZOH401: ANIMAL TAXONOMY AND EVOLUTION
## Teaching Hours 10/Unit

COURSE OUTCOMES

1. Taxonomy course uses the lessons specifically designed to achieve student understanding of biosystematics and to move quickly beyond the knowledge level to high-level thinking.
2. Through this course, aspirants are trained to utilize different taxonomic tools like identification keys to identify different groups of organisms.
3. To know and understand the seven levels of classification and apply this knowledge to classify animals from the Kingdom to Species level.
4. Molecular taxonomy and phylogeny is understood.
5. They obtain an academic speciality besides evolutionary trends, species and characteristics, significance of evolution
6. This course inculcates in students, skills required for an animal taxonomist.

UNIT-I

Importance and applications of biosystematics and taxonomy. History of Classification – Linnaeus to new systematics. Higher order taxonomy – Aristotle to Whittaker's five kingdom and Carl Woese's six kingdom and three domains. Trends in biosystematics: Chemotaxonomy, Cytotaxonomy and Molecular taxonomy. Hierarchy of categories-Taxonomic ranks.Subspecies and other Infraspecies categories.

UNIT-II

Taxonomic procedures: Taxonomic collections, preservation, curetting, process of identification. Taxonomic keys, different types of keys, their merits and demerits. International code of Zoological Nomenclature (ICZN): Operative principles, interpretation and application of important rules. Major classes of taxonomy (Phenetics, Cladistics and Phylogenetics).

UNIT-III

Dimensions of speciation and taxonomic characters. Species concepts: different types. Modes of speciation (Allopatric, Peripatric, Parapatric and Sympatric speciation).Origin and mechanisms of reproductive isolation. Patterns of speciation: gradualism and punctuated equilibrium. Adaptive radiation. Convergent evolution; Sexual selection; Co-evolution.Interactions among species (competition, predation, parasitism, mutualism and mimicry.

UNIT-IV

Concepts of evolution and theories of organic evolution.Lamarckism, Neo Lamarckism, Darwinism, Neo Darwinism, Natural selection. .Major trends in the origin of higher categories- Micro and macro evolution. The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale.Origin and Evolution of Economically important unicellular and multicellular organisms, plants and animals.

UNIT-V

Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new genes and proteins; Gene duplication and divergence. Gene evolution, Evolution of gene families.

REFERENCES


1. Avice J.C. Molecular Markers. Natural History and Evolution, Chapman & Hall, New York.
2. Batschelet, E. (1975) Introduction to Mathematics for Life Scientists,2nd edition, Springer-Verlag, Berlin-Heidelberg-New York
3. Koto, M. (2000) The Biology of biodiversity, 1st edition, Springer, Japan.
4. Mayer E. - Elements of Taxonomy.
5. Murry J.D. (1993) Mathematical Biology, 2nd edition, Springer-Verlag, New York/Berlin.
6. Simpson, G.G. (1961) Principle of animal taxonomy, Columbia University Press, New York.
7. Snecdor, G.W. and Cocharan W.G. (1989) Statistical Methods, Affiliated-East-West Press, New Delhi.
8. Sokal, R.R. and Rohlf F. J. (1995) Biometry the principles and practice of statistics in biological research, 3rd edition, New York W.H. Freeman.
9. Tikadar B.K. Threatened Animals of India, ZSI Publication, Calcutta
10. Wilson, E.O. (1988) Biodiversity, National Academy Press, Washington, D.C.

## ZOP 406: ANIMAL TAXONOMY AND EVOLUTION- LABORATORY.

**4 Hours /Week**

COURSE OUTCOME

1. Students are encouraged to do fieldwork to collect various samples and follow the identification keys to classify the animals.
2. Pupils are trained to use different devises required for sampling.
3. These practices are done at an individual level so that students will be confident enough to go to fields and taxonomically categorize the animals into different groups and also to explore new species.

Experiments

1. Construction of dichotomous key
2. Construction of Cladogram
3. Identification of major adult insects
4. Identification of major groups of Formicidae
5. Identification of major Elasmobranchs
6. Identification of major groups of Aquatic insects
7. Methods to collect and preserve insects-demonstration
8. Mouth parts of insects-adaptive radiation
9. TLC for venom of different organisms.
10. Assessment of the taxonomic diversity in a given habitat.
11. Study of wing evolution in insects
12. Detection of lipids in haemolymph of insects using TLC
13. Evolution of Insect pests of stored grains
14. Collection and estimation of zooplanktons.
15. Collection of 5 invertebrates and preparation of permanent slides/specimens.

# ZOH 402: BIOLOGICAL CHEMISTRY
## Teaching hrs. -10 hrs. /Unit

**COURSE OUTCOME**

1. The course introduces the students to different biomolecules their structure and classification.
2. Students are trained to understand the importance and biological synthesis of different biomolecules like proteins, lipids and carbohydrates.
3. Enzymes their kinetics, regulation, classification, inhibition clinical importance is studied.
4. Chemistry of nucleic acids their synthesis and breakdown are also dealt.
5. Metabolic pathways their importance, regulation and disorders associated with it are discussed.
6. On completion of the course student will have an overview of the biomolecules their importance, structure synthesis and breakdown and associated metabolic disorders.

UNIT -I

Carbohydrates-Classification, structure and properties. Monosaccharides – Glucose, Fructose and Galactose.Disaccharides – Maltose, Lactose, Sucrose, Cellobiose and Trehalose, Polysaccharides – Glycogen, Starch, Cellulose and Inulin.Heteropolysaccharides – Hyaluronic acid, chitin, heparin, chondroitin and keratin sulfate.Physiologically important carbohydrates.

UNIT - II

Lipids-Classification, structure and properties of fatty acids, triglycerides. Oxidation of fatty acids – β oxidation, regulation and disorders.Palmitate biosynthesis and its regulation.Bile salts and bile pigments.Ketone bodies and their importance.Prostglandins and their significance.

UNIT- III

Amino acids- classification, chemical nature and properties.Classification of proteins, physical-chemical properties, structure – primary, secondary, tertiary and quaternary. Methods for determining amino acid sequences – N-terminal, C- terminal and amino acid analysis of proteins.laboratory synthesis of peptides. Metabolism of aromatic amino acids. Introduction to proteomics.

UNIT -IV

Classification of enzymes.Enzyme Kinetics, Factors affecting enzyme catalyzed reactions. Enzyme inhibition. Allosteric regulatioins of enzyme activity Co-enzymes, metalloenzymes,

isoenzymes and Multienzyme complexes, Ribozymes.Clinical applications of enzymes.

UNIT -V

Nucleic acids – Classification and chemistry.Nucleosides, nucleotides, nucleoside analogs and polynucleotides.Biosynthesis and break down of purines and pyrimidines. Salvage pathway. Disorders of nucleic acid metabolism.

REFERENCES:


1. Berg, J. M., Tymoczko, J. L., Stryer, L., & Stryer, L. (2007). Biochemistry. New York: W.H. Freeman.
2. Champe, P. C., Harvey, R. A., & Ferrier, D. R. (2008). Lippincott's illustrated reviews: biochemistry. Baltimore, Lippincott Williams & Wilkins.
3. Conn, E. E., & Stumpf, P. K. (1987). Outlines of biochemistry. New York: Wiley.
4. Devlin T.M. (1993) Text Book of Biochemistry with clinical Correlations, Wiley-Liss, Inc., New York.
5. Garrett R.H. and Grisham C.M. (1995) Biochemistry, Saunders College Publishing, Florida.
6. Harvey, Richard A. (2011). Lippincott's illustrated reviews: Biochemistry. Philadelphia :Wolters Kluwer Health,
7. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2008). Lehninger principles of biochemistry. New York: Worth Publishers.
8. Murray, R. K. (2012). Harper's illustrated biochemistry. New York: McGraw-Hill Medical.
9. Voet, D., Voet, J. G., & Pratt, C. W. (2008). Fundamentals of biochemistry: Life at the molecular level. Hoboken, NJ: Wiley.
10. Zubay G. (1983) Principles of Biochemistry: General Aspects, VIIth Edition. McGraw Hill Book Co., Kogakusha

## ZOP 407: BIOLOGICAL CHEMISTRY- LABORATORY.
**4 Hours /Week**

**COURSE OUTCOME**

1. Students are trained to detect, analyze and quantify various biomolecules like carbohydrates, proteins and lipids. They are also trained in chromatography and colorimetric estimations.
2. As practical training is carried out at the individual level, skills developed by students help them to take up the clinical laboratory jobs.

**Experiments**

1. Color reactions of Carbohydrates
2. Color reactions of proteins.
3. Precipitation reactions of proteins.
4. Identification of an unknown protein.
5. Estimation of blood glucose.
6. Estimation of Free Fatty acids
7. Estimation of cholesterol.
8. Paper chromatography for sugars.
9. Estimation of total serum proteins by biuret method
10. Determination of urine creatinine by Jaffe's method.
11. Estimation of blood urea by diacetyl monoxime method.
12. Determination of DNA content.
13. Estimation of RNA content.
14. Paper chromatography for amino acids
15. Determination of molecular weight and purity of proteins by SDS-polyacrylamide gel electrophoresis.

# ZOS403: COMPARATIVE ANATOMY
## Teaching Hours 10/Unit

COURSE OUTCOME

1. Comparative anatomy explores and establishes the correspondences between body parts of organisms from different species.
2. It builds the concepts of the living structures and helps to propose homology hypotheses between different organs.
3. Students are guided to understand the anatomy of different organ systems of organisms including invertebrates.
4. A content of this course highlights the importance of anatomical structures to assess comparative study from lower to higher vertebrates.
5. It is the study of both the functional adaptation, which plays the main role, and the phylogeny.
6. Learners focus on methods and different tools used in anatomical studies.

**UNIT-I**

**Protochordates and chordates**: Historical perspective and general concepts of Comparative Anatomy, Anaplasy, Homoplasy. Body plan of animals-evolutionary perspectives.Characters and Classification of proto-chordata, significance of protochordates in the evolution.Origin of chordates and classification.Methods and tools used to study animal body.

**UNIT-II**

**Integument, Skeletal and Digestive system:** Vertebrate integument, development, structure of skin in vertebrates. Derivatives of Integument glands, scales, horns, claws, hooves, feathers & hair. Skeleton - Components of the head skeleton. Comparative account of jaw suspension. Cranial kinesis, Comparative account of vertebral column. Comparative account of girdles and limbs. Anatomy of gut in relation of feeding habits- herbivores, carnivores and omnivores.

**UNIT-III**

**Circulation and respiration**: Evolution of heart in vertebrates. Evolution of aortic arches and portal system. Respiratory organs in fishes-Internal and External gills, Lungs and gas bladder. Air sacs in birds. Evolution of lungs from amphibians to mammals.Respiratory structures among invertebrates.

**UNIT-IV**

**Nervous and muscle systems**: Comparative anatomy of brain in relation to its function. Nerves - cranial, peripheral and Autonomous nervous system. Sense organs-eye, organs of olfaction and taste, Lateral line system and Electric organs. Muscles- Gross structure of muscles; muscles of primary swimmers.Axial, Hypobranchial, Appendicular and Branchial muscles of tetrapods.

**UNIT-V**

**Urino-genital systems**: Excretory organs- Organs of excretion among invertebrates.Gross anatomy, development and evolution of kidneys in vertebrates.Structure of the nephron in relation to excretion and osmoregulation. Reproductive system in Vertebrates.

REFERENCES


1. Barnes, R.S.K. (1993) The invertebrates: a new synthesis, Blackwell Scientific Publication.
2. Cleveland, H.P., Roberts, Larry S. (Jr) and Larson A. (1995) Integrated Principles of Zoology. 9 the dition, WBC Brown publishers.
3. Gardiner, M. S. (1972) The Biology of Invertebrates, Mc. Graw Hill Book Co.
4. Hyman L. H. (2004) Anatomy of Comparative Vertebrates. Reprint.Satish Serial Publishing, Delhi.
5. Kenneth, V. K. (2006) Vertebrates: Comparative Anatomy, Function, Evolution. 4th edition, McGraw-Hill, New York, NY.
6. Kulshrestha,S. K. (2004) Comparative Anatomy of Vertebrates
7. Milton, H. (1995) Analysis of vertebrate structure. John Niley& Sons Inc, New York.
8. Romer, A.S and Parsons T. S. (1978) The Vertebrate body, 5thedition, W.B. Saunders Co & Toppan Co, Ltd
9. Saxena, R.K. and Sumitra S. (2008) Comparative Anatomy of Vertebrates. New Delhi,
10. William, K.P.(1998) Life- The Science of Biology, 5th edition, Sinauer Associates Inc.

## ZOP408: COMPARATIVE ANATOMY –LABORATORY
**2 Hours/Week**

**COURSE OUTCOME**

1. Comparative anatomy uses diverse techniques: classical dissection, examination of anatomical specimens.
2. They are made to expertise in preparing the samples for various histological studies and their comparative analysis.
3. This training provides insights into evolutionary changes of different organs within the animal kingdom and their significance.

1. Adaptive Wing modifications in insects.
2. Adaptive leg modifications in insects.
3. Dissection-study of external and internal features of Cockroach.
   (a) Digestive system
   (b) Reproductive system
4. Temporary mounts of cockroach-
   (a) Gizzard
   (b) Trachea
   (c) Cross striations and nuclei of muscle fibre.
5. Microscopic anatomy of –artery, vein, lung, kidney, liver, oesophagus, stomach, intestine, testis and ovary of frog.
6. Study of embryological slides –chick.
7. Dissection- study of external and internal features of mouse.
8. Fixation of tissue and preparation of paraffin block
9. Preparation of paraffin slides and staining of paraffin sections.
10. Types of beaks and feet in birds.
11. Types of feathers in birds.
12. Skeletal system- tetrapod's-Vertebrae, limbs and girdles.

# ZOS 404: TOOLS AND TECHNIQUES IN BIOLOGY
## Teaching Hours 10/Unit

COURSE OUTCOME

1. Here students are taught to deal with different tools and techniques applicable in biological research including various types of microscopes, centrifuges, electrophoresis, chromatography etc.
2. The theory session mainly focuses on understanding the principles and working mechanisms of different instruments.
3. Learn microbiological techniques, media preparation and sterilization.
4. Fermentation methods to study product yield.
5. Get acquainted with Cytological and histological techniques
6. Develop skills of advanced instrumentation.

**UNIT-I**

**Solution chemistry and Microscopy**: Acids and bases, pH measurement of biological fluids, types of buffers, Molarity and Normality of solutions. Microscopy, principle & applications.Light microscopy- bright field microscope, darkfeild microscope, Phase contrast microscope, Fluorescence microscope, UV microscope.Electron microscopy-SEM and TEM.Confocal microscopy.X-Ray crystallography.

**UNIT-II**

**Microbiological techniques**: Media preparation for bacteria and fungi. Sterilization-physical and chemical, Inoculation, pure culture techniques and growth monitoring, Microbial assays - Microbial identification (cytological staining methods for bacterial and fungal strains).Types and Uses of fermenters.

**UNIT-III**

**Microtomy and Histological Techniques**: Types and applications. Collection & preservation of animal tissue – fixation, embedding, Sectioning, Staining, Identification of deferent components.Tissue preparation for light microscopy and electron microscopy.Staining techniques for the localization of proteins and carbohydrates.Cryotechniques: Cryopreservation of cells, tissues, organs and organisms. Cryosurgery, Cryotomy, Freeze fracture and freeze drying.

**UNIT-IV**

**Separation Techniques**: General principle and applications of Colorimeter, Spectrophotometer,IR, NMR and MASS specrtoscory. Flame photometer, Beer and Lamberts law. Centrifugation: differential and density gradient centrifugation,Organelle separation by

centrifugation. Chromatography: partition, adsorption, Ion exchange, gel permeation and affinity, TLC,GC,HPLC. Electrophoresis: PAGE and agarose gel electrophoresis. one and two dimensional gel electrophoresis, isoelectro focusing gels.

**UNIT V**

**Molecular Techniques**: Southern, Northern Western and Eastern blot techniques, DNA finger printing, Fluorescent in Situ Hybridization (FISH), GISH. Protein and DNA sequencing methods,, Polymerase Chain Reaction- principle, RFLP, RAPD and AFLP techniques. Bioinformatics tools: sequence analysis tools, BLAST (Basic Logical Alignment Search Tool) FASTA, Multiple Alignment, Sequence analysis, using EMBOSS, DNA micro array technique.

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1. Braun,R.(1988)Introduction to instrumental analysis, J. Chem. Educ., 65 (12), pp A336.
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3. Clark, J.M. and Swizer R.L. (2000) Experimental Biochemistry, 3rd edition, W.H. Freeman & Co Ltd.
4. Cooper, G.M. (1997) The Cell-A Molecular Approach. ASM press.
5. Freifelder, D.M. (1982) Physical Biochemistry, W.H. Freeman and Co.
6. Masters, J. R.W. (2000) Animal Cell culture- A practical approach. 3 edition, OUP Oxford.
7. Practical Biochemistry By Plummer
8. Principles and techniques of Practical Biochemistry Ed. B.L. Williams & K. Wilson, Arnold Publishers
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10. Wilson, K.and Walker J.(2000) Practical Biochemistry, 5th edition, Cambridge University Press

## ZOP 409: TOOLS AND TECHNIQUES IN BIOLOGY- LABORATORY

**2 Hours/Week**

**COURSE OUTCOME**

1. In the practical course, they are trained to handle the majority of devices available in the institute.
2. This training of handling devices used in biological research labs gives them the confidence to work in different research labs in the future.

3. Solutions and buffer preparation
4. Measurement of pH of solutions using pH meter
5. Determination of absorption spectra using colorimeter.
6. One-dimensional Ascending & Descending Paper chromatography of Amino acids & sugars.
7. Two-dimensional Ascending & Descending Paper chromatography of Amino acids.
8. One-dimensional Ascending & Descending TLC of Amino acids & sugars.
9. Dialysis
10. Column Chromatography for proteins, pigments and amino acids.
11. Paper Electrophoresis of amino acids.
12. Paper Electrophoresis of proteins.
13. Agar Gel Electrophoresis of proteins.
14. Polyacrylamide Gel Electrophoresis (PAGE).
15. Nucleic acids and Protein sequence database search.
16. SDS- Polyacrylamide Gel Electrophoresis (PAGE).

# ZOS 405: ENTOMOLOGY
## Teaching Hours 10/Unit

**COURSE OUTCOME**

1. Students are trained in the basics of insect classifications and preservation of collected samples in the laboratory condition for future studies.
2. The behavioural paradigm, insect physiology and biological applications of various insects are studied in detail.
3. Plant-insect interactions are discussed to understand the biological significance of insects in controlling pests and pollination.
4. Nutritional requirements of different insects are discussed and this will help the students to establish own insect culture at home or fields.
5. The training helps the students to apply for different competitive exams and get selected.
6. Taxonomical training in identification and classification of insects helps students get job opportunities as entomologists or in related fields.

**UNIT I**

Historical review of insect classifications. Basic of insect classification. Phylogeny of the Arthropoda and the Hexapoda. Hexapoda Orders: Protura, Diplura, Collembola, Archeognatha, Zygentoma, Odonata, Ephemeroptera Orders: Orthoptera; Dictyoptera; (Mantodea, Blattodea, Isoptera), Phasmida; Dermaptera, Psocoptera. Mallophaga; Siphunculata; Hemiptera (Homoptera.Heteroptera); Thysanoptera. Orders: Coleoptera; Strepsiptera; Neuroptera; Hymenoptera. Orders: Trichoptera; Lepidoptera; Siphonaptera; Diptera

**UNIT II**

Scope of insect ecology. Ecosystem approach to insect ecology' ecosystem, levels, their structure and functions (herbivore, entomophagy, haemophagy). Population Ecology: Population dynamics: size, fluctuation, models' Biogeography, Community ecology: species interaction, community structure 'Successional' changes, diversity versus stability.

**UNIT III**

Fundamentals of Insect ethology and its application: Pattern of behaviour' periodicity and clocks. Functional aspects of behaviour: displacement' orientation' communication, reproduction, host selection, defence. Polymorphic phases (swarms, outbreaks, and migration). Locusts in making, and adaptive behaviour. Population ethology; behavioural genetics and evolution. Chromo-ecological and protective behaviour.

**UNIT IV**

Insect behaviour as control measure in plant protection. Biological control: definition; history. Biological control agents: parasites and parasitoids, predators, and competitors. Mass production and distribution. Advantages and disadvantage of biological control. Integrated Pest Management (IPM): Definition; importance; tools; basic principles and evolutionary trends. Ecological basis of IPM. Legislative methods.

**UNIT V**

Insect growth, life cycle, stages of development, metamorphosis (histolysis, histogenesis), types of metamorphosis, moulting, harmones controlling moulting. Nutritional requirements of insects. Digestion of special food stuffs (wool, collagen, keratin, pollen, silk. wax). Fat body. Heart and circulation; physical and chemical properties of haemolymph. Haemocytes. Physiological response of insect to heat.

**REFERENCES**


1. Arnett, R. (2000) American Insects: A Handbook of the Insects of America North of Mexico, 2nd edition, CRC Press.
2. Chapman, R. F. (1998) The Insects: Structure and Function, 4th edition [paperback] Cambridge University Press.
3. Daly,H. V., Doyen J. T. and Purcell A. H. (1998) Introduction to Insect Biology and Diversity, 2ndedition, Oxford University Press. .
4. Gullan, P. J. and Cranston P.(2010) The Insects: An Outline of Entomology, 4th edition, Wiley-Blackwell Press.
5. Pedigo, L.(2009) Entomology and Pest Management, 6th edition, Prentice-Hall,Upper Saddle River, New Jersy.
6. Resh, V. H. (2009) Encyclopedia of Insects, 2nd edition, Elsevier Science.
7. Triplehon, C.A and Johnson N.F (2005) Borror and Delong's Introduction to the study of Insects, 7th edition, Thomson Brooks/Col, U K.

# ZOP410: ENTOMOLOGY-LABORATORY
## 2 hours/week

**COURSE OUTCOME**

1. They are trained in collection, classification and preservations of different insect sample for long term studies.

2. Practical sessions are devoted for training the students in understanding the advantages and disadvantages of insects in pest control and different policies of pest management.

**Experiments**

1. Mounting and Taxonomy: Dry mounting and slide mounting. Sting apparatus, hypopharyngeal gland and pollen basket of honey bees. Insect taxonomy, use of taxonomic features, classification of ants.
2. Productive insects: *Bombyx mori* (Mulberry) adults, cocoons, *Exorista sorbelensis* (Uzi fly parasite).*Apis cerana* (Hive bee) and *A. mellifera*(European bee) adults, pollen, bee wax, queen cell. *Galleria mellonella* (greater wax moth)
3. Pests of stored products: *Sitophils oryzae* (Rice weevil), *Callosobruchus maculates, C. chinensis* (Pulse beetles), *Corcyra cephalonica* (Rice moth).
4. Major pests of crops(slide preparation/ permanent slides/ museum specimens): Rice: *Nilaparvata lugens* (Brown planthopper); sugarcane: *Chilo* spp. (Shoot & stem borers); *coconut*: *Oryctus rhinoceros* (Rhinoceros beetle), *Rhynchophorus ferrugineus* (Red palm weevil); *mango*: *Sternochetus mangiferae* (Mango Seed Weevil); *coffee*: *Xylotrechus quadripes* (Coffee white stem borer), *Hypothenemus hampei* (Coffee berry borer); *cotton*: *Helicover paarmigera* (American Bollworm), *Spodoptera litura* (Tobacco caterpillar); *vegetables*: *Henosepilachna vigintioctopunctata*(Spotted leaf beetle), *Leucinodes orbonalis*(Brinjal shoot & fruit borer), *Diaphania indica* (Cucumber defoliator); *p*olyphagous pests: White grubs (root grubs), *Holotrichia* sp. and *Leucopholis* sp., *Aleurodicus dispersus* (Spiralling whitefly), mealybugs.
5. Vectors and parasites: *Anopheles, Culex,* and *Aedes* adult mosquitoes. Parasites: *Leishmania* sp., *Plasmodium* spp. And *Wuchereria* spp.
6. Parasitoids, predators and biopesticides: Biocontrol agents- *Cryptolaemus montrouzieri* (Ladybird beetle), *Leptomastix dactylopii* (parasitoid wasp), *Trichogramma* spp. (egg parasitoid). Indigenous natural enemies: Predators- *Spalgisepius* (Apefly) and *Chrysoperla carnea* (Lacewing), Parasitoids- Hymenopteran parasitoids, biopesticides.
7. Insect traps: Pheromone traps- Funnel, Sleeve, Del-Ta, Wota, Fligh, Cross-vane, and bucket traps, Volatile traps- Bottle trap and Multiple plastic cup trap, pheromone dispensers (polythene vials, polythene sachet, rubber septa) and light traps.
8. Rearing techniques of pests

# II Semester

## ZOH451: ANIMAL CELL BIOTECHNOLOGY

## Teaching hrs - 10 hrs/Unit

**COURSE OUTCOME**

1. This course aims at inculcating the principles and skills of animal cell culture in students.
2. They are introduced basics of cell culture, cell lines primary cultures, types of cultures etc., media, maintenance of cultures types of cultures etc.
3. Different cell culture techniques including preparation of media, maintenance of cultures, sub-culturing, maintenance of records applications of cell culture are dealt in detail.
4. Culturing of embryonic and stem cells, Hybridoma technology and monoclonal antibodies their applications, commercial applications of cell culture are also discussed.
5. Course also introduces students to genetic engineering, plasmids, Cloning , methods of gene introduction to cells and animals, transgenic animals and genetically modified animals.
6. Students groomed in animal cell biotechnology course can be entrepreneur in cell culture based industry or can get into cell culture based research or can get employed in cell culture based industries.

**UNIT –I**

Introduction, Historical perspective, advantages and limitations of animal tissue culture. Major differences in in vitro .Types of tissue culture.

Biology of cultured cells – Culture environment, cell adhesion, cell proliferation, differentiation, Initiation of culture, cell senescence, continuous cell lines.

Design and layout of laboratory,-Construction, sterile handling area, incubation, room, service bench, Preparation, wash up, maintenance of sterile condition.

Equipments – Essential, beneficial and useful equipments, consumable items.

Culture medium- Physico-chemical properties, complete media, serum, serum free media, balanced salt solutions, selection of medium and serum.

Preparation and sterilization – Apparatus, Reagents and media, storage

Contamination- Source and types of contamination

**UNIT-II**

Primary culture- types of primary culture, Isolation of tissues – mouse and chick embryos, human biopsy material, Explant culture , primary cell culture, disaggregation- enzymatic, mechanical. Suspension culture.

Cell lines: Definition, Evolution of cell lines, continuous cell lines, cell line designation, maintenance, subculture, maintenance records. Cell line banking, cryopreservation, cell viability assays

Culture of tumor cells, application in cancer research, Lymphocyte culture technique and its applications Large scale cultures – Fermentor design, scaleup in suspension and monolayer, downstream processing.

**UNIT-III**

Culture and maintenance of human and mouse embryonic stem cells.
Stem cells in gene therapies, stem cell based therapies for autoimmune diseases
Hybridoma technology – Cell hybrids, Production and Application of Monoclonal antibodies
Use of animal cells as replacement for whole animal in toxicity testing.
Commercial application of animal tissue culture – Uses of animal cells in vaccine production
Cell cultures in the production of medicinally important compounds –pharmaceuticals, enzymes, hormones etc.

**UNIT-IV**

Genetic engineering- General introduction and concept, Transduction and transfection, cDNA, Recombinant DNA techniques, Restriction enzymes, Salient features of cloning vectors, Different types of cloning vectors, Plasmids, Cosmids, Phagemids, Shuttle vectors, Viral vector.
Outline of gene cloning, gene cloning procedures, C-DNA cloning, Gene libraries, Chromosome Walking and jumping, Recombinant selection and screening – genetic methods, immunochemical methods, South-western screening, nucleic acid hybridization, product recovery.
Application of recombinant DNA technique in Medicine and industry. Use of genetically engineered microorganisms in the environment, genetic engineering approach to detoxification.

**UNIT-V**

Methods to introduce genes into animal cells, electroporation, viral vectors, retroviruses, lipofection, calcium phosphate co precipitation.
Transferring genes into animal oocytes, Eggs and embryos – Transgenic animals. Use of transgenic technology in research, knockout mice. Production of human disease equivalents in the mouse, Novel therapies for human diseases.
Transgenic technology in the improvement of farm animals, transgenesis in animal cloning. Genetically modified (GM) plants and foods.
Regulation of genetic engineering – Biosafety regulations, risk versus benefits, ethics involved in animal cloning and stem cell research. Ethics of xenotransplantation.
Intellectual property rights, Patenting of living organisms, Ethical issues.

REFERENCES:


1. Brown, TA. (2016). Gene Cloning and DNA Analysis: An Introduction. (7th ed.) John Wiley & Sons Ltd.
2. Cartwright T(1994) Animal cells as bioreactors, Vol.VI, CU Publishers, Cambridge.
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10. Watson J. D, Gilman M, Witkowski J, Zoller M (1992) Recombinant DNA, II edition, Scientific American Books, New York.

## ZOP459: ANIMAL CELL BIOTECHNOLOGY- LABORATORY
**4 Hours/week**

**COURSE OUTCOME**

1. Students are trained in different aspects of cell culture like sterilization, media preparation, culturing, maintain cells cultures and their applications.
2. They are also learning recombinant DNA techniques, restriction enzymes, blotting techniques etc.

**Experiments**

1. Introduction to general requirements of animal tissue culture laboratory.
2. Cleaning, washing, Preparation and sterilization methods for tissue culture work.
3. Preparation of media, serum, BSS, PBS, trypsin etc.,
4. Trypan blue dye exclusion test for cell viability
5. Lymphocyte culture techniques, Preparation of human metaphase chromosomes.
6. Growth and maintenance of tumour cell lines.
7. Cell proliferation test using MTT assay
8. Separation of peripheral blood mononuclear cells (PBMCs) - Histopaque method.
9. Mouse macrophage and lymphocyte culture
10. Primary explant culture of mouse pup/adult/ chick embryo organs
11. Mouse bone marrow/hemopoetic cell cultures
12. Contamination of cultures
13. Study of restriction sites in λ DNA – Demonstration
14. Western blot technique -Demonstration.

# ZOH452: TOXICOLOGY AND CANCER BIOLOGY
## TeachingHours 10/Unit

**COURSE OUTCOME**

1. Course focuses on different toxins of animal origin.
2. Understanding the mode of action of chemicals, toxins and fundamentals of toxicological assays.
3. Students are trained in forensic toxicological techniques. They are made aware of drug abuse and its ill effects.
4. Students get basic knowledge on mutations, genotoxicity, carcinogens and carcinogenesis.
5. Advanced cancer treatment modalities are discussed.
6. Course helps students to get into various toxicological labs as drug inspectors, qualitycontrollers and even as oncologists.
7. Apply different toxicological frameworks within the professional disciplines and have awareness about different risk assessment criteria.

**UNIT-I**

Introduction- Definitions, Major subdivisions of toxicology. Dose-response relationships and their importance. Frequency response and cumulative response.Factors influencing toxicity-Route of administration, host factors-species, strain, age and sex, .Toxic responses to xenobiotics: Molecular, subcellular, cellular, allergic/sensitization reactions and Idiosyncrasy. A brief account of Regulatory Guidelines and Good Laboratory Practices, General rodent and non-rodent species and strains used in toxicological studies,

**UNIT-II**

Toxicological testing methods- Acute, sub-chronic and chronic toxicity tests, $LD_{50,}$ $LC_{50}$ and $ED_{50,}$ Teratogenicity testing(abnormal and altered growth in fetus), Reproductive toxicology– Effect of xenobiotics on male and female reproductive organs/cells in mammals.Organ/tissues specific toxicity..Toxicity of metals (Lead, Mercury, Arsenic, Cadmium).Pesticide toxicity-organophosphate, Organo-chlorine and Carbamate insecticides, Toxicity of pyrethroids.Bio-magnification.Natural toxins- microbial, plant and animal toxins..

**UNIT-III**

Foundations of forensic toxicology- classification of poisons, sign and symptoms of common poisons. Drugs: Drugs of abuse, classification and identification. Narco analysis and brain mapping.Explosives: Classification, composition and characteristics of explosives, pyrotechinques, IEDs, explosion process and affects. Courtroom testimony, Investigation of toxicity-related death/injury, documentation practices. Considerations for forensic toxicological analysis. A brief account of Ecotoxicology Antidotal therapy,

**UNIT –IV**

Mutagenesis and genetic toxicology- Bacterial Reverse Mutation Assay, Invitro mammalian cell mutation assay, Invitro mammalian cytogenetic tests,Genotoxicty testing in mammals – Bone marrow chromosomal aberration, micronucleus test, sperm abnormality assay, comet assay.Occupational and environmental exposure -endosulphan tragedy. Classification of human cancers, growth characteristics of cancer cells, tumor angiogenesis,Tumor Metastasis, Tumor staging. Causes of cancers-chemical carcinogenesis; Steps involved in chemical carcinogenesis. Radiation carcinogenesis-ionizing radiation, UV radiation.

**UNIT-V**

Oncogenes-Functional class of oncogenes (proto-oncogenes), Mechanisms of carcinogenic transformations by oncogenes.Viral oncogenes. Tumor suppressor genes- mechanisms of tumor suppressor in cancer induction (P53). Role of telomere and telomerases in cancer. Tumor immunology-mechanisms of immune response to cancer, natural killer cells, 'Danger theory'.Diagnosis of cancer.

**REFERENCES**


1. Becker, F .F. (Ed) (1975): Cancer, Vol.1-3, Plenum Press, New York.
2. Curry, (1986): Analytical Methods in Human Toxicology
3. Curtis, D. K., (2001): Casarett and Doull's Toxicology: the basic science of poisons, 6th edition, Mc-Graw-Hill Medical Publishing Division, New York.
4. Cox. S (2008): Preclinical Development Handbook- Toxicology, A John Wiley & Sons, INC.,Publications
5. Dekant, W. and Neumann H.G. (1992): Tissue –specific Toxicity: Biochemical mechanisms, Academic Press. Harcourt Brace Fovanovich, Publishers, London.
6. Darnell, J.Lodish H. and Baltimore D. (1995): Molecular Cell Biology, Scientific American Books, New York.
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8. Duffus, J.A. (1980): Environmental Toxicology, Edward Arnold, Publishers, London.
9. Ernest Hodgson, (2010): A Textbook of Modern Toxicology, 4th edition, Wiley Publications. New Jersey.
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11. Max M. Houck, (2018): Forensic Toxicology, 1st Edition, Academic Press, UK, Pp418
12. Ruddon R.W (2007): Cancer Biology, 4th Edition, Oxford University Press

## ZOP460: TOXICOLOGY AND CANCER BIOLOGY- LABORATORY
**4 Hours/Week**

**COURSE OUTCOME**

1. Students are trained in toxicological testing methods.
2. They develop skills to screen the food adulteration and detection of toxicants.
3. Aspirants are made to understand the process of tumorigenicityand staging.
4. Students are able to carry out research on screening of various phamaceticules.

**Experiments**

1. Determination of $LC_{50}$ /$LD_{50}$
2. Detection of organo-phosphates by chromatographic methods.
3. Estimation of Catalase activity.
4. Effect of heavy metals on enzyme activity.
5. Transplantal- teratogenesis.
6. Detection of mercury chloride by enzyme inhibition technique.
7. Detection of adulterants in food samples.
8. Analysis of presence of toxicants like pesticides etc. from samples
9. Study of life history of insects of forensic importance.
10. Experiments to study the genotoxicity of chemicals in mouse.
11. Transplantation and induction of mouse ascites tumour and studies on the characteristic of tumour cells.
12. Induction of solid tumour in mice and study the chromosomal aberrations in cancer.
13. Histological observation of different types of cancers (Permanent slides).
14. Zebra fish model to screen pharmaceuticals
15. Demonstration of different routes of administration in rodents and non-rodents
16. Eco toxicological testing of known insecticide with algae, earthworm and daphnia as model organisms.

# ZOS 453: MOLECULAR CELL BIOLOGY
## Teaching Hours 10/Unit

**COURSE OUTCOME**

1. Structural organization of the cell and functioning of different cell organelles are taught.
2. Types of cell divisions in organisms and their scientific relevance is to be studied.
3. Student will gain an understanding of chemical and molecular processes that occur in and between cells.
4. In molecular biology, aspirant learns about how molecules interact within the cell to promote proper growth, division, and development.
5. This course will emphasize the molecular mechanisms of DNA replication, repair, and protein synthesis.
6. At the end of this course students should be excited about basic science and its applications and gain higher level thinking skills that is necessary for scientists.

UNIT-I

Discovery of cell, cell theory, prokaryotic and eukaryotic cells. Structural organization of virus, bacteria and eukaryotic cell- ultra structure of animal cell. Biomembranes : chemical composition and molecular arrangement, models of membranes (Davson – Danielli model, fluid mosaic). Cytoskeleton-Microtubules, microfilaments and their dynamics. Centrosome, cilia, flagella.

UNIT-II

Cell surface receptors, Celladhesion molecules, Cell Junctions, Membrane Transport: Difffusion (simple and facilitated) and active transport (primary and secondary).Second messenger system. Cell Signalling- from plasma membrane to nucleus, signal transduction. Structure and functions of Endoplasmic Reticulum and Golgi Complex.

UNIT-III

Structural organization of nucleus -components, nuclear pore complex, export and import of proteins. Nucleolus-structure and biogenesis of ribosomes. Morphology and functional elements of eukaryotic chromosomes-Centromere, nuclear organizers, Telomere, heterochromatin and Euchromatin.Molecular organization of chromatin, Nucleosome model.

UNIT-IV

Phases of cell-cycle, Cyclins and Cyclin dependent kinases. Regulation of Cdk-cyclin activity.Molecular aspects of Mitosis.Mitotic apparatus and movement of chromosomes. Mitotic poisons. Meiotic division and genetic recombination. Biology of ageing,
Apoptosis – definition, mechanism and significance.

UNIT-V

DNA as a data storage medium, C-value paradox, Evidences for DNA as genetic material. Transformation experiment. Structure of DNA and RNA, Replication of DNA in prokaryotes and eukaryotes.Transcription in prokaryotes and eukaryotes, RNA processing, Spliceosomes.Catalytic RNA.Translation in prokaryotes and eukaryotes.Effect of antibiotics on protein synthesis. Post translational modifications.

REFERENCES


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2. Cooper, M. G (1997) The Cell: The Molecular approach, ASM Press, Washington.
3. Darnell, J. H., Lodish J. H and Baltimore D. (1995) Molecular Cell Biology, Scientific American Books, New York.
4. De Robertis, E. D. P, De Robertis E. M.F (1995) Cell and Molecular Biology, VIII edition, Indian edition.
5. Friefelder, D. (1987) Molecular Biology, II Edition, Jones and Barlett Publishers Inc., Boston.
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11. Principles of Biochemistry by Lehninger
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14. Watson, J. D, Hopkins N. H, Roberts J. W, Steitz J. A and Weiner A. M (1987) Molecular Biology of the Gene, Vol.I& II general principles, IV edition, The Benjamin Cummings Publishing Co., Inc.,

ZOP 461: MOLECULAR CELL BIOLOGY- LABORATORY

3 Hours/Week

**COURSE OUTCOME**

1. To be skilled in protocols of cell divisions-mitosis and meiosis in different organisms.
2. To perform different molecular techniques that is primarily used in biological research.
3. The main methods included are the isolation of RNA/DNA, DNA amplification and studies to understand the different types of cell division.

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Experiments

1. Microscopy
2. Micrometry.
3. Mitosis in plants.
4. Mitosis in insects / Meiosis in insects.
5. Mitotic chromosomes from bone marrow of mouse.
6. Sperm shape abnormality assay in mice.
7. Isolation of RNA from yeast.
8. Isolation of DNA from normal and infested plants.
9. Isolation of DNA from liver/spleen.
10. Spectroscopic determination of purity of DNA.
11. Study of UV absorption spectra of native and denatured DNA.
12. Restriction digestion of DNA/DNA electrophoresis.
13. DNA Sequence Reading from autoradiogram.
14. SDS-PAGE for proteins
15. Problems-Transcription, Translation, Restriction Digestion, Gene cloning.

# ZOS454: COMPARATIVE PHYSIOLOGY
## Teaching Hours 10/unit

**COURSE OUTCOME**

1. The teaching session is involved in making students to understand different physiological systems and their functional role in human and other animals.
2. Students are also taught about various disorders due to functional and cellular defect in different physiological pathways.
3. The complete gastrointestinal physiology is dealt in great details to make students aware of molecular and physiological aspects of gut functions and its abnormality.
4. The studies on respiratory, reproductive and osmoregulation physiology are discussed.
5. The reproductive physiology of both invertebrates and vertebrates are discussed.
6. Importance of hormones and their functions.

**Unit I**

Gastrointestinal physiology:

Organization of gastro-intestinal tract- process of digestion, Digestive enzymes, Digestion and absorption of carbohydrates, proteins and lipids, Digestion in Ruminants and non-ruminants.

Regulatory mechanisms of digestion, Gastro-intestinal hormones, Gastro-intestinal motility.

Gastro-intestinal disorders- Dyspepsia, Achalasia, peptic ulcer, Appendicitis, Inflammatory Bowel's disease, Crohn's disease, Hernia, Malrotation.

**Unit II**

Respiratory physiology:

Organization of respiratory system- Types of respiratory surfaces, Ventilation, Tidal volume, Dead space, Comparative study of aquatic and terrestrial respiration, Respiration in birds and insects.

Diffusion of gases- Transport of $O_2$ and $CO_2$, Oxygen-Haemoglobin Dissociation curve, Haldane effect, Bohr Effect, Role of blood as buffer, Haemodynamics.

Regulation of respiration.

**Unit III**

Osmoregulation:

Osmoregulation in aquatic, amphibious and terrestrial animals.

Patterns of $N_2$ excretion- Urea, Uric acid, Ammonia

Formation of urine by kidney- Physiological anatomy of kidney, Structure of nephron, Formation of urine in nephrons, Normal, Inorganic and abnormal constituents of urine, Factors affecting urine formation, Factors controlling volume of urine.

Regulation of renal function- Hormones, Renin angiotensin-Aldosterone system (RAAS), Homeostatic regulation of kidney.

**Unit IV**

Endocrinology:

Nature of Hormones, Classification of hormones, Storage and secretion of hormones.

Hormone-receptor interactions- Mechanism of water and lipid soluble hormone action.

Overview of important endocrine glands and their hormones- Pituitary hormones and their control by the Hypothalamus.

Oestrous cycle and its hormonal basis.

Endocrine regulation of insect metamorphosis.

**Unit V**

Reproductive physiology:

Reproductive and hormonal functions of the male- Spermatogenesis, Testosterone and other hormones, Pineal gland and its function in controlling seasonal fertility.

Oogenesis, Fertilization, Molecular mechanisms of fertilization in mammals.

Chemical, mechanical and immunological methods of controlling fertility.

Insect reproductive systems- Male and female reproductive systems, types of sperms, types of ovarioles.

**REFERENCES**


1. Guyton, A.C., Hall J.E. (1991) Textbook of Medical Physiology, 8th edition. Saunders Co., Jovanovich.
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8. Shepherd, G.M. (1994) Neurobiology, 3rd edition. Oxford University Press, USA.
9. Silverthorn, D.U. (2016) Human Physiology, An Integrated Approach, 6th edition (Indian edition). Pearson Education, Limited, Tamil Nadu.
10. Wison, I.A. (1979) Principles of Animal Physiology, 2nd edition. Macmillan Pub. Co. Inc. New York.

## ZOP462: COMPARATIVE PHYSIOLOGY- LABORATORY
**4 Hours/Week**

### COURSE OUTCOME

1. In the practical session, they are trained in measuring physiological parameters like pH, blood glucose, glycogen, starch, respiration quotient, urine metabolites etc.
2. Different enzyme assays are carried out in the practical sessions to teach the biological importance and functional mechanism of different enzymes and hormones.

### Experiments

1. Determination of glucose by glucose-oxidase method.
2. Lipase activity in the intestinal content of fish.
3. Starvation and liver glycogen levels.
4. Enzymatic digestion of carbohydrates and proteins.
5. Rate of oxygen consumption in fishes.
6. Determination of respiratory quotient.
7. Total count (TC) of blood cells in man.
8. Preparation of Haemin crystals.
9. Detection of urea, uric acid, ammonia and creatinine in the test sample provided.
10. Detection of excretory products in the urine.
11. Active uptake of indigo carmine by Malpigian tubules.
12. Measurement of Gastro-intestinal tract pH of cockroach.
13. Effect of tonicity at cellular level/organism level.
14. Study of oestrous cycle by vaginal smear technique in rat/mice.
15. Reproductive systems of insects- Demonstration.

# ZOS455: ADAPTATION BIOLOGY
## Teaching Hours 10/week

**COURSE OUTCOME**

1. To learn biological rhythms in animals including humans.
2. To acquaint the students with different patterns of animal adaptations and chronobiology
3. To enable to get knowledge on animal responses to light and temperature.
4. Students are made to understand the importance of chronobiology and chrono medicine.
5. To learn importance of hibernation, aestivation and insect diapause.
6. Aspirants are made to appreciate the maternal, foetal and neonatal physiology.

**UNIT-I**

Types of adaptation, environmental variables, environmental conditions of aquatic, terrestrial and xeric habitats. Light condition-eclosion in insects. Biological rhythms, circadian rhythms,Introduction to Chronobiology: Historical developments in chronobiology; Biological oscillation: the concept of average, amplitude, phase and period. Biological clocks, Adaptive significance of biological clocks

**UNIT-II**

Evolution of biological timing system, clocks genes and evolution, Phase shift, Phase response curves (PRC) and phase transition curves (PTC);Photoreception and photo-transduction, The physiological clock and measurement of day length; Role of photic and non-photic cues in seasonality; Reversal of roles of principal and supplementary cues, The relevance of biological clocks for human welfare - Clock function (dysfunction)

**UNIT-III**

Photoperiod and regulation seasonal reproduction of vertebrates; Role of melatonin.Depleted oxygen availability and its effects.Anhydrobiosis and hibernation. Adaptation to deep sea living and diving. Physiology of insect diapauses. Inter tidal animals and their adaptations. Concepts of homeostasis, acclimation and acclimatization.Basic mechanisms of biochemical adaptation. Adaptation during physical exercise.

**UNIT-IV**

Temperature relations, Adaptations to temperature variations, molecular mechanisms of adaptations.Endothermy and ectothermy.Extremophiles varieties and their adaptations. Mechanisms of body temperature regulation, Fever. Heat shock proteins. Chronopharmacology, Chronomedicine, Chronotherapy.

**UNIT-V**

Alterations and adaptations in maternal physiology during pregnancy. Material and fetalprolactin.Placenta: Endocrine functions, transport mechanisms, Foetal physiology, growth and metabolism, Neonatal physiology. Lactation and Lactogenesis.

**REFERENCES**


1. Dejours, P. (1985) Principles of Comparative Respiratory Physiology, Academic Press NY.
2. Hadley. F. (1975) Environmental physiology of Desert organisms, Dowden, Hutchinson & Ross, University of California.
3. Hochachka, P.L. and Somero G.N. (1994) Biochemical Adaptations, Princeton University Press.
4. Jay, C. D., Jennifer. J. Loros, Patricia J. DeCoursey (ed), (2004) Chronobiology Biological Timekeeping: Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
5. Keele, C.A., Neil E.,Joels N.(1993) Sarson Wright's Applied Physiology.14th Edition, Oxford University Press.
6. Kumar, V. (2002) Biological Rhythms: Narosa Publishing House, Delhi/ Springer-Verlag, Germany.
7. Louw, G.N. (1993) Physiological Animal Ecology, Longman Scientific and Technical Publishers. U.K.
8. Prosser, C.L. (1986) Adaptation Biology: Molecular to organisms. John Wiley and Sons.
9. Saunders, D.S. SteelC.G.H. andAfopoulou X., (2002) Insect Clocks (ed.) R.D. Lewis. (3rd Ed) Barens and Noble Inc. New York, USA.
10. Schmidt-NeilsenK. (1995) Animal physiology, Adaptation and Environment. Cambridge University Press.

## ZOP463: ADAPTATION BIOLOGY-LABORATORY
**2 Hours/Week**

**COURSE OUTCOME**

1. Experiments are designed to train how animals show behavioural changes and adaptations based on varied environmental conditions.
2. Students are well trained to conduct circadian rhythms using various animal models.

**Experiments:**

1. Assay of circadian rhythms using animal model systems.
2. Assay of circadian activity rhythms in human temperature patterns
3. Effect of physical exercise on haematological parameters and cardiac activity.
4. Experiments demonstrating the photoperiodic clock
5. Regulation of eclosion rhythm in *Drosophila*.
6. Excretion of chloride as a function of salinity in fish.
7. Seasonal and daily variations in salinity, temperature and tides.
8. Haemolymph ions during aestivation in molluscs (*Pila*)
9. Effect of temperature on physiological functions.
10. Study of circadian functions in humans daily eating, sleep patterns
11. Experiments demonstrating the photoperiodic clock.
12. Study of parasitic adaptations.
13. LDH isozymes in foetal tissues.
14. Food consumption and assimilation by pregnant and normal mice.
15. Quantifying oscillations: phase, period and amplitude

# ZOE456: HUMAN GENETICS
## Teaching 10 hours/Unit

**COURSE OUTCOME**

1. The process of cell division and sex determination in human
2. Genesis and effect of Chromosomal abnormalities in human
3. Structure of DNA and Gene, Mutation, DNA fingerprinting
4. Mendelian and Non Mendelian inheritance in human
5. Basis of autosomal dominant and recessive traits and sex linked inheritance
6. Principle of hardy-Weinberg's law and important of twin study
7. Genetic counselling and it's important for the genetic disorder

**UNIT-I**

**Cytogenetics**: Cell cycle, Mitosis, Meiosis, Gametogenesis, Fertalization.Human Chromosomes- Chromosome Morphology, Karyotyping and its application. Sex Chromatin-Barr Body, Lyon's Hypothesis, Sex determination, Genetic significance of X Inactivation. Milestones in the development of genetics

**UNIT-II**

**Chromosomal Aberrations**: Structural aberrations, abnormalities: Structural abnormalities: Deletions, translocation, Insertion, Inversion, Isochromosomes, Ring chromosomes. Factors Playing role in Chromosomal Aberrations. Antosomal Abnormalities-Down's syndrome (Trisomy-21), Edward's syndrome (Trisomy-18), Patau's syndrome (Trisomy-13). Sex chromosome abnormalities- Klinefelter's syndrome and Turner's syndrome

**UNIT-III**

**Molecular Genetics:** Structure of Nucliec acid, Types of DNA-Unique sequences, Satellite DNA, Interspersed repetitive DNA sequences, Single nucleotide polymorphism (SNPs) Short Tandem repeats(STRs), Variable number of tandem repeats (VNTRs), Restriction fragment length polymorphism (RFLP), Mitochondrial DNA, Triplet code. Brief introductions to Genes and its structure, Mutation, Gene bank, Recombinant DNA, DNA fingerprinting technology, DNA markers used for tracing human ancestry.

**UNIT-IV**

**Modes of inheritance**: Mendel and Mendelism, Mendel's laws,Brief Introduction to Alleles, Phenotype, Genotype, Dominant and Recessive alleles, Wild type and mutant alleles, Codominant Alleles, Lethal Alleles, Multiple Alleles, Heterozygotes, Homozygotes, Penetrance and Expressivity. Pedigree analysis, Mode of Mendelian inheritance in human

(single gene disorders): Autosomal dominant, autosomal recessive, X-linked dominant,X-linked recessive. Non mendelian Inheritance -Polygenic/complex inheritance and extra chromosomal inheritance – Erythroblastosis Fetalis in Humans

**UNIT-V**

**Population Genetics**: Definition of population genetics, Calculation of allele frequencies (MN and ABO blood groups); Random mating, Hardy-Weinberg's Law, factors influencing Hardy-Weinberg equilibrium, Endogamy, consanguineous marriage. Eugenics, Twins and type of twins Prenatal diagnosis: Invasive and non-invasive techniques, Amniocentesis, Chorionic villus sampling, Ultrasound, Foetoscopy, Foetal blood sampling (FBS), Maternal serum screening, Carrier screening for autosomal recessive and X-linked disorders, Genetic Counselling.

**REFERENCES**


1. Elrod, S., & Stansfield, W. (2010) *Schaum's Outline of Genetics*. McGraw Hill Professional.
2. Falconer, D. S., and Mackay, T.F. (1996) *Introduction to quantitative genetics*, Essex, England: Longman.
3. Gangane, S.D. (2017) *Human Genetics*, 5th ed. New Delhi, Elsevier.
4. Gersen, S., & Keagle, M. (2013). The principles of clinical cytogenetics. S. L. Gersen, & M. B. Keagle (Eds.). New York: Springer
5. Hartl, Daniel L., and Elizabeth W. Jones (1998) *Genetics: principles and analysis*, Sudbury, Mass: Jones and Bartlett Publishers.
6. Jorde LB, Carey JC and Bamshad, M.J.(2009) Medical Genetics, Elsevier Publication
7. Orlando J. Miller (2000) Human Chromosomes Springer-Verlag New York
8. Snustad, D P., and Simmons M.J. (2012) *Principles of genetics*. Hoboken, NJ: Wiley.
9. Strachan T and Read, A.P. (2011), Human Molecular Genetics, Garland Science/Taylor and Francis Group Publication, 4th Edition.
10. Steven L. Gersen and Martha B. Keagle (1999) The Principles of Clinical Cytogenetics Humana Press

# ZOE457: ORNAMENTAL FISH PRODUCTION AND MANAGEMENT
## Teaching Hours 10 /unit

**COURSE OUTCOME**

1. Course focuses on the importance of ornamental fish farming in relation with entrepreneurship development.
2. Enable to setup aquarium
3. Enable to manage the home as well as commercial aquariums
4. Learn to handle different aquarium equipment's and decoration
5. Learn decorations of aquarium
6. Study breeding of Aquarium Fishes.
7. Students' knowledge about various techniques of ornamental fish breeding, rearing and its marketing to make them self-sustainable after completing course.

**UNIT-I**

**Culture of ornamental fishes**: Introduction, definition, classification, varieties, relevance Breeding: Brood stock development, Breeding, larval rearing, induced breeding, environmental manipulation, water quality parameters, feeding, harvesting and conditioning. Commercially important- indigenous, exotic (egg –layers and livebears) ornamental fishes. Breeding of live bearers and egg layers. Types of breeding, selective breeding and cross-breeding and hormonal induction and sex-reversal.

**UNIT-II**

**Fabrication and setting up of aquarium**- Principles of setting up and maintenance of aquaria different types fish tanks, requirements, construction, and fabrication of glass tanks, Steps of aquarium fabrication, Aquarium accessories for small and large-scale units. Aeration and filtration. Latest trends in aquarium tanks. Uses of aquarium plants, Use of test kits for regular monitoring water quality. Common diseases and parasites of freshwater and marine ornamental fish. Fish diseases and their prophylactic measures.

**UNIT-III**

**Management practices in ormental fish farm-** Pond fish keeping, sitting a pond, size of ponds, equipments, stocking of pond with plants, Pond construction fish production facilities, Permission from the competent authority, resources of water, water quality management, selection of suitable species of ornamental fishes. Construction of cement cisterns for indoor-facility, FRPTanks, and water re-circulation facility, water filtration systems, eco-friendly approach to manage the effluents. Quarantine policy and facility.

**UNIT-IV**

**Feeds and feed management –** Feeding and nutrition of ornamental fishes. Nutritional requirements of aquarium fish. Larval feeding. Live feed culture. Artemia culture, infusoria, brachionus culture, development of live feed culture lab. Formulated feeds. Preparation of aquarium fish food. Colour enhancement techniques.Feeding frequency. Feeding fry, feeding of young ones, feeding of adults. Water quality management.

**UNIT-V**

**Ornamental fish transportation and Marketing**- Fish packing systems, steps to be taken while transporting, condition of fish for packing, ornamental fish trade-supply - demand situation in India. Quality control, prices, demand. Global trade of ornamental fishes, contribution of culture and capture; marketing strategies; Green certification. Govt policies and subsidies.

**REFERENCES**


1. Anna Mercy, T V and Gopalakrishnan, A and Kapoor, D and Lakra, W.S (2007): Ornamental Fishes of the Western Ghats of India. National Bureau of Fish Genetic Resources, Kochi.
2. Arumugam N., Jayashree C. S., K.V 2015: Home Aquarium and Ornamental Fish Culture, Saras publication.
3. Dholakia A. D.2016:Ornamental Fish Culture and Aquarium Management, Daya Publishing House
4. Edward J. Noga,2010 :2nd Edition, Iowa State University Press
5. Felix S., Anna Mercy T. V., Saroj Kumar Swain 2013: Ornamental Aquaculture: Technology and Trade in India, Publisher: Daya Publishing House.
6. Heiko Bleher, 2018 Indian Ornamental Fishes Volume1, Aqua press Publishers.
7. ICAR, 2019: Fresh water ornamental fish breeding and aquascaping techniques (A training manual) CIARI, India.
8. Lewbart Gregory A, 2018: Ornamental Fish, Publisher: Manson Publishing Ltd
9. Smith S.A, 2019: Fish diseases and Medicine:1st Edition, CRC press, Taylor and Francis publishers.
10. Wester C.D. 2015: Nutrient requirements and feeding of finishes for aquaculture publishers,CIBI, India.


***Visiting ormental fish farmingUnit and aquarium trading industry is compulsory and submit to the report.**

# III Semester

# ZOH501- GENETICS AND QUANTITATIVE BIOLOGY
## Teaching Hours 10 /Unit

**COURSE OUTCOME**

1. The course is mainly focused on principles of classical genetics, environmental and genetic influences on expression of traits.
2. Both animal and human models are used to explain the phenomenon of inheritance of characters. Structural and functional components of genes are also studied.
3. Consequences of gene modifications and the possible mechanism of its repair, genetic control in the development of adult characters are also dealt.
4. Genetic disorders prevailing in human population, their chances of inheritance, and genetic methods of screening and preventive measures are included.
5. The students will be trained in various statistical tools commonly used which are included in understanding and interpreting the probable chances of genetic pattern of inheritance of human traits.
6. In the biological research fields, statistical analysis plays an essential role in concluding data and postulating different hypothesis. So Biostatistics is an essential subject for those who go for a research carrier.

**UNIT-I**

Historical highlights - Development of the gene concept. Mendelian principles; Mendelian inheritance and probability. Modified genetic ratios – Co-dominance – incomplete dominance – Lethal alleles. Interaction between different genes – Complementary genes, Penetrance and expressivity, pleiotropy, epistasis. Extra chromosomal inheritance. Sex determination in drosophila and man. Sex linked inheritance in Drosophila and man. Multiple alleles – genetics of blood group inheritance.

**UNIT-II**

Molecular structure of gene, genetic code, transposable elements, gene mutations and DNA repair mechanism. Regulation of gene expression in prokaryotes and eukaryotes- Operon concept, attenuation and anti-termination. Giant chromosomes. Linkage, recombination and gene mapping: Linkage groups and types of linkage. Construction of linkage maps in Drosophila. Genetic basis of development in Drosophila- genes involved in Drosophila development and their functional role.

**UNIT-III**

Human karyotype- International System for Human cytogenetic Nomenclature (ISCN) Chromosome aberrations- structural and numerical variations. Chromosomal syndromes. Human genome project; Genetic counselling. Genetic Screening- Amniocentesis, Chorionic Villus sampling, Cardiocentesis, Dermatoglyphics.

**UNIT-IV**

Genetics of behaviour- twins in genetic studies. Genome imprinting. Pedigree analysis. Inheritance of autosomal and sex chromosomal traits. Multi- factorial and polygenic inheritance. Population genetics- Hardy Weinberg law. Factors changing allelic frequencies – mutation, selection, genetic drift, migration etc. Meiotic drive.

**UNIT-V**

Population and sample- sampling techniques. Organization of biological data –tabular and graphical methods. Analysis of data – measures of central tendency (Mean, Median, Mode), Standard deviation. Probability & Frequency distribution –normal, binomial and Poisson distributions. Correlation and regression. Chi-Square test. Test of significance. t –test. Analysis of Variance (ANOVA).

**REFERENCES**


1. Brown, T. A. (1998) Genetics a molecular approach, 3rd edition, Chapman & Hall Publishers, London.
2. Burns, G. W. (1983) The science of genetics, V edition, McMillan Pub. Co., Inc., New York.
3. Connor, J. M. and Smith M. A. F. (1987) Essential Medical Genetics, 2nd edition, Black well scientific publications.
4. Fraser, C. F. and Nora J. J. (1986) Genetics of man, 2nd edition, Lea and Febiger publishers, Philadelphia.
5. Gardner, E. J., Simmins M. J. and Snusstad D. P. (1991) Principles of Genetics, 8th edition, John Wiley and Sons Inc.
6. Hartl, D. L. (2001) Genetics: Analysis of genes and genomes, 4th edition, Jones & Bartlett publishers, Boston.
7. Hassard, T.H. (1991) Understanding Biostatistics, Mosby year Book St. Louis.
8. Hutt, F. B. and Rasmusen B. A. (1982) Animal genetics, 2nd edition, John Wiley & sons, New York.
9. Jha, A. P. (1997) Genes and evolution, McMillan Publishers, New Delhi.
10. Lawrence, P. A. (1992) The making of a fly: The genetics of animal design, Blackwell scientific publishers, London, Boston.
11. Lewin, B. (1996) Genes, VII edition, John Wiley & Sons, New York.
12. Mange, E. J. and Mange A. P. (1994) Basic Human Genetics, Rastogi Publications, Meerut, India.
13. Norman, T. J. Bailey (1994) Statistical methods in biology, 3rd edition, Cambridge University Press.
14. Strickberger, M. W. (1995) Genetics, 3rd edition, Prentice Hall of India Pvt. Ltd.
15. Tamarin, R. H. (1994) Principles of genetics, III edition, PWS Publishers, Boston.

## ZOP508: GENETICS AND QUANTITATIVE BIOLOGY – LABORATORY
**4 Hours/Week**

### COURSE OUTCOME

1. Structure of specialized chromosome explains their significance in the expression of adult normal and mutant characters in drosophila.
2. Drosophila crossing experiments using various mutants with normal flies helps in understanding the Mendelian principles of inheritance of characters.
3. Preparation of Human Karyotype and chromosome banding to study the normal and abnormal chromosomes is included to understand the possible mode of inheritance of diseased traits in the family.
4. Pedigree analysis using human blood groups and dermatoglyphics (palmar/ finger print) pattern from different families of the region are included to study the variations and their possible genetic significance at the population level.
5. Drosophila crossing experiments are included to understand the pattern of character inheritance, where the students on their own conduct different crosses using normal and mutant flies.

**Experiments:**

1. Preparation of culture media and maintenance of *Drosophila* – To Study the life cycle.
2. Study of morphological features of *Drosophila* and *Drosophila* mutants
3. DAPI staining of *Drosophila* eggs and larvae.
4. Study of - Study on Antennopedia – a *Drosophila* developmental mutant
5. Mounting of genital plate and sex comb
6. Dissection and mounting of *Drosophila* imaginal discs.
7. Study of Polytene chromosome of *Drosophila*.
8. Preparation of metaphase chromosomes from brain ganglia of *Drosophila* larvae
9. Studying expression of a given gene by lacZ reporter expression in *Drosophila*
10. Chromosome banding techniques and karyotyping.
11. Study the dermatoglyphics pattern and its significance.
12. Chromatographic separation of eye pigments in *Drosophila.*
13. Study of Human blood group genetics and estimation of allelic frequencies
14. Experiments to demonstrate the pattern of inheritance of characters in *Drosophila* –
    a. Expt. 1: To demonstrate Mendel's law of segregation
    b. Expt. 2: To demonstrate Mendel's law of independent assortment
    c. Expt .3: To demonstrate Pattern of inheritance of X- linked genes
15. Genetic and Biostatistics problems

## ZOH502- NUTRITION AND METABOLISM

**Teaching Hours 10 /Unit**

**COURSE OUTCOME**

1. Basic training includes types of nutrients and their importance.
2. Evaluation of nutrient quality and quantity of nutrients, their balancing in animal nutrition.
3. Concept of human nutrition with balanced nutrition and their importance with reference to health and in chronic diseases.
4. Students are groomed to understand different energy currencies, regulation of metabolic pathways.
5. They learn energy metabolism and related disorders. Importance of minerals and vitamins in nutrition.
6. Course initiates interested student's to become an entrepreneur as a nutritionist and dietician.

**UNIT I**

Concepts of nutrition: Nutrients and nourishment, Basic concepts, Nutrients and their functions, the feed nutrients their classification. Nutrients analysis and energy concepts: Methods of analysis of nutrients and feed stuff and its merits and demerits, Van Soest analysis, Specialized analytical methods, total digestible nutrients, apparent and true digestibility, energy utilization. Feed and nutrient requirements in animals: Methods for determining utilization and requirements in animals, merits and demerits.

**UNIT II**

Applied animal nutrition: Principles of animal nutrition, Animal husbandry and nutrition requirements, Feeding standards and productivity, Factors affecting feed consumption

Feed preparation and processing: Hot and cold processing methods, feed processing for ruminants and non-ruminants, feed mixing, Chemical treatment, Cubed forges.

Diet formulation- Pearson square method and algebraic method.

Nutrition of laboratory animals: Requirements of mice rat and rabbits.

Nutrition of wild animals: Concept of wildlife nutrition, dietary husbandry of herbivores, Underutilized sources of feed, feeding animal wastes.

**UNIT III**

Human nutrition: Nutritional basis of health, BMR, balanced nutrition, Nutrients and their importance, Dietary fibre, Antioxidants and phyto-chemicals.

Eating disorders: Anorexia nervosa, Binge eating disorder, Protein energy malnutrition, under- nutrition and over-nutrition

Nutrition and chronic diseases: Hypertension, Diabetes mellitus, Osteoporosis

Food safety: Food processing, Harmful substances in food, Food borne illness and genetically modified foods.

**UNIT IV**

Energy metabolism: Metabolic pathways and their regulation, Types of metabolic pathways, Regulation of pathways, Signal transduction and role of second messengers in regulation. High energy phosphate compounds. Overview of metabolism and the provision of metabolic fuels. Glycolysis and oxidation o pyruvate; Pathway, regulation and energetics of pathway. Citric acid cycle: Importance, pathway regulation and energetics, Glyoxylate cycle, amphibolic role. Respiratory Chain and oxidative phosphorylation; Chemiosmotic theory, ATP synthesis, Inhibitors and uncouplers of respiratory chain.

**UNIT V**

Carbohydrate, mineral and vitamin metabolism: Glycogen metabolism, Importance of glycogen, formation and breakdown of glycogen, Role of Glucagon and insulin in glycogen metabolism, Glycogen storage diseases. Gluconeogenesis: Glucose homeostasis, Precursors, pathway, regulation and energetics, Pentose phosphate pathway: importance, pathway, regulation and energetics, Role of NADPH

Water and minerals: Water the essential ingredient for life, Major minerals (Sodium, potassium, chloride, calcium, phosphorus and magnesium). Trace minerals (Zinc, iron, Selenium, Iodine, Copper, Manganese, Fluoride, Chromium, and Molybdenum).

Vitamins: Water and fat soluble vitamins, functions, dietary recommendations, sources, and deficiency symptoms. Role of vitamins and minerals in intermediary metabolism.

**REFERENCES**


1. Bamji, M. S., Rao N. P. and Reddy V. (2003) Text Book of Human Nutrition, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
2. Gillespie, J. R. (1987) Animal nutrition and feeding Delmar Publishers Inc., New York.
3. Insel, P., Turner R. E. and Ross D. (2002) Nutrition, Jones and Bartlett Publishers Massachusetts
4. Mathews, C. K., van Holde K.E. and Ahern K. G. (2005) Biochemistry, 3rd edition, Pearson Education Pvt. Ltd., New Delhi.
5. McArdel, W. D., Katch F. I. and Katch V. L. (2005) Sports and Exercise Nutrition Second edn., Lippincot Williams & Wilkins, Philadelphia.
6. Murray, R. K., Granner D. K. Mayes P. A. and Rodwell V. W. (2003) Harper's Illustrated Biochemistry, 26$^{th}$edition, Mcgraw Hill Companies, Boston.
7. Perry, T. W., Cullison A. E. and Lowrey R. S. (2004) Feeds and feeding 6th edition., Prentice Hall, New Jersey
8. Pond, W. G., Church D. C., Pond K. R. and Schoknecht P. A. (2004) Basic Animal Nutrition and Feeding, 5th edition. John Wiley and Sons, New York.
9. Rodwell V. W., Bender D. A., Botham K. M,. Kennelly P. J., and Weil P. A.(2018) Harper's Illustrated Bochemistry 31 Edition, McGraw Education. New York.
10. Voet, D. and Voet J. G. (2005) Biochemistry 3rd edition, John Wiley and Sons, New York.

## ZOP 509: NUTRITION AND METOBOLISM – LABORATORY

**4 Hours/ week**.

**COURSE OUTCOME**

1. Students are nurtured individually to measure the nutrient contents of different feeds used in the animal husbandry.
2. They are trained in enzyme assays and enzyme kinetics.
3. Students also learn different techniques like RIA, UB Test, Flourimetry, and flame photometry.

**Experiments**

1. Assay of phosphatases
2. Assay of transaminases
3. Assay of dehydrogenases

*Enzyme kinetics:*

4. Effect of substrate concentration, enzyme concentration and time
5. Effect of temperature on enzyme activity
6. Effect of pH on enzyme activity
7. Effect of metal ions on enzyme activity

*Proximate analysis of feed;*

8. Determination of moisture
9. Crude protein determination
10. Ether extract
11. Crude fibre
12. NFE and energy calculation
13. Estimation of phosphorus.
14. Estimation of ascorbic acid.
15. *In vitro* antioxidant assay

# ZOS 503- FISHERIES AND AQUATIC BIOLOGY

## Teaching Hours 10 /Unit

**COURSE OUTCOME**

1. Course introduces learners to fish diversity & distribution, classification of fishes their food & feeding habits and reproductive characteristics.
2. Fish culture practices types of fish culture, preservation and economics of fishery techniques are learned.
3. Aquatic community, abiotic and biotic factors that influence fishery industry both in freshwater and marine environment is highlighted
4. Enable to understand plank tonic productivity and management of water bodies for aquaculture is focused.
5. Enable to learn pollution impact on fishery industry their management.
6. Student on completion of this course can become an entrepreneur in fishery/aquaculture based industry. He can also take up job in fishery based industry.

**UNIT I**

**Fish diversity and body design**: Distribution of freshwater fishes of India. Distribution of marine fishes of India. Classification of fishes with special reference to evolutionary trends and adaptations. Gas exchange and swimming– Air breathing organs and gas bladder, swimming modes. Fish growth and reproduction: Growth curves, length weight relationship, length frequency analysis, Food and feeding habits. Reproduction- The gonads, types of reproduction, endocrine regulation of reproduction, parental care.

**UNIT II**

**Fish culture practice in India**: Freshwater carps (Indian major and minor) and lacustrine fish culture (ornamental). Mariculture – Finfish and shellfish culture and live feed culture. Setting up and maintenance of an aquarium. Hybridization and cryopreservation. Fish and shell fish diseases, prophylaxis and therapy. Fishery technology and fishery economics .Fishing gears and crafts. Fishing industry in India (including preservation and processing). Fishery research Institutes in India. Economic importance and nutritional value of fishes.Marine nutraceuticals, Drugs from sea. Drugs used in aquaculture.

**UNIT III**

**Aquatic environment:** Classification of freshwater habitats - Lotic and lentic ecosystems, lakes and rivers. Physical factors (light and temperature). Chemical factors- methods for measurement of salinity and chlorinity. BOD, COD, and oxygen and their importance. Biological zonation. Oceanography - general features, waves, tides, current and upwelling. Coral reefs.Physico-chemical properties of estuary – Salinity and temperature. Inorganic

nutrients, phosphates, silicates and nitrate, their cycle N: P ration and its signification, wealth of the sea – minerals. Mangrove ecosystems.

**UNIT IV**

**Aquatic community**: Planktons - classification, distribution and migration, phyton and zooplankton- Method of collection of plankton and estimation of primary, secondary and tertiary productivity, factors affecting productivity, regional differences and seasonal variations. Phytoplankton and zooplankton inter relations. Benthos – Animal communities in lakes, streams and reservoirs. Management and conservation of aquatic habitats: Management of lakes - Eutrophication, control of nutrient and macrophyte biomass.Seaweeds and sea grasses.

**UNIT V**

**Aquatic Pollution**: Major pollutants, sources, dynamics, transport paths and agents. Sewage, industrial and agricultural discharges, composition, disposal systems. Nutrients- detergents, heavy metals and pesticides composition and fate in the marine environment, biological concern, and toxicity and treatment methods. Thermal pollution: thermal stratification, effects of thermal pollution and management of heat. Radioactive pollution. Oil pollution - biological effects biodegradation, biomonitoring, bacterial pollution and seafood poisoning

**REFERENCES.**


1. Beaven, C. R.(1998) Handbook of the freshwater fishes of India, Narendra Publishing House.
2. Biswas, K. P. (1996) A Text Book of Fish, Fisheries and Technology, 2nd edition, Narendra Publishing House.
3. Brown, E and Margret (1957) Physiology of Fishes Vol I & II, Academic Press, Inc. Publishers.
4. Brown, M.E. (1957) Physiology of fishes, Vols. 1 and 2, Academic press,
5. Cormack, D. (1983) Responses to oil and chemical Marine pollution, Applied science publishers.
6. Daniels, R. J. R. (2002) Freshwater fishes of Peninsular India, Universities press.
7. Day. F. (1889) Fauna of British India: Fishes of India.FishesVol -1 and Vol-2, Taylor and Fran
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9. Eeoffrey M. (1987) Pollution threat of Heavy Metal in Aquatic Environments, Elsevier Applied science publishers, England.
10. Erichsen Jones, J.R. (1973) Fish and river pollution, Butterworths, London.

## ZOP 510: FISHERIES AND AQUATIC BIOLOGY - LABORATORY
**2 Hours/week**

## COURSE OUTCOME

1. Students get expertise in identification of fish and shell fishes and other aquatic organisms.
2. Enable to get train culture of fin fish, shellfish and live feed culture.
3. Get trained in fish breeding, hatchery techniques and pond management
4. Enable them in getting employment in fishery based industry.

### Experiments

1. Identification of fishes (Museum and local fishes)
2. Determination of length-weight analysis in fishes.
3. Determination of absolute and relative fecundity in fishes.
4. Determination of food and feeding habit of fishes.
5. Gonado somatic index of fish.
6. Demonstration of Weberian - ossicles, respiratory organs, air bladder and Skeletal system (Alizarin preparation
7. Identification of important fish parasites (external and internal).
8. Demonstration of fish breeding techniques and ulturec of live feed organisms
9. Field visit to fish ponds, fish landing center and fish processing unit.
10. Identification of fishing gears and fish byproducts.
11. Qualitative and quantitative analyses of planktons.
12. Use of immunological equipment's: Sacchi disc. Ekmans grab, water sampling bottle. Plankton net, Sedgwick rafter counting cell.
13. Determination of total alkalinity and dissolved organic matter, COD and BOD
14. Determination of total hardness, calcium and magnesium.
15. Quantitative and qualitative study of the fauna of rocky, sandy and muddy shores, Planktons, benthic, macrophytes etc.

# ZOS: 504- ANIMAL BREEDING

**Teaching Hours 10 /unit**

## COURSE OUTCOME

1. Expertise on identification of various animal breeds such as cattle breeds, sheep, goat, swine, horse and poultry breeds etc
2. Trained in different animal husbandry practices and known the animal husbandry issues to deal with scientific temper.
3. Students trained to understand different process adopted by various scientific labs and animal breeding centres.
4. To understand inbreeding and crossbreeding effects related to production and conservation of species.
5. To understand complex inheritance and to be able to design a breeding program.
6. To be able to assess animal physical structure and make selection decisions based on that structure.
7. To be able to set goals relevant to overall aims.

## UNIT I

Introduction to animal husbandry: Animal husbandry Practices in India. Issues in animal husbandry –Assessing risk, Animal welfare, environmental Issues, consumer issues, marketing issues. Diseases of domestic animal and preventive measures.History of Animal Breeding, Classification of livestock breeds, Traits of economic importance of different species of livestock, Traits of economic importance of different species of livestock, breeding research - Conservation of breeds. Conservation of animal genetic resources. IPR - issues pertaining to animal genetic resources/animal products or by-products.

## UNIT II

Selection of animals for breeding-Methods of selection- selection criteria – Artificial selection, Long term artificial selection. Gametic selection, zygotic selection, heterozygous advantage. Heritability and genetic improvements- broad and narrow -sense heritability. Selection differential, generation interval, genetic gain.Evaluation of breeding animals-desirable traits, Identification system. Performance record, Reproductive efficiency, production traits, Selection indices. Selection of superior breeding stock-Breeding value, aids to selection.

## UNIT III

Breeding methods –Inbreeding Systematic inbreeding measurement of inbreeding, panmictic index, Advantages and disadvantages of inbreeding. Cross breeding line breeding –Hybrid vigor, advantages and disadvantages. Methods of breeding of farm animals-cattle, swine, poultry, horse. Requirements and methods of breeding small laboratory animals (Rats and mice).

**UNIT IV**

Definition of breed-Breeds of animals- Cattle breeds-Beef cattle, Dairy cattle, Dairy goats, Sheep, Swine, Poultry and Horse breeds. Practical breeding plans –Dairy cattle breeding-Beef cattle breeding –Sheep breeding- Pig breeding –Poultry breeding. Feeding and managing of Dairy animals, Feeding and managing of swine, sheep poultry and horse breeds.Livestock Products Technology.

**UNIT V**

Modern trends in animal breeding-artificial insemination: super ovulation-embryo transfer techniques. Animal cloning. Institutional animal ethics committee. Advanced techniques in genetic manipulation for multiplication and improvement of livestock species.Current livestock and poultry breeding programme in country, Current livestock and poultry breeding programme in state.Bio-informatics in animal genetics and breeding.Pharming of Pharmaceuticals.

**REFERENCES**


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3. Crow JF & Kimura M. (1970) An Introduction to Population Genetics. Theory. Harper & Row.
4. Dalton D.C (1980) An Introduction to practical animal breeding, Granada publishing Ltd., London.
5. Falconer DS & Mackay TFC. 1996. An Introduction to Quantitative Genetics. Longman.
6. Fox, J.G. and Cohen B.J (Ed)(1984) Laboratory animal in medicine Academic Press Inc.,
7. Jain, JP. 1982. Statistical Techniques in Quantitative Genetics. Tata McGraw-Hill.
8. Lasley J.F (1987) An introduction to Practical animal breeding, II Edition, Collins Publishing Ltd, London.
9. Ross CV. 1989. Sheep Production and Management. Prentice Hall.
10. Schmidt GM & Van Vleck LD. 1974. Principles of Dairy Science. WH Freeman.

## ZOP 511: ANIMAL BREEDING - LABORATORY
## 2 Hours/week

### COURSE OUTCOME

1. Students may trained to breed small laboratory animals and ornamental fishes
2. Students are made to visit different animal farms, poultry, dairy processing and feed production industry in and around Mangalore regions get industries knowledge.
3. To learn various animal breeding techniques and some of them take up as job opportunities in animal husbandry industries.

Experiments

1. Mouse breeding experiments
2. Demonstration of fish breeding techniques
3. Important economic traits of livestock
4. Collection, evaluation and dilution of semen
5. Grading of egg, defects in eggs and their grading
6. Collection ,preservation and Identification of tics and Mites
7. Judging of sheep by Score card method
8. Problems relating to gene and genotypic frequencies under different conditions.
9. Estimation of inbreeding in regular and irregular systems.
10. Estimation of effective population size.
11. Computation of quantitative genetic effects.
12. Estimation of variance components.
13. Field visit to Dairy farm and preparation of report.
14. Computation of sire index
15. Visit to Piggery and Poultry farm and preparation of report.

# ZOS505- ENVIRONMENTAL BIOLOGY
## Teaching Hours 10 /Unit

**COURSE OUTCOME**

1. The course provides a broad outline on 'Ecology and ecosystem functions' covering various aspects. They include, types of ecosystem, components of ecosystem, community and populations, factors regulating community origination, species interactions.
2. Concept of habitat, ecological niche ecological pyramids are dealt.
3. Community ecology , types of interactions and ecological succession
4. Emphasis is given on marine ecosystem including 'Exclusive Economic Zone (EEZ). Environmental pollutions on biological system.
5. Microbial influence on ecosystem, impact assessment and development of sustainable ecosystems are also included.
6. The theoretical foundation will help the students to understand the impact of various environmental pollutions on ecosystems in general and biological resources in particular.

**UNIT I**

Ecosystems: Structure, function and types of ecosystem- terrestrial, fresh water, marine and estuarine. Abiotic and Biotic components, basic laws of energy flow, food chain, food web, ecological pyramids. Concept of habitat, niche and guild, concept of ecotone, edge effect and Concept of Gaia hypothesis.

**UNIT II**

Population ecology, population dynamics, stochastic and time lag models of population growth, population characteristics- mortality, fecundity, density, age distribution, population explosion. Community ecology- prey and predator relationships and various types of interactions. Ecological succession, its mechanism and its type. Ecological climax.

**UNIT III**

Biogeochemical cycles- carbon, nitrogen and phosphorus. Biomes- classification, biotic elements of biome and their characteristic in the biome. Microbial distribution in nature, interaction within microbial communities, with man and animals, dispersal of microorganisms in different environments.

**UNIT IV**

Marine ecosystem – Biological zones and its type, inter-tidal ecosystem: rocky - zonation pattern -physical and biological factors, sandy shores and protected sand flats – physical and biological factors, bio-geographical zones of India, faunal composition and adaptations. Exclusive Economic Zones (EEZ).

**UNIT V**

Environmental pollution, control and its effect on biological systems. Conservation management of natural resources. Environmental impact assessment. Sustainable development.

## REFERENCES


1. Cherrett, J. M. (1990) Ecological Concepts. Blackwell Science Publication, Oxford, U. K.
2. Elseth, G. D., & K. D. Baumgardner (1981) Population biology. Van Nostrand , New York.
3. Findlay, S. &Sinsabaugh R. L. (2002) Aquatic Ecosystem. Elsevier Science Publishing Co Inc.
4. Krebs, C.J. (1972). Ecology: the Experimental Analysis of Distribution and Abundance. Harper & Row, New York.
5. Noor M. (2012) Environment and water pollution cause effect and control, Cyber tech Publication, New Delhi.
6. Odum, E.P. (1971) Fundamentals of ecology, W.B. Saunders, Philadelphia.
7. Prabu, P. C., Udayasoorian C. and Balasubramanian G. (2009) An introduction to ecology and environmental science, Arihant.
8. Saha, T. K. (2013) Ecology and environmental biology, 1st edition, Books and Allied (P) Ltd.
9. Sharma, P. D. (2014) Ecology and environment. 12th edition, Rastogi Publication.
10. Sharma, P. D. (2013) Environmental biology and toxicology, 3rd Rev edition, Rastogi Publication.


## ZOP 512: ENVIRONMENTAL BIOLOGY - LABORATORY

**2 Hours/week**

## COURSE OUTCOME

1. The students will be trained on various methods of assessment of pollutions.
2. The impact of various pollutions on biotic community will be assessed through analysis of samples collected from different habitat (polluted / un polluted). The seasonal impact also will be assessed wherever possible.
3. It makes learners to understand the importance of a healthy environment for the survival of different living organisms.

### Experiments

1. Aspirants are exposed to nature and its components
2. Exploration of ecosystems to study life cycle of different organisms.
3. Calculation of biodiversity Index.
4. Vegetation studies by line, quadrate and belt transect methods.5.
5. Construction of ecological pyramids of different ecosystems.
6. Productivity of aquatic ecosystem by plankton study,
7. Study of wetland flora and fauna.
8. Field visit to aquatic, forest and other ecosystems for identification of biota.
9. Surveillance and quality of analysis of potable water.
10. Physico-chemical properties of polluted water.

# ZOE506: INFECTIOUS DISEASES

## Teaching Hours 10/Unit

COURSE OUTCOME

1. This course mainly deals with different parasites that are responsible for various human diseases and their epidemiology and to introduce the students to current knowledge on the morphological features and life cycles of principal human parasites.
2. Outstanding progress will be achieved to understand serious parasitic infections caused by obligate parasites, facultative and opportunistic parasites.
3. To learn methods for accurate diagnosis of parasites responsible for food poisoning.
4. To know disease transmission processes.
5. Methods of prevention and to control the spread of these parasites.
6. This course is offered as an open elective choice for students from other departments who are interested in understanding different parasite born human infections and its control.

UNIT-I

Introduction to parasitic infections : historic perspectives, Koch's hypothesis, General events in establishment of infection, infection dose, lethal dose, infectious diseases, epidemiology types of infections, nosocomial infections, antisepsis.
Modes of disinfection/sterilization

UNIT-II

Different types of animal association- parasitism and types of parasites, primary and secondary hosts, transmission of parasitic infection. Host- parasitic interactions (with reference to bacterial, viral, fungal and parasitic infections). Epidemiology of parasitic zoonosis,

UNIT-III

Parasitic protozoans- Life cycle, pathology and control measures of Mastigophora – Trypanosoma, Giardia. Sarcodina- Entamoeba. Chilophora-Balantidium. Sporozoa-Toxoplasma. Helminth parasites - Life cycle, pathology and control measures of Nematode (Ascaris, Enterobius, Wuchereria),Trematoda( Fasciola) ,Cestoda( Taenia)

UNIT-IV

Morphology, life history and medical importance of disease transmitting vectors- Diptera-Aedes, Culex, Anopheles, and House fly. Siphonoptera:,Echidnophaga, Tunga. Phthiraptera – Pediculus, Pthirus. Hemiptera _ Cimex, Triatoma

Morphology, life history and importance of Acarines Ticks: Argas,Boophilus. Mites: Sarcoptes, Psoroptes

UNIT V

Antibiotics and drug resistance: Principles for mechanisms of antibiotic action, bacteriostatic and bacteriocidal effect. Mechanisms of antibiotics resistance and its importance within the healthcare: MRSA, MDR and XDR in tuberculosis. Antiviral, antifungal, antihelminth drugs.

REFERENCES


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2. Arora, D.R., Brij Bala Arora (2012). Medical Parasitology.3rd Edition.CBS Publishers and Distributors Pvt Ltd. India.
3. Berger, S. A., MarrJ. (2006)Human Parasitic Diseases Sourcebook, Jones & Bartlett.
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5. Despommier, Gwadz, Hotez, Knirsch(2005) Parasitic Diseases 5th edition, Apple Trees Productions, LLC.
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7. Margo, W. M. S., PybusJ. And KocanA.A. (2008). Parasitic Diseases of Wild Mammals, 2ndedition, Iowa State University Press, Ames, Iowa, USA
8. Pommerville J.C. Alcamo's Fundamentals of Microbiology. Jones and Bartlett Publishers.
9. Sherman I.W. Malaria Parasite Biology, Pathogenesis and protection. ASM Press.
10. Smyth J.D, Introduction to Animal Parasitology. Cambridge University Press.

# ZOS507 – VERMITECHNOLOGY

**Teaching Hours 10 /unit**

COURSE OUTCOME

1. The course is structured to impart training on Earthworm culture technology, to create knowledge on Self - Employment opportunity
2. In general soil earthworms, their characteristic features, occurrence, their influence on soil fertility and solid waste management are included.
3. Vermicomposting technology broadly followed at the global level and some Indigenous methods, role of microbes in increasing the soil fertility by the action of earthworms, their advantages and limitations dealt.
4. Role of microbes in worms and in decomposition is discussed.
5. Vermiculture products and their benefits in agriculture practice, economics of vermitechnology along with the practical difficulties are included.
6. Students will be trained on how to maintain a small vermicompost bin as a simple method for converting the Kitchen waste.

UNIT I

Introduction to Vermitechnology. General characters and classification of Annelida. The habitat of earthworm: soil-major types (red soil, black soil, alluvial soil). Diversity and distribution of earthworms. Collection and preservation of earthworms. Earthworm as farmer's friend-role of earthworms in soil fertility. The selection of earthworms (endemic and exotic species) for vermitechnology.

UNIT II

Vermiculture and vermicomposting techniques. Methods of vermicomposting. Large scale manufacture of vermicompost. Factors affecting –Ph, moisture, temperature. Worm casts, vermiwash production and its applications. Evaluation of nutritional status of vermicomost. Use of vermicompost for crop production, use of vermicompost in land improvement and reclamation.

UNIT III

Role of earthworms in waste management, solid wastes an option for resource recovery, expert system for hotel waste management. Recycling of food and agricultural wastes. Growth response of some forest tree species to its application in a nursery. Vermifilter. Earthworms as bioreactors. Influence of chemical inputs on earthworm activity.

UNIT IV

Earthworms and microorganisms. The effects of earthworms on the number, biomass and activity of microorganisms. Importance of microorganisms as food for earthworms. Dispersal of microorganisms by earthworms. Role of intestinal microbes of earthworms on the decomposition of organic wastes.

UNIT V

Economic importance of earthworms. Uses of earthworms in food and medicine - ayurvedic and unani. Influence of pests and parasitic microbes affecting earthworms. Measures to control them. Packaging and marketing of vermicompost products and financial support by governments and NGOs for vermiculture. Potentiality of vermibiotechnology in India.

REFERENCES


1. Chauhan, A. (2012) Vermitechnology, Vermiculture, Vermicompost and Earthworms: Vermiculture, Vermicomposting, Vermitechnology and Mirobes, Lambert Academic Publishing, Germany.
2. Christy, M. V. (2008) Vermitechnology, 1st edition, MJP Publishers.
3. Dash, M. C. (2012) Charles Darwin's Plough Tool for Vermitechnology, I.K.. International Publishing House Pvt Ltd. New Delhi, India.
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6. Ismail,S.A. 1997. Vermitechnology.The biology of Earthworm. Orient Longman, India, 92 pp.
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10. Sinha, R. K. et.al (2010) Vermitechnology-The Emerging 21st Century Bioengineering technology for sustainable development and protection of human health and environmentReview, Dynamic Soil and Dynamic Plant, Global Science Books.
11. Sharma S. et .al, (2009) Earthworm and Vemitechnology –Review, Dynamic Soil and Dynamic Plant, Global Science Books.
12. Talashikar, S.C. 2008: Earthworms in Agriculture – Agrobios - India

# IV Semester

**ZOH551- BIOLOGY OF IMMUNE SYSTEM**
**Teaching Hours 10 /Unit**

## COURSE OUTCOME

1. It is an important paper as students are trained to understand the basics of immunology
2. Evolution of immune cells and organs in vertebrates and invertebrates is discussed.
3. To know about antigen, immunogen, epitopes and their properties.
4. Development of immune responses, organs and molecules involved in it are also dealt in detail.
5. How our immune system fights different pathogens and evasive mechanisms developed by the microbes.
6. The discussion also includes autoimmunity and applied aspects like immunological basis of organ transplantation, development and applications of vaccines.

**UNIT I**

Overview of the immune system: Historical perspectives and important concepts.
Cells, organs and micro environments of immune system: Cells of immune system, Primary lymphoid organs, Secondary lymphoid organs, Tertiary lymphoid organs
Innate immunity: Components of innate immunity, Interactions between innate and adaptive immunity systems. The complement system: Major pathways of complement activation, diverse functions, Regulation of complement activation, Complement deficiencies and microbial evasion strategies.

**UNIT II**

Antigens and Immunogens: Immunogens and immunogenicity, Properties of immunogens, Epitopes and their characteristic properties, Adjuvants, Haptens.
Major histocompatibility complex: Structure and function of MHC molecules, General organization and Inheritance of the MHC, Role of MHC and Expression patterns,
MHC and immune responsiveness, MHC alleles and suceptiblity to diseases.
Processing and presentation of antigens: Endogenous and Exogenous pathway of antigen processing and presentation of antigens, Cross presentation of exogenous antigens, presentation of nonpeptide antigens.

**UNIT III**

Structure and function of antibodies: Structure of Antibodies, Antibody binding site, Antibody mediated effector functions, Antibody classes and biological activities, Antigenic determinants on antibodies, B-Cell receptor, Immunoglobulin super family and monoclonal antibodies, abzymes.
B – Cell development: Development in bone marrow, Development of B-1 and marginal-zone B cells, B cell activation, Differentiation and Memory generation.

Receptor and signalling: Receptor ligand interactions, Common strategies used in many signalling pathways, Signal transduction in B cells.

**UNIT IV**

T – Cell development: Early thymocyte development, T-cell activation differentiation and memory .T- cell receptor and co-receptor complex, accessory molecules and signalling.
Cell mediated effector responses, Experimental assessment of cell –mediated cytotoxicity.
T-cell responses to tumors, regulatory T-cell responses and memory.

**UNIT V**

Tolerance: Establishment and maintenance of tolerance; Immunosuppression and induction of immunosuppression.
Autoimmunity: autoimmune diseases, factors responsible for induction, mechanisms of induction and treatment.
Infectious diseases; Bacterial, Viral, Protozoan and Fungal infections and evasive mechanisms developed by microbes.
Vaccines: Active and passive immunization, Vaccine strategies, Types of vaccines advantages and challenges
Transplantation immunology: Types of transplants, Graft rejection, Tissue typing Immune tolerance to allografts, clinical transplantations.

**REFERENCES**


1. Abbas, A.K. and Lichtman, A.H. (2003) Cellular and Molecular Immuology, 5th edition, Saunders Publication, Philidelphia.
2. Coleman, R.M., Lombard M.F., and Sicard R.E. (2014) Fundamental Immunology, 2nd 3dition, McGraw Hill Education (India) Private Limited, New Delhi.
3. Delves, P.J., Martin S.J., Burton D.R., and Roitt I.M. (2011) Roitt's Essential Immunology. John Wiley and Sons Ltd, U.K.
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9. Paul W. E. (1984) Fundamental Immunology 6 edition Garland Science Publications, New York
10. Punt J., Stanford S. A., Jones P. and Owen, J A, (2013) Kuby Immunology Seventh Edn. Macmillan Higher Education International edition, New York

## ZOP 556: BIOLOGY OF IMMUNE SYSTEM- LABORATORY
**4 Hours/Week**

### COURSE OUTCOME

1. In the practical session, students are trained to understand the basics of antigen-antibody reactions, electrophoresis, antibody development and other techniques routinely used in an immunobiology laboratory.
2. The technical training provided here helps students to develop skills in immunological techniques and their applications.

**Experiments**

1. Study of cells of immune system
2. Organs of immune system.
3. Agglutination reaction
4. Precipitation reaction
5. Quantitative precipitation assay.
6. Immunoelectrophoresis
7. Rocket immunoelectrophoresis
8. Countercurrent immunoelectrophoresis
9. Preparation of antisera
10. Precipitation of immunoglobulins by ammonium sulphate method.
11. Isolation and purification of immunoglobulin G
12. Enzyme Linked Immno Sorbent Assay (ELISA)
13. Dot ELISA
14. Hapten conjugation method
15. Scale grafting in fish.

# ZOP552 – PROJECT WORK

**COURSE OUTCOME**

1. Here students are given individual projects and they are supposed to perform the experiments/field works separately to complete their projects.
2. They are trained to go through literature survey before they start any project work. The subject of the projects may be the taxonomical description of different animal groups available in and around Mangalore University or laboratory work where they are trained to perform experiments using various animal models, molecular tools etc.
3. Project works are mainly focused for students to develop some scientific questions and solutions based on their experience.
4. In summary this session helps them have good scientific reading, design experiments and conclude scientific hypothesis based on their experimental data.
5. At the end of the semester, they are asked to present 10-15 minutes seminar and two examiners will evaluate their work.
6. Students are also encouraged to present their work in different national/state level conferences or workshops. Thus the project work develops in students the skill of planning, executing and presenting the research work.

**ZOP552: PROJECT WORK**
**8 Hours(Field/ Laboratory Work)**

# ZOS 553- WILDLIFE CONSERVATION AND MANAGEMENT
## Teaching Hours 10 /Unit

**COURSE OUTCOME**

1. The course provides a broad outline on various aspects of 'Biodiversity conservation'
2. It includes levels of understanding biodiversity in different ecological biomes, methods of population study and documentation.
3. Interaction of the species and their uniqueness, threats and conservations strategies, legal aspects on conservation of biodiversity, special projects and their current status are also included.
4. Threats to our environment and how it is possible to solve these issues scientifically.
5. Students will be visiting the *in-situ* and *ex-situ* conservation and management facilities to learn more about the effective steps taken by the conservation authority in saving the unique /rare/ threatened animals.
6. The theoretical foundation will help the biologist to take part in the effective wildlife conservation and management program with the advanced scientific methods.

**UNIT I**

Biodiversity concepts- Ecosystem diversity, genetic diversity, species diversity. Biodiversity from ecological, taxonomical and evolutionary prospective (Alpha, Beta and Gamma diversity). Biodiversity assessment- Inventorying and monitoring biodiversity- sources of information, data collection and management. Taxon data sheet. Biodiversity indices.

**UNIT II**

Zoo geographical regions of the world and ecological subdivisions of India. Biodiversity hotspots. Biome essays- Tropical and Temperate forests, Tundra forests, Boreal forests, Cave and Mountains, Coastal ecosystems, Mangroves and Estuaries, Coral reefs, Lakes and Rivers.

**UNIT III**

Endemic species. Species interaction. Concept of niche, territory and home range. Keystone species. Unique Indian animals- diversity and distribution. Capturing and marking techniques- entrapment, darting, tagging and banding. Population analysis- territory mapping, line transects, capture-recapture, pellet count, pug mark, call track count. Radio telemetry. Still and Video photography.

**UNIT IV**

Threats to biodiversity- habitat destruction, climate change, exotic species introduction, over exploitation. Wildlife diseases and their control. Species extinction. Extinction vertex. IUCN Red list criterions and categories; Biodiversity conservation- in-situ methods- National parks and Sanctuaries. Ex-situ methods- captive breeding program- role of Zoos and Botanical gardens. Gene bank/ seed bank.

**UNIT V**

Legal aspects- National and International conventions- CITES, TRAFFIC; Wildlife laws- Wildlife (protection) Act-1972; Indian biodiversity laws; Biodiversity Act, Earth summit, Ramsar convention. Special projects- Project Tiger, Gir Lion project, Project Elephant, Crocodile breeding project.

**REFERENCES**


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2. Charles, G. Scalet, L.D. Flake and Willis D.W. (1996). Introduction to wildlife and fisheries an integrated approach.
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12. Sagreiya, K. P. (1967) . Forests and Forestry, National Book Trust, India.
13. Saharia, V. B. (1982). Wildlife in India, Natray Publishers.
14. Shaw, J. H. (1975). Introduction to Wildlife Management, McGraw Hill, New York.
15. Sinha, R. K. (1996). Biodiversity Global Concerns, Common Wealth Publishers.

## ZOP 557: WILDLIFE CONSERVATION AND MANAGEMENT - LABORATORY
## 4 Hours/Week

### COURSE OUTCOME

1. Students will be trained in the collection, preservation and identification of important groups of regional fauna.
2. The data on diversity, richness, population structure of animal groups in the study area will be assessed using appropriate methods and documentation will be done. This will help the students to know the current conservation status of the species and in the implementation of possible step in saving the regionally threatened species.
3. The data the ecological role of the species by studying their feeding behavior will help in understanding their interaction in the sustainable manner.
4. Bird species identification will be done indirectly by using audio-visual methods, so that the animal s is not disturbed in their natural habitat.
5. The students will be trained by using the appropriate statistical methods to know the diversity and abundance of species
6. Various ecosystems will be visited to understand the nature, distribution, ecological functions of species. Threats to species and the possible conservation strategies adopted, their impact will be studied.

### Experiments

1. Aquatic habitat- water quality analysis- salinity, pH, Temp. etc
2. Terrestrial habitat- Soil analysis- Nutrient test
3. Collection, preservation and identification of local species of animals- vertebrates (aquatic and terrestrial)
4. Collection, preservation and identification of local species of animals- invertebrates (aquatic and terrestrial)
5. Food habit analysis of insectivorous animals- Lizards, Bats etc.
6. Identification of bird species by audio- visual methods
7. Study the nesting activity in spiders, ants and wasps.
8. Identification of frogs using their calls
9. Pitfall trap, beat sheet, sweep nets for insects collection
10. Pug mark and hoof mark castings
11. Line transect analysis
12. Quadrate analysis
13. Biomass analysis
14. Biodiversity indices- calculation and interpretation,
    i) Simpson's index ii) Evenness iii) Morishita Horn
15. Visit to observe and record types of ecosystem and associated flora and fauna (Protected and unprotected areas, Biological parks etc.).

## ZOS554- NEUROBIOLOGY AND BEHAVIOUR

**10 Hours/Unit**

### COURSE OUTCOME

1. This course is focussed on understanding the structural complexity and functioning of the nervous system across the animal kingdom.
2. Complexity of nervous systems among different animal groups and its evolutionary significance with respect to its structural and functional organizations are discussed.
3. Students are taught different mechanisms of communication between animals of same/different species.
4. Levels of learning by animals and how this information is stored in the form of memory are highlighted.
5. Animal behavioural studies are also dealt to understand how the nervous system helps animals to face different psychological conditions caused due to stress, anxiety, depression, etc.
6. In addition different classical and modern tools for labelling neurons and understanding its functional role are discussed. This knowledge will help students to take up neurobiology as long term research carrier.

### UNIT- I

**Organization of nervous systems**: Structural organization of vertebrate brain (Human, Mouse and Zebra fish) and invertebrate brain (Aplysia and *Drosophila*). Structure and functions of neuron and glia cells. **Resting membrane potential**: Potassium and Sodium ions across the neural membrane. Role of Sodium and Potassium Channels in maintaining resting membrane potential. **Action potential:** Axon hillock and generation of action potential. **Neural transmission**: chemical and electrical synapses, excitatory and inhibitory neurotransmitters

### UNIT- II

**Neuromuscular junction**: Synaptic connection between neurons and muscles. Molecular basis of synaptic transmission across the neuromuscular junction. **Muscle contraction**: Types and functions of muscle fibres. Molecular mechanism of muscle contraction. **Neuro-Muscular disorders:** Etiology of Amyotrophic lateral sclerosis (ALS), Multiple sclerosis and Muscular dystrophy

### UNIT- III

**Associative learning:** Types of associative learning (Classical and Operant conditioning). Neuronal regulations of classical and operant conditioning. **Non-Associative learning:** Types of non-associative learning (Habituation and Sensitization). Molecular mechanisms of habituation and sensitization. **Memory in Animals**: Types of memory (sensory, short-term

and long-term memory). Memory storage sites in vertebrates (hippocampus) and insects (mushroom bodies). Molecular mechanisms of short-term and long-term memory

**UNIT- IV**

**Pheromones:** types, chemistry and significance of pheromones in animal communications. Neural circuits regulating pheromone communications in insects and mammals. **Dance language in honeybee**: types and significance of dance language in honeybee. **Auditory communication in insects**: Types and significance of sound production in insects. Different types of sound producing organs in insects. **Reproductive strategies and mating system in animals**: polygamy, monogamy and polygyny

**UNIT- V**

**Classical Neuroanatomical tools**: Golgi-silver staining and cobalt filling of neurons in vertebrate and insect nervous system. Camillo Golgi and Ramon Cajal. **Transgenic tools**: Gal4-UAS system for labelling neurons in insects and zebra fish. BRAIBOW in mouse brain. **Electrophysiological tools**: Patch-clamp techniques (voltage and current clamp). **Immuno-histochemical methods**: Antibody staining for localization of different neurotransmitters (GABA, Acetyl Choline, Glutamate Dopamine and Serotonin) and its receptors

**References**


1. Burrows M. (1996) The Neurobiology of Insect Brain, Oxford University Press
2. Kandel E, Schwartz J H and Jessell T (2012). Principles of Neural Science. 5th Edition. Elsevier Publisher
3. Manning A. and Dawkins M. S. (2012). An introduction to Animal Behaviour, Cambridge University Press
4. Meriney S D and Fanselow E (2019). Synaptic transmission. First Edition. Academic Press
5. Munz T (2016). The dancing bees. University of Chicago Press
6. Patel B A, Yadav R S and Khadilkar S V (2017). Neuromuscular Disorders: A Comprehensive Review with Illustrative Cases. Springer Press
7. Sajikumar S (2015). Synaptic tagging and capture. First Edition. Springer Press
8. Sheng M, Sabatini B and Südhof T C (2012). The Synapse: A Subject Collection from Cold Spring Harbor Perspectives in Biology. Cold Spring Harbor Press
9. Simmons P. and David Y. (2010) Nerve Cell and Animal Behaviour, 3rd Edition. Cambridge University Press
10. Wyatt T D (2014). Pheromones and Animal Behavior: Chemical Signals and Signatures. 2nd Edition. Cambridge University Press

**ZOP558: NEUROBIOLOGY AND BEHAVIOUR- LABORATORY**

**4 hours/week**

## COURSE OUTCOME

1. In the practical session, students are trained to label neurons using some of the new transgenic techniques like the Gal4-UAS system and one of the Nobel Prize winning tool: Golgi techniques.
2. They are trained in taking up ethno biology studies.

Experiment

1. Differentiation of mechanoreceptors and chemoreceptors in Insects
2. Golgi-staining technique
3. Campaniform sensilla in insects
4. Olfactory discrimination in insects
5. Social insects – study of insect colonies
6. Gal4-UAS system to label neural circuits
7. Geotaxis assay in insects
8. Feeding preferences in insects
9. Slit sensilla in insects
10. Courtship behavior in insects
11. Spectral sensitivity in insects
12. Estimation of neurotransmitter acetyl choline
13. Demonstration of nuclear staining in brain tissues
14. Immuno-staining of chemical synapses
15. T-maze learning in Mice

# ZOS555- STATISTICS AND BIOINFORMATICS

**Teaching Hours 10 /Unit**

**COURSE OUTCOME**

1. It is an important paper and students are trained to use different statistical tools applicable to biological research and field work.
2. Terminologies used, data collection, tabulation, graphical representation of data are dealt.
3. Data analysis, types of data analysis and errors, accuracy, methods for large sample analysis are discussed.
4. Some of the recent tools and various soft wares used for statistical analysis are discussed.
5. Information on databases for protein and genome analysis, networking and bioinformatics tools are also introduced.
6. Skill based course that grooms students in application of statistics and bioinformatics in data analysis. On successful completion they can take up data analysis assignments

They learn data handling skills such as recording, collating and analysing data using appropriate techniques and equipment.

**UNIT I**

Basic Concepts & Descriptive Statistics: Biostatistics terminology, variables in biology, Levels and measurements of biological data, Classification, tabulation and frequency distribution of the data, graphical representation of data by histogram, Polygon, Ogive curve and pia diagram. Measures of central tendency, measures of dispersion, Comparison of two CVs; Skewness- Kurtosis.

**UNIT II**

Correlation & Regression: Positive and Negative correlation and calculation of Karl-Peasrson's Co-efficient of correlation, Spearman's rank correlation, Partial and multiple correlation, regression analysis; Sample linear and non-linear regression; multiple regression, regression equation, Calculation of an unknown variable using regression equation, Confidence interval level of confidence.

**UNIT III**

Errors in measurements & Statistical Analysis: Errors, Accuracy, Precision, general theory of Errors, Classification, standard errors. Ways of expression of precision, Accuracy detection of determinates errors, Statistic analysis of biochemical data with spread sheet applications, Use of statistical packages, Data management with computer Basic idea of significance test – Hypothesis testing. **,** Null and alternative hypothesis; Large sample tests (z-test); Test of significance of single and two sample means; Testing of single and two proportions - Small sample tests: F-test — testing of single mean; Testing of two sample means using

independent t test, paired t test; ANOVA and Chi-Square Tests: One-way and two-way ANOVA – Latin Square tests for association and goodness of fit; testing linkage; segregation ratio.

**UNIT IV**

Information theory and Bioinformatics Network: Biological data exploration through internet Resources– EMB net, NCBI, BTIS network, Bioinformatics landscape intrinsic & extrinsic view, Cheminformatics and medical informatics. Biological databases sequence databases, Protein sequence databases, Structural databases, PDBs, Motif databases, Protein motif database, Genome databases, Proteome databases etc.

**UNIT V**

Bioinformatics tools: Pair wise Alignment, Alignment algorithms, sequence analysis tools, BLAST (Basic Logical Alignment Search Tool) FASTA, Multiple Alignment, Sequence analysis, using EMBOSS, DNA micro array technique.

**REFERENCES**


1. Arora, P. W., Malhan P.K. (2002) Biostatistics, Himalaya's pub. House, Mumbai.
2. Bailey, (2000), Statistical Method in biology.
3. Bliss, C. I.K. (1967), Statistics in biology vol. 1 Mac-Graw Hill.
4. Campbell, R.C. (1974) Statistics for biologist, Cambridge University Press.
5. Daniel, W. W., Biostatistics (A foundations for analysis in health sciences).
6. Dixit, M. (2000) Internet an Introduction, Tata McGraw-Hill.
7. Khan, I. A and Khanum A. (1994) Fundamental of Biostatistics.Ukaaz publications.
8. Lachin, J.M. (2010) Biostatistical Method: the assessment of relative risks, 2nd edition, Wiley online publications, ISBN: 978-0-470-50822-0.
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## ZOP 559: STATISTICS AND BIOINFORMATICS - LABORATORY
**2 Hours/Week**

### COURSE OUTCOME

1. Expertise to collect, analyse and interpret data using appropriate statistical tools.
2. Attain mastery in biological data analysis using bioinformatics tools.

### Experiments

1. Representation of Statistical data by: - Histogram, Ogive curves, Pie diagram.
2. Measurement of central tendencies: - Arithmetic & Geometric mean, mode and median.
3. To calculate the measures of dispersion.
    a) Mean deviation.
    b) Standard deviation and Coefficient of variation.
    c) Quartile deviation.
4. Test of Significance.
    a) Chi-Square test.
    b) t- test.
5. Internet search for Bioinformatics resources.
6. DNA and Protein sequence, file format conversion.
7. Nucleic acids and Protein sequence database search.
8. Multiple sequence alignment and Conserved Amino acid residues.