PANSKURA BANAMALI COLLEGE (AUTONOMOUS)

B. Sc. (Hons.) Zoology

(Effective from Academic Year 2021-2022)

Revised Syllabus as approved by

Academic Council

Date: No:

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Preamble

The objective of any program at Higher Education Institute is to prepare their students for the society at large. The Panskura Banamali College(Autonomous)envisions all its programmes in the best interest of their students and in this endeavour; it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programs.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the program of their choice. The Under-Graduate Programs will prepare the students for both, academia and employability.

Each program vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The program also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each program prepares students for sustainability and life-long learning.

The Panskura Banamali College(Autonomous) hopes the LOCF approach of the program B.Sc. (Hons. & Gen.) Zoology will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

1. Introduction

The learning outcomes-based curriculum framework for B.Sc. degree in Zoology is structured to offer a broad outline within which a Zoology program could be developed. The course is upgraded keeping in mind the aspirations of students, changing nature of the subject as well as the learning environment. Courses within Zoology have been revisited to incorporate recent advancements, techniques to upgrade the skills of learners. The new structure is expected to enhance the level of understanding among students and maintain the standard of Zoology degrees/program across the country. Effort has been made to integrate use of recent technology and use of MOOCs to assist teaching-learning process among students. This framework permits the review of graduate attributes, qualification descriptors, program learning outcomes and course-level learning outcomes periodically. The framework offers flexibility and innovation in syllabi designing and in methods adopted for teaching- learning process and learning assessment. The major objective is to elevate the subject knowledge of the students, making them critical thinkers and able to solve problems and issues related to Zoology logically and efficiently. Overall, this course has been modified to upgrade skills related to biological science and provide our students a competitive edge in securing a career in academia, industry, pharmaceutical research and development in private as well as public sectors.

2. Learning Outcome-based Curriculum Framework

2.1 Nature and Extent of the Program

Zoology is broad subject encompassing classical and modern systemic aspects of animal diversity, as well as contemporary subjects like Molecular Biology, Principles of Genetics and Developmental Biology to foster comprehensive understanding about various aspects of animal science. The scope of Zoology as a subject is wide-ranging. The major areas of study within the discipline of Zoology are: Diversity of Non-chordates and Chordates; Comparative Anatomy of Vertebrates; Cell Biology; Biochemistry; Molecular Biology; Evolutionary Biology; Principles of Genetics; Principles of Ecology. Diversity of Non-chordates and Chordates deals with the classification and adaptive diversity of animals from diverse phyla; Comparative Anatomy of Vertebrates deals with structural comparisons among all vertebrates; Cell Biology deals with the study of structure and functions of the cell; Biochemistry deals with the study of chemical substances and vital processes occurring within the living organisms; Molecular Biology deals with the nature of biological phenomena at the molecular level; Evolutionary Biology studies the evolutionary processes that produced the diversity of life on Earth, starting from a single common ancestor; Principles of Genetics deals with the molecular structure and function of genes, and gene behavior in context of a cell or organism; Principles of Ecology studies the structure and function of nature; Physiology deals with the functions and activities of life or of living matter (such as organs, tissues, or cells) and of the physical and chemical phenomena involved. Degree program in Zoology deals with other topics that overlap with the areas outlined above (Immunology; Parasitology; Animal Behavior and Chronobiology; Animal Biotechnology; Agrochemicals and Pest Management; Biology of Insecta; Endocrinology; Computational Biology; Fish and Fisheries; Reproductive Biology and Wildlife Conservation and Management); and that address the topics related to applied fields (such as Apiculture; Aquarium Fish Keeping; Medical Diagnostics; Research Methodology and Sericulture). The applied topics include visits to industries, fields or commercial culture units to get in-depth knowledge of the subject and also to explore employment opportunities in the field. In addition, some interdisciplinary topics are offered to students of other disciplines such as Parasitology and Endocrinology.

2.2 Aim of Bachelor Degree Program

Zoology is one of the most Multi branches of biology studied at undergraduate level. It helps to learn and understand the concepts regarding animal diversity to appreciate the variability in relation to their morphology, anatomy and behavior among different animals. After studying this courses, our students will be more equipped to learn and know about different human systems, their coordination and control. This course will also provide an opportunity to understand their own evolution along with other animals. They will be able to qualitatively and quantitatively analyse evolutionary parameters using various bioinformatics and computational tools used in modern sciences. This will provide them ample opportunities to explore different career.

The Zoology degree program will also provide a platform to comprehend classical genetics in order to understand distribution of different traits among populations, their inheritance, ethnicity and correlate with contemporary and modern techniques like genomics, meta-genomics, genome editing and molecular diagnostic tools. Practical and theoretical skills gained in this course will be helpful in designing different public health strategies for social welfare. The course has been designed to provide in-depth knowledge of applied subjects ensuring their calculation of employment skills so that students can make a career and become an entrepreneur in diverse fields of aquatic biology, sericulture, apiculture etc. After completion of this course, students can contribute as policy makers in wild life conservation, animal preservation and environment protection.

3. Graduate Attributes in B.Sc. (Hons.) Zoology

Some of the characteristic attributes of a graduate in Zoology may include the following: **Disciplinary knowledge:** Capable of demonstrating (i) comprehensive knowledge of major concepts, theoretical principles and experimental findings in Zoology and its different subfields including biodiversity, anatomy, physiology, biochemistry, ecology, evolutionary biology, cell biology, molecular biology, immunology and genetics, and some of the other applied areas of study such as wildlife conservation and management, apiculture, sericulture, neurosciences, aquatic biology, fish and fisheries sciences, (ii) Interdisciplinary knowledge of allied biological sciences, environmental science and chemical science; (iii) learning of the various techniques, instruments, computational software used for analysis of animal's forms and functions.

Effective communicator: Capability to convey the intricate zoological information effectively and efficiently.

Critical thinker and problem solver: Ability to rationally analyze and solve the problems related to animal sciences without relying on assumptions and guess work.

Logical thinking and reasoning: Capability of seeking solutions and logically solving them by experimentation and data processing either manually or through software. **Team spirit:** Ability to work effectively in a heterogeneous team.

Leadership quality: Ability to recognise and mobilise relevant resources essential for a project, and manage the project in a responsible way by following ethical scientific conduct and bio-safety protocols.

Digitally literate: Capable of using computers for biological simulation, computation and appropriate software for biostatistics, and employing search tools to locate, retrieve, and evaluate zoology-related data.

Ethical-awarreness: Avoiding unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, as well as appreciate environmental and sustainability issues.

Lifelong learners: Capable of self-paced and self-directed learning aimed at personal and social development.

4. Qualification Descriptors

The qualification descriptors for a Bachelors' Degree program in Zoology may include the following:

Demonstrate a logical and consistent understanding of the broad concepts in Zoology, its applications, and related interdisciplinary subjects

Technical knowledge that produces varied types of professionals in the fields like research and development, teaching, government and public sector service

Utilise wide-range knowledge, logical thinking and skills for evaluating problems and issues related to Zoology

Collection of pertinent quantitative and/or qualitative data obtained from various sources/experiments, and analysis of the data using appropriate research methodologies to formulate evidence-based solutions

Effective and precise communication of the investigations undertaken in a variety of contexts using the major concepts, principles and techniques of the subject(s)

Meet one's own learning desires, employing broad range of research and development work and professional materials

Apply one's subject knowledge and skills to novel circumstances enabling to solve complicated problems with evidence-based well-defined elucidations

Demonstrate subject-related skills relevant to Zoology-related jobs and employment opportunities

5. Program Learning Outcome

Students enrolled in B.Sc. (Hons.) degree program in Zoology will study and acquire complete knowledge of disciplinary as well as allied biological sciences. At the end of graduation, they should possess expertise which will provide them competitive advantage in pursuing higher studies from India or abroad; and seek jobs in academia, research or industries.

Students should be able to identify, classify and differentiate diverse chordates and non-chordates based on their morphological, anatomical and systemic organization. They will also be able to describe economic, ecological and medical significance of various animals in human life. This will create a curiosity and awareness among them to explore the animal diversity and take up wild life photography or wild life exploration as a career option. The procedural knowledge about identifying and classifying animals will provide students professional advantages in teaching, research and taxonomist jobs in various government organizations; including Zoological Survey of India and National Parks/Sanctuaries.

Acquired practical skills in biotechnology, biostatistics, bioinformatics and molecular biology can be used to pursue career as a scientist in drug development industry in India or abroad. Our students will be acquiring basic experimental skills in various tecniques in the fields of genetics; molecular biology; biotechnology; qualitative and quantitative microscopy; enzymology and analytical biochemistry. These methodologies will provide an extra edge to our students, who wish to undertake higher studies. In-depth knowledge and understanding about comparative anatomy and developmental biology of various biological systems; and learning about the

organisation, functions, strength and weaknesses of various systems will let students critically analyse the way evolution has shaped these traits in the human body.

Students undertaking skill enhancement courses like aquaculture, sericulture and apiculture will inculcate skills involved in rearing fish, bees and silk moth which would help them in starting their own ventures and generating self employment making them successful entrepreneurs. Acquired skills in diagnostic testings, haematology, histopathology, staining procedures etc. used in clinical and research laboratories will provide them opportunity to work in diagnostic or research laboratory. Deep understanding of different physiological systems and methods available to measure vital physiological parameters and to comprehend the mechanism behind occurrence of different life threatening disease *via* laboratory examination, assessment of basic physiological functions by interpreting physiological charts will help to find their career options.

Students undertaking wild life management courses would gain expertise in identifying key factors of wild life management and be aware about different techniques of estimating, remote sensing and Global positioning of wild life. This course will motivate students to pursue a career in the field of wildlife conservation and management.

6. Course Structure

6.1 Credit distribution for the course

Semester	Course Opted	Course Name	Credits
I	Ability Enhancement Compulsory Course-I	English Communication/ Environmental Science	4
	Core Course-I	Non-chordates I: Protista to Pseudocoelomates	4
	Core Course-I Practical		2
	Core Course-II	Principles of Ecology	4
	Core Course-II Practical		2
	Generic Elective -1	GE-1	4
	Generic Elective -1 Practical/Tutorial		2
II	Ability Enhancement Compulsory Course-II	English/ Communication/ Environmental Science	4
	Core Course-III	Non-chordates II: Coelomates	4
	Core Course-III Practical		2
	Core course-IV	Cell Biology	4
	Core Course-IV Practical		2
	Generic Elective -2	GE-2	4
	Generic Elective -2 Practical		2
III	Core Course-V	Diversity of Chordates	4
	Core Course-V Practical		2
	Core Course-VI	Physiology: Controlling and Coordinating system	4
	Core Course-VI Practical		2
	Core Course-VII	Fundamentals of Biochemistry	4
	Core Course-VII Practical		2
	Skill Enhancement Course-1	SEC-1	4
	Generic Elective -3	GE-3	4
	Generic Elective -3 Practical		2

Semester	Course Opted	Course Name	Credits
IV	Core Course-VIII	Comparative Anatomy of Vertebrates	4
	Course-VIII Practical		2
	Core Course-IX	Physiology: Life Sustaining Systems	4
	Course-IX Practical		2
	Core Course-X	Biochemistry of Metabolic Processes	4
	Core Course- X Practical		2
	Skill Enhancement Course-2	SEC-2	4
	Generic Elective -4	GE-4	4
	Generic Elective -4 Practical		2
V	Core Course-XI	Molecular Biology	4
	Core Course-XI Practical		2
	Core course-XII	Principles of Genetics	4
	Core Course-XII Practical		2
	Discipline Specific Elective -1	DSE-1	4
	Discipline Specific Elective -1 Practical		2
	Discipline Specific Elective -2	DSE-2	4
	Discipline Specific Elective- 2 Practical		2
VI	Core Course-XIII	Developmental Biology	4
	Core Course-XIII Practical		2
	Core course-XIV	Evolutionary biology	4
	Core Course-XIV Practical		2
	Discipline Centric Elective -3	DSE-3	4
	Discipline Centric Elective -3 Practical		2
	Discipline Centric Elective-4	DSE-4	4
	Discipline Centric Elective -1 Practical		2
			Total:148

6.2 Semester-wise Distribution of Courses

Sem	Core Course(14)	Ability Enhancement Compulsory Course AECC (2)	Skill Enhancement Course SEC (2)	Discipline Specific Elective DSE (4)	Generic Elective GE (4)
I	Non-chordates I: Protista to Pseudocoelomates	English Communication/Environmental Science			GE-1
	Principles of Ecology				
II	Non-chordates II: Coelomates	English Communication/Environmental Science			GE-2
	Cell Biology				
III	Diversity of Chordates		SEC -1		GE-3
	Physiology: Controlling and Coordinating Systems				
	Fundamentals of Biochemistry				
IV	Comparative Anatomy of Vertebrates		SEC -2		GE-4
	Physiology: Life Sustaining Systems				
	Biochemistry of Metabolic Processes				
V	Molecular Biology			DSE-1	
	Principles of Genetics			DSE-2	
VI	Developmental			DSE -3	,

	Biology				
	Evolutionary Biology			DSE-4	

Discipline Specific Electives (DSE)

1. Fish and Fishries
2. Wildlife conservation and Management
3. Immunology
4. Biology of Insecta
5. Animal behavior and chronobiology
6. Basics of Neuroscience
7. Computational Biology
8. Endocrinology
9. Parasitology
10. Reproductive Biology
11. Animal Biotechnology
12. Agrochemicals and pest manage ment

Skill Enhancement Courses (SEC)

1. Sericulture
2. Aquarium Fish Keeping
3. Medicine Diagonistics
4. Research Methodology
5. Apiculture

Generic Electives (GE)

1. Animal Diversity
2. Aquatic Biology
3. Environment & Public Health
4. Human Physiology
5. Food, Nutrition & Health
6. Animal Cell Biotechnology
7. Insect Vector & Diseases
8. Animal Cell Biotechnology
9. Exploring the Brain: Structure and Function
10. Food, Nutrition & Health
11. Aquatic Biology

7. Courses for B.Sc. (Hons.) Zoology

Core Course e -I: Non-Chordates I: Protists to Pseudocoelomates

Course Learning Objective:

The coursewould provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organisation of the animals based on their evolutionary relationships, structural and functional affinities. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- Appreciate the diversity of non-chordates living in varied habit and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically analyse the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 4] **60hrs**

Unit 1: Protista,Parazoa and Metazoa 19 hrs

General characteristics and Classification up to classes; Study of *Euglena* and *Paramecium*. Life cycle and pathogenicity of *Plasmodium vivax;* Locomotion and Reproduction in Protista *(Chapter 3: Barnes, R.D.; Chapter 3: Barrington)*

Unit 2: Porifera 7 hrs

Introduction to Parazoa; General characteristics and Classification up to classes; Study of *Sycon;* Canal system in sponges

(Chapter 5: Barnes, R.D.; Chapter 4: Pechenik, J. A.

Flagellar apparatus structure of choanocyte in Sycon sp. and its significance for phylogeny of Porifera.Pozdnyakov, I.R. & Karpov, S.A. Zoomorphology (2013) 132: 351)

Unit 3: Cnidaria 12 hrs

Introduction to Metazoa: General characteristics and Classification up to classes; Metagenesis in *Obelia;* Polymorphism in Cnidaria; Corals and coral reefs

(Chapter 6, 7 and 9: Barnes, R.D.; Chapter 6: Pechenik, J. A.)

Unit 4: Ctenophora 3 hrs

General characteristics and evolutionary significance
(Chapter 8: Barnes, R.D.; Chapter 7: Pechenik, J. A.)

Unit 5: Platyhelminthes 10 hrs

General characteristics and Classification up to classes; Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium;* Parasitic adaptations in Platyhelminthes
(Chapter 10: Barnes, R.D.; Chapter 8: Barrington

Unit 6: Nemathelminthes 7 hrs

General characteristics and Classification up to classes; Life cycle, and pathogenicity of *Ascaris lumbricoides;* Parasitic adaptations in Nemathelminthes
(Chapter 11: Barnes, R.D.; Chapter 16: Pechenik, J. A.)

Practical[Credits 2]

1. Study of whole mount of,,*Paramecium.*
2. Study of *Sycon.*
3. *Identifications characterstic Features and Significance Amoeba, Euglena, Obelia, Physalia, Aurelia, Corallium, Gorgonia, Metridium/Adamsia, Pennatula, Fungia, Meandrina, Madrepora,* Ctenophora
4. Study of adult *Fasciola hepatica*, *Taenia solium* and their life stages (Slides/micro-photographs)
5. Study of adult *Ascaris lumbricoides* and its life cycle(Slides/micro-photographs)
6. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs)
7. To submit a project report on the Diversity of pond protista.

Note: Classification to be followed from "Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition, Cengage Learning, India"

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and round tables on the various aspects of non-chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of Classification.Curriculum related assignments would improve the reading ,writing and abstracting skills and enhance the critical thinking of the students.

Assessment Methods:

Various measures adopted will be as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones during which students will be evaluated.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***VIVA-VOCE:*** *Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Keywords:

Acoelomates, Classification, Cnidaria, Ctenophora, Diploblastic, Helminths, Metazoa, Parazoa, Porifera, Protista, Protostomia, Pseudocoelomates, Structural organization, Symmetry, Triploblastic

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education

*Note: Classification to be followed from "Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India"

Suggested Readings:

- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis. III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

- Swayam (MHRD) Portal
- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity)
- Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology)
- ePG Pathshala (MHRD)Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35

Core Course e -II: Principles of Ecology

Course Learning Objective:

The primary aim of the syllabus is to sensitize the students about the paramount role and importance of nature. The study of Ecology imparts us the knowledge about the judicious use of existing ecological resources for sustainable development. Ecology is the only branch of science which briefs us on the ways and means of living with nature for mutual benefit. Study of ecology will provide students opportunity to understand its practical aspects and helps them to solve many contemporary ecological issues such as global warming, land degradation, habitat loss, desertification and pollution etc. The hands-on experiences of laboratory will also enable students to understand the ecosystem and ecology in a better way.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors.
- Comprehend the population characteristics, dynamics, growth models and interactions.
- Understand the community characteristics, ecosystem development and climax theories.
- Know about the types of ecosystems, food chains, food webs, energy models, and ecological efficiencies.
- Apply the basic principles of ecology in wildlife conservation and management.
- Inculcate scientific quantitative skills, evaluate experimental design, read graphs, and analyse and use information available in scientific literature.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit1: Introduction to Ecology 5 hrs

History and Scope of ecology, Autecology and synecology, Laws of limiting factors, Study of physical factors: Temperature and Light

(Chapter 1: Smith, R. L.; Chapter 1 and 5: Odum, E.P.; Chapter 1 and 5: Odum, E. P. and G. W. Barrette)

Unit 2: Population 24 hrs

Unitary and Modular populations; Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion; Exponential and logistic growth, equation and patterns, *r* and *k* strategies, Population regulation; Density-dependent and independent factors; Population interactions; Gause's Principle with laboratory and field examples; Lotka-Volterra equation for competition and predation; Functional and numerical responses

(Chapter 17, 18, 19, 20, 22 and 23: Smith, R. L.; Chapter 6 and 7: Odum, E. P. and G. W. Barrette)

Unit 3: Community 12 hrs

Community characteristics: species richness, dominance, diversity, abundance, Guilds, Ecotone and edge effect; Ecological succession with examples and types; Theories pertaining to climax community.

(Chapter 28 and 30: Smith, R. L.; Chapter 7: Odum, E. P. and G. W. Barrette)

Unit 4: Ecosystem 14 hrs

Types of ecosystems with detailed study of any one: Forest Ecosystem, Pond or Lake ecosystem, Mangrove and Coral reef ecosystem. Vertical stratification in Forest and Aquatic ecosystem, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies, Nutrient and biogeochemical cycle with one example of Nitrogen cycle *(Chapter 10, 11 and 12: Smith, R. L.; Chapter 2 and 4: Odum, E. P. and G. W. Barrette)*

Unit 5: Applied Ecology 4hrs

Ecology in wildlife conservation and management.
(Chapters 1 and 3: Saha and Mazumdar)

Practical [Credits: 2]

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: phytoplankton and zooplankton, measurement of area, temperature, turbidity/penetration of light, determination of pH, and dissolved oxygen content (Winkler's method), chemical oxygen demand and free CO_2, alkalinity
4. Report on a visit to National Park/Biodiversity Park/Wildlife sanctuary

Teaching and Learning Process:

The course involves four hours each of classroom teaching and laboratory activity per week. Classroom work would include lectures based on textbook and scientific journal readings. Lectures will consist of traditional board teaching as well as power point presentations. Learning process will also include participatory activities like focused group discussions, presentations by students, experience sharing, brainstorming and project writing. Field trip activities to National parks and Eco-parks would complement and enhance understanding of the course concepts and information about the wildlife and its conservation. Laboratory work will provide students the first hands-on experience for better understanding of the subject.

Assessment Methods:

- Evaluation will determine the extent to which the students demonstrate desired learning outcomes.
- Multiple assessment methods will be used as evaluation criteria which include continuous assessment, assignments, tests, class presentations and mock tests.
- Project writing based on leanings from field trips will also be held for comparative evaluation of students.

Keywords:

Ecology, Community ecology, Population ecology, Biodiversity, Wildlife, Food Chain, Food web, Food pyramids

Recommended Books:

- Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
- Smith, R. L. (2000). Ecology and field biology. Harper and Row publisher

Suggested Readings:

- Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
- Ricklefs, R.E. (2000). Ecology. V Edition. Chiron Press.

Core Course -III: Non-Chordates II: Coelomates

Course Learning Objective:

The coursewould provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organisation of the animals based on their evolutionary relationships, structural and functional affinities. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- Appreciate the diversity of non-chordates living in diverse habit and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically think about the organization, complexity and characteristic features of non-chordates.
- Getting familiarized with the morphology and anatomy of representatives of various animal phyla.
- Comprehendthe economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Introduction to Coelomates 2 hrs

Evolution of coelom and metamerism

(Chapter 9 and 27: Barnes, R.D.; Chapter 5: Pechenik, J. A.)

Unit 2: Annelida 14 hrs

General characteristics and Classification up to classes; Excretion in Annelida

(Chapter 13: Barnes, R.D.; Chapter 13: Pechenik, J. A.)

Unit 3: Arthropoda 17 hrs

General characteristics and Classification up to classes, Classification of Insecta up to orders Vision and Respiration in Arthropoda; Metamorphosis in Insects; Social life in bees and termites

(Chapters 16-21: Barnes, R.D.; Chapter 14: Pechenik, J. A.)

Unit 4:Onychophora 2 hrs

General characteristics and Evolutionary significance

Unit 5: Mollusca 14 hrs

General characteristics and Classification up to classes; Respiration in Mollusca; Torsion and detorsion in Gastropoda; Pearl formation in bivalves.Evolutionary significance of trochophore larva
(Chapter 12: Barnes, R.D.; Chapter 12: Pechenik, J. A.)

Unit 6: Echinodermata 11 hrs

General characteristics and Classification up to classes; Water-vascular system in Asteroidea; Larval forms in echinoderms.Affinities with Chordates.
(Chapter 28: Barnes, R.D.; Chapter 20: Pechenik, J. A.)

Practical [Credits: 2]

1. Study of *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria,* Trochophore larva

Arthopods-*Limulus*, *Palamnaeus, Palaemon, Daphnia*, *Balanus*, *Sacculina*, *Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx*, *Periplaneta,* termites, *Apis,termites*.

Molluscs- Chiton, Dentalium, Pila, Doris, Helix, Unio, Patella,Ostrea, Pinctada, Sepia, Octopus, Nautilus
Echinoderms-Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria, Antedon

2. Study of digestive system and septal nephridia of earthworm.
3. T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm
4. Study of *Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria, Antedon*
5. Mount of mouth parts, dissetion digestive system and nervous system and reproductive system of *Periplaneta**
6. Submit a Project Report on any related topic to larval forms(crustacean,mollusk and echinoderm)

7. Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted not only through classroom lectures to inculcate a conceptual base among the students about the subject but also through observations in nature and through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of non-chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:

Various measures adopted will be as follows:

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones during which students will be evaluated.
- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.
- Regular Presentations: Presentations by the students on a particular topic will enhance students' learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- *Viva-voce: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Keywords:

Annelida, Arthropoda, Coelomates, Classification, Deuterostomia, Echinodermata, Insecta, Metamerism, Metazoa, Mollusca, Onychophora, Structural organization, Symmetry, Triploblastic

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education

*Note: Classification to be followed from "Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition, Cengage Learning, India"

Suggested Readings:

- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

- Swayam (MHRD) Portal
- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity)
- Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology)

Core Course IV: Cell Biology

Course Learning Objective:

The objective of the course is to help the students to learn and develop an understanding of a cell as a basic unit of life. This course is designed to enable them to understand the functions of cellular organelles and how a cell carries out and regulates cellular functions.

Course Learning Outcome:

Upon completion of the course, students should to be able to:

- Understand fundamental principles of cell biology.
- Explain structure and functions of cell organelles involved in diverse cellular processes.
- Appreciate how cells grow, divide, survive, die and regulate these important processes.
- Comprehend the process of cell signalling and its role in cellular functions.
- Have an insight of how defects in functioning of cell organelles and regulation of cellular processes can develop into diseases.
- Learn the advances made in the field of cell biology and their applications.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Overview of Cells 3 hrs

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions
(Chapter 1: Cooper; Chapter 4: Becker; Chapter 1: Karp)

Unit 2: Plasma Membrane 7 hrs

Various models of plasma membrane structures, Transport across membranes: active and passive transport, facilitated transport; Cell-cell junctions, structures and functions: Tight junctions, adherens junctions, gap junctions
(Chapter 13: Cooper; Chapter 7: Becker; Chapter 4; Karp)

Unit 3: Endomembrane System 12 hrs

Structure and Functions: Endoplasmic Reticulum, Signal hypothesis, Vesicular transport from ER to Golgi apparatus; Protein sorting and transport from Golgi apparatus; Golgi apparatus, Vesicular transport: Coated Vesicles; Lysosomes; Peroxisomes.
(Chapter 10, 11: Cooper; Chapter 12: Becker; Chapter 8: Karp)

Unit 4: Mitochondria 8 hrs

Structure, Semi-autonomous nature, Endo-symbiotic hypothesis; Respiratory chain, Chemi-osmotic hypothesis and ATP Synthase.
(Chapter 11: Cooper; Chapter 10: Becker; Chapter 5)

Unit 5: Cytoskeleton 7 hrs

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments.
(Chapter 12: Cooper; Chapter 15: Becker; Chapter 9: Karp)

Unit 6: Nucleus 8 hrs

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Transport of molecules across nuclear membrane, Chromatin: euchromatin, heterochromatin and packaging, nucleosome, nucleolus. *(Chapter 9: Cooper; Chapter 18: Becker)*

Unit 7: Cell Division 8 hrs

Mitosis, Meiosis, Cell cycle and its regulation
(Chapter 16: Cooper; Chapter 14: Karp)

Unit 8: Cell Signalling 7 hrs

Cell Signalling through G-protein coupled receptor (GPCR) and role of secondary messenger:
cAMP and protein kinase; Apoptosis.
(Chapter 15: Cooper; Chapter 14: Becker; Chapter 15: Karp)

Practical [Credit: 2]

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1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
2. Study of various stages of meiosis of Grass hopper
3. Preparation of temporary stained mount to show the presence of Barr body in human female blood cells/ chick cells.
4. Cytochemical staining and preparation of permanent slide to demonstrate:
   (a) DNA by Feulgen reaction
   (b) Mucopolysaccharides by PAS reaction

Teaching and Learning Process:

· The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.

· A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this.

· Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

The assessment of students' achievement in Cell Biology will be aligned with the course learning outcomes.

· Continuous evaluation of learning by diagnostic and formative methods.

· Project work, quiz, problem solving exercise, classroom assessment methods, closed-book and open-book tests, problem-solving exercises, practical assignment, laboratory reports, seminar presentation, *viva voce* interviews, computerized adaptive testing, literature surveys and summative evaluations by end-semester examination etc. will constitute the different components of the overall assessment.

Keywords:

Cell organelles, cell membrane, cell junctions, endomembrane system, cytoskeleton, mitosis, meiosis, cell signaling

Recommended Books:

- Cooper, G.M., Hausman, R.E. (2009) The Cell: A Molecular Approach. V Edition, ASM Press and Sinauer Associates.
- .
- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments,VI Edition, John Wiley & Sons Inc.

Suggested Readings:

- De Robertis, E.D.P. and De Robertis, E.M.F. (2009) The Cell and Molecular Biology, Lippincott Williams & Wilkins, Philadelphia.
- Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Robert Keith and Watson James. (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.

Online Tools and Web Resources:

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology
- https://www.khanacademy.org/science/biology

Core course V: Diversity of Chordates

Course Learning Objective:

The course is designed with an aim to provide scope and historical background of chordates. It will impart knowledge regarding basic concepts of origin of chordates and make the students understand the characteristics and classification of animals with notochord. The exclusive phenomena in chordates like biting mechanism in snakes, flight adaptations in birds etc. will be explained. The adequate explanation to the students regarding various mechanisms involved in thriving survival of the animals within their geographic realms will create interest among students.

Course Learning Outcome:

Upon completion of the course, the students will be able to:

- Understand different classes of chordates, level of organization and evolutionary relationship between different subphyla and classes, within and outside the phylum.
- Study about diversity in animals making students understand about their distinguishing features.
- Appreciate similarities and differences in life functions among various groups of animals in Phylum Chordata.
- Comprehend the circulatory, nervous and skeletal system of chordates.
- Know about the habit and habitat of chordates in marine, freshwater and terrestrial ecosystems.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Introduction to Chordates 2 hrs

General characteristics and outline classification
(Chapter 2: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 2: Protochordata 8 hrs

General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata
(Chapter 3: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 3: Origin of Chordata 3 hrs

Dipleurula concept and the Echinoderm theory of origin of chordates,
(Chapter 3: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 4: Agnatha 2 hrs

General characteristics and classification of cyclostomes up to Class
(Chapter 4: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 5: Pisces 8hrs

General characteristics of Chondrichthyes and Osteichthyes, Classification up to order Migration, Osmoregulation and Swim bladder in Fish
(Chapter 6, 7, 8, 9 and 10: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 6: Amphibia 6 hrs

Origin of Tetrapoda (Evolution of terrestrial ectotherms); General characteristics and classification up to order; Parental care in Amphibians
(Chapter 11 and 12: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 7: Reptilia 8 hrs

General characteristics and classification up to order; Affinities of *Sphenodon*; Poison apparatus and biting mechanism in snakes
(Chapter 13 and 14: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 8: Aves 8 hrs

General characteristics and classification up to order; *Archaeopteryx*- a connecting link; Flight adaptations and migration in birds
(Chapter 15, 16 and 17: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 9: Mammals 7 hrs

General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages
(Chapter 18-31: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 10: Zoogeography 7 hrs

Zoogeographical realms, Plate tectonic and Continental drift theory, Distribution of vertebrates in different realms
(Chapter 1: Young, J. Z.; Chapter 1, 7, 8 & 9: Darlington P.J.)

Practical [Credits: 2]

1. Protochordata: *Balanoglossus, Herdmania, Branchiostoma*, Colonial Urochordata, Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slide of *Herdmania* spicules
2. Agnatha: Petromyzon, Myxine
3. Fish: Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/ Diodon, Anabas, Flat fish
4. Amphibia: Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra
5. Reptilia: Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus; Key for Identification of poisonous and non-poisonous snakes
6. Aves: Study of six common birds from different orders. Types of beaks and claws
7. Mammalia: *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus, Loris, Herpestes, Erinaceous.*
   Mount of Weberian ossicles of *Mystus*, pecten from fowl head and brain of fowl
8. Power point presentation on study of any two animals from two different classes by students

Teaching and Learning Process:

- Animal pictures and models
- Related videos
- Powerpoint presentations
- Maximizing interaction with students
- Mentoring
- Analysis of scientific articles

Assessment Methods:

- Assignments
- Class test
- *Viva-voce*
- MCQs
- Paper presentations
- Continuous assessment

Keywords:

Chordata, Origin, General characteristics, Classification, Protochordata, Agnatha, Cyclostomes, Pisces, Tetrapoda, Amphibia, Reptiles, Aves, Mammals, Zoogeography

Recommended Books:

- Young, J. Z. (2004). The Life of Vertebrates. III Edition, Oxford university press.
- Parker T.J. and Haswell W.A. (1972). Textbook of Zoology Vertebrates.VII Edition, Volume II
- Pough H. (2018). Vertebrate life X Edition, Pearson International.

Suggested Readings:

- Darlington P.J. (1966). The Geographical Distribution of Animals, R.E. Krieger Pub. Co.
- Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.

Online Tools and Web Resources:

- https://www.khanacademy.org/science/biology/crash-course-bio-ecology/crash-course-biology-science/v/crash-course-biology-123
- https://opentextbc.ca/biology2eopenstax/chapter/chordates/

Core Course -VI: Physiology: Controlling and Coordinating Systems

Course Learning Objective:

Physiology is the study of life, specifically, how cells, tissues and organ function. It is a core and fundamental scientific discipline that underpins the health and well-being of living organisms. Besides satisfying a natural curiosity about how our body systems function, it gives us knowledge about the functions of all the parts and systems of the body. It is also of central importance in medicine and related health sciences. The course has been designed to extend the fundamental or coherent understanding of the subject to related disciplinary areas/subjectsthrough understanding of normal body functions, assisting in more effective treatment of abnormal or diseased states. It will equip the students with skill-based knowledge, enabling them to undertake further studies in physiology and related areas as well as in multidisciplinary subjects.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Know the basic fundamentals and understand advanced concepts so as to develop a strong foundation that will help them to acquire skills and knowledge to pursue advanced degree courses.
- Comprehend and analyze problem-based questions
- Recognize and explain how all physiological systems work in unison to maintain homeostasis in the body and use of feedback loops to control the same
- Learn an integrative approach to understand the interactions of various organ systems resulting in the complex overall functioning of the body. Synthesize ideas to make connection between knowledge of physiology and real world situations, including healthy life style decisions and homeostatic imbalances
- Know the role of regulatory systems *viz.* endocrine and nervous systems and their amalgamation in maintaining various physiological processes.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Tissues 6 hrs

Structure, location, classification and functions of Epithelial tissue, Connective tissue, Muscular tissue and Nervous tissue
(Chapter 4: Tortora, G.J & Grabowski, S)

Unit2: Bone and Cartilage 4hrs

Histology of different types of bones and cartilages
(*Chapter 6: Tortora, G.J & Grabowski, S)*

Unit 3: Nervous System 12 hrs

Structure of neuron, Resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission, Neuromuscular junction; Physiology of hearing and vision. (*Chapter 12: Tortora, G.J & Grabowski, S)*

Unit 4: Muscle 12 hrs

Histology of different types of muscle; Ultrastructure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, Summation and tetanus

(*Chapter 10: Tortora, G.J & Grabowski, S)*

Unit 5: Reproductive System 8 hrs

Histology of testis and ovary; Physiology of male and female reproduction(*Chapter 28: Tortora, G.J & Grabowski, S)*

Unit 6: Endocrine System 18 hrs

Histology of endocrine glands- pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; Hormones secreted by them and their physiological action; Classification of hormones; Regulation of their secretion; Mode of hormone action- Signal transduction pathways for steroidal and non-steroidal hormones
(*Chapter 18: Tortora, G.J & Grabowski, S)*

Practical [Credits: 2]

1. * Recording of simple muscle twitch with electrical stimulation (or Virtual)
2. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
3. Preparation of temporary mounts: Squamous epithelium, Striated muscle fibres, Nerve cells
4. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
5. Demonstration of technique of microtomy to have hands-on experience and learning of the technique.

Teaching and Learning Process:

The Learning Outcomes-Based Approach to curriculum planning and execution requires that the teaching learning processes are oriented towards enabling students to attain the defined learning outcomes relating to the courses within a programme. This, particularly in the context of undergraduate studies, requires a significant shift from teacher centric to learner/ student centric, pedagogies and from passive to active/participatory pedagogies. Practical skills, including an appreciation of the link between theory and experiment will constitute an important aspect of the teaching-learning process.

Teaching methods will include:

- Lectures supported by group tutorial work; invited lectures
- Practical and field-based learning;
- Use of prescribed textbooks and e-learning resources and other self-study materials;
- Project work
- Assignments, seminars, oral presentations
- Activities designed to promote the development of generic/transferable and subject specific skills;
- Internships and visits to field sites and hospitals or other research facilities
- Guidance by the mentors and specialists in the field etc.

Assessment Methods:

A variety of assessment methods will be used to assess progress towards the course learning outcomes. Priority will be accorded to formative assessment. Progress towards achievements of learning outcomes will be assessed using the following:

- Theory and practical examinations;
- Problem based assignments;
- Practical assignment, laboratory exercises and reports; observation of practical skills;
- Individual project reports (case-study reports); team project reports;
- Oral presentations, including seminar presentations; viva voce interviews;
- Peer and self-assessment, literature survey evaluations etc.

Keywords:

Epithelial and connective tissues, Bones, Cartilage, Neuron, Membrane potential, Graded potential, Synapse, Neuromuscular junction, Neurotransmitter, Skeletal muscle, Sarcomere, Testes, Ovary, Endocrine glands, Hormones, Negative feedback mechanism, Signal transduction pathway.

RecommendedBooks:

- Tortora, G.J. and Grabowski, S. (2006). Principles of Anatomy & Physiology. XI edition.John Wiley & Sons
- Vander, A., Sherman, J., and Luciano, D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, Mc Graw Hills

Suggested Readings:

- Ganong, W.F. (2019) Review of Medical Physiology. 26th Edition, Mc Graw-Hill
- Guyton, A.C. & Hall, J.E. (2006).Textbook of Medical Physiology. XI Edition.Hercourt Asia PTE Ltd/W.B. Saunders Company
- Marieb, E.N. (1998) Human Anatomy and Physiology. IV Edition, Addison Wesley Longman Inc.

Online Tools and Web Resources:

- e portals like SWAYAM and
- http://nsdl.niscair.res.in

Core course-VII: Fundamentals of Biochemistry

Course Learning Objective:

Biochemistry is to understand the core biological phenomena at the molecular level. The aim of the course is to comprehend the fundamental principles of chemistry that govern complex biological systems.The program is designed to enable a student acquire sound knowledge of biochemistry and its practicable applicability. To make the study relevant, interesting, encouraging to the students to join the industry or to prepare them for higher studies including research. The new and updated syllabus is based on a basic and applied approach to ensure that students develop problem solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics.

Course Learning Outcome:

- Upon completion of the course, students should be able to: Gain knowledge and skill in the fundamentals of biochemical sciences, interactions and interdependence of physiological and biochemical processes.
- Get exposed to various processes used in industries and gain skills in techniques of chromatography and spectroscopy.
- Demonstrate foundation knowledge in biochemistry; synthesis of proteins, lipids, nucleic acids, and carbohydrates; and their role in metabolic pathways along with their regulation.
- Know about classical laboratory techniques, use modern instrumentation, design and conduct scientific experiments, and analyze the resulting data.
- Be knowledgeable in proper procedures and regulations in handling and disposal of chemicals.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Carbohydrates 8 hrs

Structure and Biological importance:: monosaccharides, disaccharides, polysaccharides and Glycoconjugates

(Chapter 7: Cox, M.M and Nelson, D.L.; Chapter 11: Berg, J.M., Tymoczko, J.L. and Stryer, L.).

Unit 2: Lipids 8hrs

Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids

(Chapter 10: Cox, M.M and Nelson, D.L.; Chapter 12: Berg, J.M., Tymoczko, J.L. and Stryer, L.).

Unit 3: Proteins 14 hrs

Amino acids: Structure, Classification and General properties of -aminoacids; Physiological importance of essential and non-essential -amino acids; Proteins: Bonds stabilizing protein structure; Levels of organization in proteinmotifs, folds anddomains; Denaturation; Introduction to simple and conjugate proteins. Immunoglobulins: Basic Structure,

(Chapter 4 and 5: Cox, M.M and Nelson, D.L.; Chapter 3: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Unit 4: Nucleic Acids 12hrs

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids; Cot Curves: Base pairing, Denaturation and Renaturation of DNA; Types of DNA and RNA, Complementarity of DNA, Hypo-Hyperchromicity of DNA

(Chapter 8: Cox, M.M and Nelson, D.L.; Chapter 5: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Unit 5: Enzymes 18 hrs

Nomenclature and classification; Cofactors; Specificity of enzyme action;Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affectingrate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation,Concept of Km and Vmax, Lineweaver-Burk plot; Multi-substrate reactions;Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme reaction

(Chapter 6: Cox, M.M and Nelson, D.L.; Chapter 8: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Practical [Credits: 2]

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Paper chromatography of amino acids.
3. Action of salivary amylase under optimum conditions.
4. Action of salivary amylase under different conditions.
5. Demonstration of proteins separation by SDS-PAGE.

Teaching and Learning Process:

At the end of the IV Semester, the UG student is expected to demonstrate clear understanding of general concepts and fundamental biochemical principles; such as structure/function of biomolecules metabolic pathways, regulation of biological and biochemical processes through class room lectures and encourage interactive learning with simulation studies including animations, presentations. Principles of various biochemical techniques will be explained through advanced instrumentations. The data will be analysed and interpreted with computer-assisted software.Project-based studies will help students devise experiments independently.

Assessment Methods:

- Continuous Assessment by regular class tests; Projects and Assignments both individual/group projects to inculcate independent thinking as well as team work among the students. Regular Presentationsto be assessed based on the content, novelty, explanation and response to queries.
- Online Assignment/Project Submission; Self-assessment through Quiz.
- Concept maps (Diagram with hierarchical nodes, labeled with concepts), Concept (The instructor presents one or more questions during class along with several possible answers), Oral/Poster Presentation.

- Use of free video recording tool and online video platform (such as PresentationTube; http://presentationtube.com/). It helps to connect and train teachers and students to record, publish, and share quality video tutorials.

Keywords:

Carbohydrates, Lipids, Proteins, Enzymes, Amino acids, Nucleic acids, DNA, RNA, Conjugates, Steroids

Recommended Books:

- Cox, M.M and Nelson, D.L. (2008).Lehninger's Principles of Biochemistry. VEdition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry. VI Edition,W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. andWell, P.A. (2009). Harper's Illustrated Biochemistry. XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.

Suggested Reading:

- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry. II Edition, BIOS Scientific Publishers Ltd., U.K.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene. VI Edition, Cold Spring Harbor Lab.Press, Pearson Pub.

Online Tools and Web Resources:

- CECGurukul (www.cec.nic.in)
- https://www.youtube.com/user/cecedusat/featured.
- National Institute of Science Communication and Information Resources (NISCAIR)

  (http://www.niscair.res.in/) and National Science Digital Library (NSDL) (www.nsdl.niscair.res.in).
- National Digital Library of India (NDL India; https://ndl.iitkgp.ac.in/).

Core course-VIII: Comparative Anatomy of Vertebrates

Course Learning Objective:

This course aims to provide the undergraduate students a thorough knowledge of structural details and comparative account of the different organ systems of the body from lower to higher vertebrates, and protochordates, thus enabling them to appreciate the incredible vertebrate diversity. The course furnishes an understanding of evolutionary basis of morphological and anatomical differences as well as similarities that occur among vertebrates. It helps students propose possible homology between structures, and understand how they evolved as the vertebrates dwelled different habitats. The structural modifications of digestive, circulatory, respiratory and skeletal system relates to the distribution of animals in their different comfort zones of habitat and ecological niches. The understanding of anatomical details of organ systems of mammals like rat and mice aims to gives the basic information for their use in experimental and research studies in different branches of Zoology like Immunology, Medical Zoology and Reproductive Biology etc.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Explain comparative account of the different vertebrate systems
- Understand the pattern of vertebrate evolution, organisation and functions of various systems.
- Learn the comparative account of integument, skeletal components, their functions and modifications in different vertebrates.
- Understand the evolution of heart, modification in aortic arches, structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and digestive system and its anatomical specializations with respect to different diets and feeding habits.
- Learn the evolution of brain, sense organs and excretory organsto a complex, highly evolved form in mammals;

- Learn to analyze and critically evaluate the structure and functions of vertebrate systems, which helps them to discern the developmental, functional and evolutionary history of vertebrate species.
- Understand the importance of comparative vertebrate anatomy to discriminate human biology.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit1: Integumentary System 7hrs

Structure and derivatives of integument, functions of skin.

(Chapter 6: K.V.Kardong; Chapter 6: G.C. Kent)

Unit2: Skeletal System 9 hrs

Overveiw of axial and appendicular skeleton, Jaw suspensorium, Visceral arches. *(Chapter 7, 8 and 9: K.V.Kardong; Chapter 7, 8, 9 and 10: G.C.Kent)*

Unit 3: Digestive System 8 hrs

Alimentary canal and associated glands, dentition

(Chapter 13; K.V.Kardong; Chapter 12: G.C. Kent)

Unit 4: Respiratory System 8hrs

Skin, gills, lungs and air sacs; Accessory respiratory organs
(Chapter 11: K.V.Kardong; Chapter 13:G.C.Kent)

Unit 5: Circulatory System 8hrs
General plan of circulation, Evolution of heart and aortic arches
(Chapter 12: K.V. Kardong; Chapter14: G.C.Kent)

Unit 6: Urinogenital System 6 hrs
Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.
(Chapter 14: K.V. Kardong; Chapter 15:G.C.Kent)

Unit 7: Nervous System 8 hrs
Comparative account of brain; Autonomic nervous system, Spinal cord, Cranial nerves in mammals
(Chapter 16 : K.V. Kardong ; Chapter 16 :G.C. Kent)

Unit 8: Sense Organs 6 hrs Classification of receptors; Brief account of visual and auditory receptors in man *(Chapter 17:K.V.Kardong; Chapter 17:G.C. Kent)*

Practical [Credits: 2]

1. Study of placoid, cycloid and ctenoid scales of fish through permanent slides/photographs.
2. Disarticulated skeleton of Frog, Fowl
3. Carapace and plastron of turtle/tortoise.
4. Mammalian skulls: One herbivorous and one carnivorous animals
5. Dissection of fish (Tilapia/Bata) tostudy arterial and urogenital system(subject to permission)
6. Study of structure of any two organs(Heart,Lung,Kidney)
7. Project on skeletal modification in amphbiaReptilia and Mammaliamay be included if dissection not permitted.
   textbooks and E-resources available in NCBI, SWAYAM etc. Project work will encourage students to undertake projects on certain topics like modifications in GI tract, appendages, respiratory organs etc. with respect to different habitats. Peer teaching including presentation and group discussions on various topics of vertebrate comparative anatomy will allow effective participation of students in class room and develop confidence in students. Computer-aided methods by showing virtual dissections or videos of anatomy of circulatory, digestive and reproductive systems of frog and rat, will provide an understanding of animal systems.Viewing documentary films or visiting biodiversity parks, aquarium, sanctuaries and zoological parks will help students correlate the anatomical changes in the vertebrates studied in the classroom with actual observation in living animals. Assignments will improve the writing and abstracting skills of students.

Assessment Methods:

- Formative assessment on regular basis: This includes putting up questions in order to monitor students' learning. Students are marked on the basis of continuous assessment and end term exam.
- Continuous assessment: includes class test, assignment and attendance.
- Marks for the attendance: to maintain regularity in the class.
- Practical: provide a great opportunity to assess students for their understanding about a concept lectured, and demonstrate activity in small groups. Additionally, regular assessment of the practical skills gained by students can also be done.
- Summative assessment: includes project reports, assignments, oral presentations, *viva-voce*, evaluation of practical records, regular tests.

Keywords:

Anatomy, integument, axial, appendicular, cranium, jaw suspensorium, pectoral and pelvic girdle, visceral arches, dentition, air sacs, accessory respiratory receptors, visual,cranial, spinal nerves,

RecommendedBooks:

- Kardong, K.V. (2005). Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
- Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
- Leiem C.F., Bermis W.E, Walker, W.F, Grande, L. (2001). Functional anatomy of the vertebrates, An evolutionary perspective. III Edition, Brookes/Cole, Cengage Learning.

Suggested Readings:

- C.K Weichert and W. Presch (1970). Elements of Chordate Anatomy, IV Edition, McGraw-Hill.
- Pough.H. (2018). Vertebrate Life.X Edition. Pearson International.

Online Tools and Web Resources:

- SWAYAM (Functional anatomy and regulation of vision, hearing, taste, smell and touch, Link - https://www.swayamprabha.gov.in/index.php/program/upcoming/9).
- SWAYAM (Structure of heart), Link- https://www.swayamprabha.gov.in/index.php/program/archive/9.
- COURSERA (PALEONTOLOGY: Early vertebrate evolution, Link – https://www.coursera.org/learn/early-vertebrate-evolution).

Core CourseIX: Physiology: Life Sustaining Systems

Course Learning Objective:

Physiology is the study of life, specifically, how cells, tissues and organ function. It is a core and fundamental scientific discipline that defines the health and well-being of living organisms. Besides satisfying a natural curiosity about how our body systems function, it gives us knowledge about the functions of all the parts and systems of the body. It is also of central importance in medicine and health sciences. The course has been designed to apply the theoretical concept to the laboratory exercises for acquiring skills. The fundamental or coherent understanding of the subject will be extended to related disciplinary areas/subjects through understanding of normal body functions, enabling effective treatment of abnormal or diseased states. The students will be equipped with skill-based knowledge to help them undertake further studies in physiology and related areas as well as in multidisciplinary subjects.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Have a clear knowledge of basic fundamentals and understanding of advanced concepts so as to develop a strong foundation that will help them to acquire skills and knowledge to pursue advanced degree courses.
- Comprehend and analyse problem-based questions on physiological aspects.
- Recognize and explain how all physiological systems work in unison to maintain homeostasis in the body; and use of feedback loops to control the same.
- Learn an integrative approach to understand the interactions of various organ systems resulting in the complex overall functioning of the body.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Physiology of Digestion 16 hrs

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.
(*Chapter 24: Tortora)*

Unit 2: Physiology of Respiration 12 hrs

Histology of respiratory tract; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration. (*Chapter 23: Tortora)*

Unit 3: Renal Physiology 12 hrs

Structure of kidney and its functional Unit; Mechanism of urine formation; Regulation of water balance; Regulation of acid-base balance. (*Chapter 26 and27: Tortora)*

Unit4: Blood

Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis: Blood clotting system, Kininogen Kinin system, Fibrinolytic system. (*Chapter 19: Tortora*

8 hrs

<u>Unit 5:</u> Physiology of Heart 12 hrs

Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers. Origin and conduction of cardiac impulses; Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure and its regulation. (*Chapter 20 and 21: Tortora)*

Practical [Credits: 2]

1. Determination of ABO Blood group.
2. Enumeration of red blood cells and white blood cells using haemocytometer
3. Estimation of haemoglobin using Sahli's haemoglobinometer
4. Preparation of haemin and haemochromogen crystals.
5. Recording of blood pressure using a sphygmomanometer.
6. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney

Teaching and Learning Process:

The Learning Outcomes-Based Approach to curriculum planning and execution requires that the teaching learning processes are oriented towards enabling students to attain the defined learning outcomes relating to the courses within a programme. This, particularly in the context of undergraduate studies, requires a significant shift from teacher centric tolearner/ student centric, pedagogies and from passive to active /participatory pedagogies. Therefore, planning for teaching becomes critical. Practical skills, including an appreciation of the link between theory and experiment, will constitute an important aspect of the teaching-learning process. Teaching methods will include:

- Lectures supported by group tutorial work; invited lectures
- Practical and field-based learning;
- The use of prescribed textbooks and e-learning resources and other self-study materials;
- Project work
- Assignments, seminars, oral presentations
- Activities designed to promote the development of generic/transferable and subject specific skills;
- Internships and visits to field sites and hospitals or other research facilities
- Guidance by the 'mentors' and specialists in the field etc.

Assessment Methods:

A variety of assessment methods will be used to assess progress towards the course learning outcomes. Priority will be accorded to formative assessment. Progress towards achievements of learning outcomes will be assessed using the following:

- Theory and practical examinations,Problem based assignments;

Practical assignment, laboratory exercises and reports; observation of practical skills;

- **Course-X: Biochemistry of Metabolic Processes**

Course Learning Objective:

The program is designed to enable a student acquire sound knowledge of biochemistry and its practicable applicability. Effort has been madeto make the study relevant, interesting and encouraging to the students to join the industry or to prepare them for higher studies including research. The new and updated syllabus is based on a basic and applied approach to ensure that students develop problem solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics.

Course Learning Outcome:

Upon completion of the course, students will be able to

- Gain knowledge and skill in the interactions and interdependence of physiological and biomolecules
- Understand essentials of the metabolic pathways along with their regulation.
- Know the principles, instrumentation and applications of bioanalytical techniques.
- Get exposure to various processes used in industries.
- Become aware about classical laboratory techniques, use modern instrumentation, design and conduct scientific experiments and analyze the resulting data.
- Be knowledgeable in proper procedures and regulations in handling and disposal of chemicals

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Overview of Metabolism 10 hrs

Catabolism *vs*. Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways; Shuttle systems and membrane transporters; ATP as"Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms

(Chapter 15: Cox, M.M and Nelson, D.L; Chapter 14:Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Unit 2: Carbohydrate Metabolism 16 hrs

Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

(Chapter 14 and 16: Cox, M.M and Nelson, D.L.; Chapter 16 and 17: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Unit 3: Lipid Metabolism 12 hrs

-oxidation and omega-oxidation of saturated fatty acids with even and odd number of carbon atoms and their regulation; Biosynthesis of palmitic acid; Ketogenesis.

(Chapter 17: Cox, M.M and Nelson, D.L; Chapter 22: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Unit 4: Protein Metabolism 8 hrs

Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

(Chapter 18: Cox, M.M and Nelson, D.L.; Chapter 23: *Berg, J.M., Tymoczko, J.L. and Stryer, L.)*

Unit 5:Oxidative Phosphorylation 10 hrs

Redox systems; Review of mitochondrial respiratory chain:Electron carriers, sites of ATP production, inhibitors and un-couplers of Electron Transport System.

(Chapter 19: Cox, M.M and Nelson, D.L.; Chapter 18: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Practical [Credits: 2]

1. Estimation of total protein in given solutions by Lowry's method.
2. Detection of SGOT and SGPT or GST and GSH in serum/ tissue
3. To study the enzymatic activity of Trypsin and Lipase.
4. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.

Teaching and Learning Process:

At the end of the IV Semester, the UG student is expected to demonstrate clear understanding of general concepts and fundamental biochemical principles; such as structure/function of biomolecules metabolic pathways, regulation of biological and biochemical processes through class room lectures and encourage interactive learning with simulation studies including animations, presentations. Principles of various biochemical techniques will be explained through advanced instrumentations. The data will be analysed and interpreted with computer-assisted software. Project-based studies will help students devise experiments independently.

Assessment Methods:

- Continuous Assessment by regular class tests; Projects and Assignments both individual/group projects to inculcate independent thinking as well as team work among the students. Regular Presentations to be assessed based on the content, novelty, explanation and response to queries.
- Online Assignment/Project Submission; Self-assessment through Quiz.
- Concept maps (Diagram with hierarchical nodes, labeled with concepts), Concept (The instructor presents one or more questions during class along with several possible answers), Oral/Poster Presentation.
- Use of free video recording tool and online video platform (such as PresentationTube; http://presentationtube.com/). It helps to connect and train teachers and students to record, publish, and share quality video tutorials.

Keywords:

Metabolism, Catabolism, Anabolism, Oxidative phosphorylation, Electron Transport System, ATPase, Liver, Fatty acids

Recommended Books:

- Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry. VEdition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry. VI Edition,W.H. Freeman and Co., New York.

Suggested Readings:

- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. andWell, P.A. (2009). Harper's Illustrated Biochemistry. XXVIII Edition,International Edition, The McGraw-Hill Companies Inc.
- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, IIEdition, BIOS Scientific Publishers Ltd., U.K.

Online Tools and Web Resources:

- CECGurukul (www.cec.nic.in) and their YouTube webpage (https://www.youtube.com/user/cecedusat/featured)
- https://swayam.gov.in/courses/5638-biochemistry

Core Course-XI: Molecular Biology

Course Learning Objective:

The course aims to provide students with an introduction of the underlying molecular mechanisms of various biological processes in cells and organisms. The study primarily involves learning about structure and synthesis of deoxyribo- and ribo-nucleic acids, formation of proteins, and regulation of gene expression.The course aims to develop basic understanding of structure-function relationships of nucleic acids and proteins.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Describe the basic structure and chemistry of nucleic acids, DNA and RNA;
- Compare and contrast DNA replication machinery and mechanisms in prokaryotes and eukaryotes.
- Elucidate the molecular machinery and mechanism of information transfer processes– transcription and translation-in prokaryotes and eukaryotes;
- Explain post-transcriptional modification mechanisms for the processing of eukaryotic RNAs;
- Discuss general principles of transcription regulation in prokaryotes by exploring the structure and function of lactose and tryptophan metabolism operons;
- Give an overview of gene expression regulation in eukaryotes;
- Explain the significance of DNA repair mechanisms in controlling DNA damage;
- Recognise role of RNAs (riboswitches, siRNA and miRNA) in gene expression regulation.
- Demonstrate practical knowledge of raising, handling, maintenance and special features such as antibiotic resistance of a simple prokaryotic model organism, *Escherichia coli*.
- Quantitatively estimate concentration of DNA and RNA by colorimetric methods.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Nucleic Acid 6 hrs

Salient features of DNA and types of RNA (mRNA, rRNA and tRNA); Watson and Crick model of DNA
(Chapter 6: Watson; Chapter 18: Becker)

Unit 2: DNA Replication 12 hrs

DNA replication in prokaryotes and eukaryotes – replication machinery and mechanisms, semi-conservative, bidirectional and semi-discontinuous replication, Replication of circular and linear double stranded DNA, Replication of telomeres.
(Chapter 8: Watson; Chapter 19: Becker)

Unit 3: Transcription 10 hrs

RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors *(Chapter 12: Watson; Chapter 21: Becker)*

Unit 4: Translation 12 hrs

Genetic code, Degeneracy of the genetic code and Wobble hypothesis; Process of protein synthesis in prokaryotes: Ribosome structure, fidelity of protein synthesis, aminoacyl-tRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain, Inhibitors of protein synthesis; Difference between prokaryotic and eukaryotic translation.

(Chapter14: Watson; Chapter21 and 22: Becker)

Unit 5: Post Transcriptional Modifications and Processing of Eukaryotic RNA

Structure of globin mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of tRNA

(Chapter 13: Watson)

Unit 6: Gene Regulation 10 hrs

Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from *lac* operon and *trp* operon; Overview of transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing and Genetic imprinting.

(Chapter 16 and 17: Watson; Chapter 22: Becker)

Unit 7: DNA Repair Mechanisms 2 hrs

Pyrimidine dimerization and mismatch repair.

(Chapter 9: Watson)

Unit 8: Regulatory RNAs 4 hrs

Ribo-switches; RNA interference: miRNA and siRNA.

(Chapter 18: Watson)

Practical [Credits: 2]

1. Study of Polytene chromosomes from *Chironomous/ Drosophila* larvae.
2. Preparation of liquid culture medium (LB) and raise culture of *E. coli*.
3. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking.
4. Estimation of the growth kinetics of *E. coli* by turbidity method.
5. Demonstration of antibiotic sensitivity/resistance of *E. coli* to antibiotic pressure and interpretation of results.
6. Quantitative estimation of DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A260 measurement).
7. Quantitative estimation of RNA using Orcinol reaction
8. Study and interpretation of electron micrographs/ photograph showing: DNA replication, Transcription, Split genes.

Teaching and Learning Process:

It is important for any course to enhance conceptual understanding of the subject content in the students, provide related hands-on training as well as aid in developing required skill-set for making them advance towards a field of choice. Molecular Biology course is designed to equip students with a strong foundation in molecular mechanisms of biological processes which instigates a plethora of ideas in them that will motivate them to pursue advance research. Practical exercises further provide them with required basic molecular microbiology laboratory training that will build in them confidence and make them competent to pursue

advance research in this field in India or abroad. Apart from the enriched content, use of teaching learning methodologies such as active learning, inquiry-based learning, project learning, peer learning etc. in the classrooms will help in developing higher order thinking skills of analysing, evaluating and creating knowledge. Further usage of general and specific information & communications technology (ICT) and digital tools such as projectors, simulations, scientific games, etc. will make the teaching learning process most rewarding an experience.

Assessment Methods:

Any teaching method needs to be matched by an appropriate assessment that relates to the objectives of the teaching. Thus, it is important to ensure that our molecular biology curriculum matches the teaching that occurs and the assessments we make. Students may or may not learn what is in the curriculum or what we teach, but they will learn what we assess them.

- Assessment based on project work, quiz, problem solving exercise, practical assignment, laboratory reports, presentation, *viva-voce*, computerized adaptive testing, and literature surveys by end-semester examination etc.are reliable and valid measure of a student's performance, and can be relatively easily used to assess the final cumulative performance.
- It is also important to identify the focus areas required for individual student study and ranks student performance.

Keywords:

DNA, RNA, nucleic acids, replication, transcription, translation, RNA processing, regulation of gene expression, *lac* operon, attenuation, splicing, RNA interference, riboswitches

Recommended Books:

- Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene.VI edition. Cold Spring Harbour Lab. Press, Pearson Pub.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.

Suggested Readings:

- Cooper G. M. and Robert E. Hausman R. E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.
- Lewin B. (2008). Gene XI. Jones and Bartlett.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: Molecular Biology of the Cell, IV Edition.

Online Tools and Web Resources:

- https://swayam.gov.in/courses/5065-molecular-biology
- https://swayam.gov.in/courses/4916-molecular-biology
- https://www.youtube.com/user/cecedusat

Core Course XII: Principles of Genetics

Course Learning Objective:

Unknown to them, human beings had been applying the principles of genetics by engaging in selective breeding of domesticated animals for many centuries. However, it was only with the work of Mendel and advent of 20th century, that basic principles of the science of genetics were formulated. In about a century of its existence, this field has generated tremendous amount of knowledge through observational and experimental research. The information amassed in the last century has laid the foundation for more discoveries in this important field of life science. This course aims to provide an overview of genetics starting from the work of Mendel to the current understanding of various phenomena like recombination, transposition, sex determination and mutations. The course will help in building sound fundamental knowledge of the principles of genetics, to be used as a stepping stone for higher studies and research in this field.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Have a deeper understanding of the varied branches of the biological sciences like microbiology, evolutionary biology, genomics and metagenomics.
- Gain knowledge of the basic principles of inheritance.
- Analyse pedigree leading to development of analytical skills and critical thinking enabling the students to present the conclusion of their findings in a scientific manner.
- Know the mechanisms of mutations, the causative agents and the harmful impact of various chemicals and drugs being used in day to day life.
- Find out the effects of indiscriminate use of various chemicals, drugs or insecticides in nature by studying their effect on various bacterial species in soil and water samples from different industrial or polluted areas.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Mendelian Genetics and its Extension 10hrs

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, penetrance and expressivity, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited characters inheritance .

(Chapter 3 and 4: Klug and Cummings; Chapter 3, 4, 5: Benjamin A. Pierce; Chapter 3, 4: Snustad and Simmons)

Unit 2: Linkage, Crossing Over and Chromosomal Mapping 10 hrs

Linkage and crossing over, Cytological basis of crossing over, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Linkage map, coefficient of coincidence and Interference, Gene mapping by Somatic cell hybridization.

(Chapter 5: Klug and Cummings; Chapter 7: Benjamin A. Pierce; Chapter 7: Snustad and Simmons)

Unit 3: Mutations 10 hrs

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecularbasis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB method,attached *x* method.

(Chapter 8, 15: Klug and Cummings; Chapter 9, 18: Benjamin A. Pierce; Chapter 6, 13:
Snustad and Simmons)

Unit 4: Sex Determination 5 hrs

Chromosomal mechanism of Sex determination in *Drosophila* and Man.

(Chapter 7: Klug and Cummings; Chapter 4: Benjamin A. Pierce; Chapter 5: Snustad and Simmons)

Unit 5: Extra-chromosomal Inheritance 5hrs

Comparison of nuclear and extra nuclear inheritance; Organelle inheritance: Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces* and human disorders, Infective heredity in *Paramecium*. Maternal effects: Shell coiling in *Limnaea*, pigmentations in *Ephestia*.
(Chapter 9: Klug and Cummings; Chapter 20: Gardner, Simmons and Snustad)

Unit 6: Polygenic Inheritance 3hrs

Polygenic inheritance with suitable examples and numerical based on it.
(Chapter 23: Klug and Cummings; Chapter 21: Gardner, Simmons and Snustad; Chapter 22:
Benjamin A. Pierce)

Unit 7: Recombination in Bacteria and viruses 9 hrs

Conjugation, Transformation, Transduction in bacteria, Complementation test in Bacteriophage
(Chapter 6: Klug and Cummings; Chapter 8: Benjamin A. Pierce; Chapter 7: Snustad and Simmons; Chapter 8: Gardner, Simmons and Snustad)

Unit 8: Transposable Genetic Elements 8hrs

Transposons in bacteria, Ty elements in yeast, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in humans.
(Chapter 15: Klug and Cummings; Chapter 11: Benjamin A. Pierce; Chapter 17: Snustad and Simmons; Chapter 16: Russell; Chapter 16: Griffith)

Practical [Credits: 2]

1. To study the Mendelian laws and gene interactions.
2. Chi-square analyses using seeds/beads/*Drosophila*.
3. Linkage maps based on data from conjugation, transformation and transduction.
4. Linkage maps based on data from *Drosophila* crosses.
5. Study of human karyotype (normal and abnormal).
6. Pedigree analysis of some human inherited traits.

Teaching and Learning Process:

Lectures, using blackboard and power-point presentations will be delivered by the teachers and the queries of students will be addressed after they have revised the topic. Concepts can be clarified by giving assignments e.g. constructing linkage maps, pedigree analysis, probability calculations etc. As a part of peer learning, regular group discussions will be held

amongst the students to enhance their knowledge. In order to develop scientific temperament and hone communication skills of students, power point presentations, paper presentations and debates can be organized on various themes as prescribed in the syllabi, while focusing on the latest development in them. An essential part of learning is through observation and experimentation. Thus, visit of students to laboratories working in the field of Genetics (e.g. *Drosophila*, microbial genetics) can be organized. Also, students can be encouraged to undertake internships in these labs so as to deepen their interest in this field. Lectures of researchers can be organized to update students about the latest developments in this field, so that they get motivation to make a career in this highly versatile field of biological sciences.

Assessment Methods:

Students can be assessed by following methods for proper understanding of the subject.

- Problem solving assignments.
- Assessment of case history projects to prepare pedigrees and find out the probabilities of occurrence of diseases in next generations.
- Power point presentation evaluation on different topics.
- Holding debates and assessment for understanding of the subject.
- Multiple choice questions (Test) for assessing grasping of the topics.
- Laboratory visits to understand the research going on in the field of Genetics and to submit reports.

Keywords:

Mendelian inheritance, Multiple alleles, Penetrance, Epistasis, Pleiotropy, Gene, Chromosomal mapping, Recombination, Interference, Mutagens, chromosomal aberrations, Sex determination, Dosage compensation, Nuclear inheritance, Mitochondrial inheritance, Polygenic inheritance, Complementation, Transposons, Ty elements, Ac-Ds elements.

Recommended Books:

- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons In.
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cumming
- Pierce B. A. (2012). Genetics-A Conceptual Approach. IV Edition. W. H. Freeman and Company

Suggested Readings:

- Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition. Benjamin Cummings
- Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co.
- Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4922-genetics-and-genomics
- https://www.coursera.org/learn/genetics-evolution
- https://onlinelearning.hms.harvard.edu/hmx/courses/hmx-genetics/
- https://learn.genetics.utah.edu/

Core Course-XIII: Developmental Biology

Course Learning Objective:

The main aim of the paper on Developmental Biology is to provide the undergraduate students an in-depth knowledge on the embryonic and post embryonic developmental processes. An important aspect of developmental biology is its implication in medicine which is also dealt with in this course. The approach of this paper is to make the students realize the most fascinating aspect of developmental biology that a single fertilized egg can give rise to a fully developed complex organism. The course explains the basic principles and concepts underlying the developmental processes at the cellular and molecular level. To understand morphogenesis, the students are introduced to model organisms like Sea urchin, *Drosophila,* Frog and Chick to study different types of eggs, cleavage patterns and various morphogenetic movements during gastrulation leading to formation of germ layers and their fate. By understanding the developmental processes, the students can relate to errors occurring during development leading to congenital disorders and human diseases. The paper also addresses the problems of infertility in humans. The students are familiarized with the technique of IVF and pre-diagnostic methods to identify any abnormality arising during development. The students are made aware of the areas of great interest including stem cell therapy, tissue engineering and regenerative medicine.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Understand the events that lead to formation of a multicellular organism from a single fertilized egg, the zygote.
- Acquire basic knowledge of the cellular processes of development and the molecular mechanisms underlying these.
- Describe the general patterns and sequential developmental stages during embryogenesis; and understand how the developmental processes lead to establishment of body plan of multicellular organisms.
- Discuss the general mechanisms involved in morphogenesis and to explain how different cells and tissues interact in a coordinated way to form various tissues and organs.
- Understand about the evolutionary development of various animals.
- Know the process of ageing leading to interventions that can improve the overall health and quality of life in aged people.
- Learn the importance of latest techniques like stem cell therapy, *in vitro* fertilization and amniocentesis etc. to be applied for human welfare.
- Develop the skill to raise and maintain culture of model system; *Drosophila* in the laboratory.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Introduction 4 hrs

Historical perspective and basic concepts: Phases of development, cell-cell interaction, pattern formation, differentiation and growth, differential gene expression, cytoplasmic determinants and asymmetric cell division

(Chapter 1: Gilbert, S.F.; Chapter 1: Balinsky, B.I.; Chapter 1: Wolpert, L.)

Unit 2: Early Embryonic Development 26 hrs

Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers

(Chapter 4, 5, 7 and 8: Gilbert, S.F.; Chapter 2and 10:Balinsky, B.I.;Chapter 7 and 9:Slack, J.M.W.)

Unit 3: Late Embryonic Development 10 hrs

Fate of Germ Layers; Formation of neural tube, Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta) *(Chapter 8 and 9: Gilbert, S.F.; Chapter 10: Balinsky, B.I.; Chapter 9 and10: Slack, J.M.W.)*

Unit 4: Post Embryonic Development 11 hrs

Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories
(Chapter 15: Gilbert, S.F.; Chapter 18 and 19: Balinsky, B.I.)

Unit 5: Implications of Developmental Biology 9 hrs

Teratogenesis: Teratogenic agents and their effects on embryonic development; *in vitro* fertilization, Stem cell (ESC), Amniocentesis.
(Chapter 17: Gilbert, S.F.)

Practical [Credits: 2]

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak)-13 hours, Stage 4 (Definitive Streak)-18 hours, Stage 5 (Head Process)-21 hours, Stage 7-24 hours, Stage 8-28 hours, Stage10-33 hours, Stage 11-40 hours, Stage 13-48 hours, Stage 19-72 hours and Stage 24-96 hours of incubation
3. Demonstration of culture of chick embryo from fertilized eggs to study various developmental stages.
4. Study of the developmental stages and life cycle of *Drosophila* from stock culture.
5. Study of different sections of placenta (photomicrographs/ slides).
6. Project report on *Drosophila* culture/chick embryo development.

Teaching and Learning Process:

Various teaching methodologies including: interactive lectures, classroom discussions and practical exercises based on the theory paper will be employed. Video digital format will be adopted to supplement theoretical lessons and lectures presented in the classroom to stimulate discussion and increase learning. Students will be encouraged to access the e-learning resources like Swayam, Coursera etc. so that the concepts are better understood of the topics of developmental biology. Permanent slides/ photomicrographs/animations will be used for better understanding of the development processes. Educational trips such as visit to a poultry farm and dairy research institute will be conducted to enhance their understanding of the theoretical concepts. Embryological models will be employed to understand difficult concepts and relationships in development. Students can be encouraged to undertake project work

on maintaining culture of *Drosophila* to observe its life cycle. Fertilized eggs of chick obtained from poultry farm can be incubated in the laboratory to study the developmental stages. Students can be motivated to engage themselves in informal discussions on various topics outside the classroom. Topics of developmental biology can be assigned for presentation so that the students improve their oral skills. The students should be encouraged for thorough self-study by encouraging them to refer to different books and on-line resources.

Assessment Methods:

- Series of tests consisting of short answer questions prepared throughout the semester related to the theory lectures.
- Group assessment of the students distributed in small groups (3-4 students) to carry out projects prepared throughout the semester.
- Continuous assessment of the students including marks for attendance, assignments and class tests.
- Level of understanding and ability to answer questions by taking *viva-voce* as a part of practical exam assessment.
- Evaluation of practical records, assignments and power point presentations.

Keywords:

Differentiation, Cytoplasmic determinants, Morphogens, Gametogenesis, Ovulation,

Vitellogenesis, Graafian follicle, Embryo, Fertilization, Cleavage, Blastula, Gastrula, Epiboly, Emboly, Koller's Sickle, Organogenesis, Notogenesis, Somites, Neurula,

Embryonic Induction, Placenta, Metamorphosis, Neoteny, Regeneration, Epimorphosis, Morphallaxis, Blastema, Ageing, Senescence, Teratology, Teratogens, Stem Cells, *IVF*

Recommended Books:

- Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA
- Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition, International Thompson Computer Press.
- Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell.

Suggested Readings:

- Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.
- Kalthoff, K. (2001).Analysis of Biological Development. II Edition, McGraw Hill Publishers.
- Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.
- Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand & Company

Online Tools and Web Resources:

- https://www.hhmi.org/biointeractive/human-embryonic-development
- https://www.khanacademy.org/science/biology/developmental-biology
- https://ocw.mit.edu/courses/biology/7-22-developmental-biology-fall-2005/index.htm
- https://embryology.med.unsw.edu.au/embryology/index.php/Main_Page

Core Course XIV: Evolutionary Biology

Course Learning Objective:

The study of evolutionary biology is essential for anyone who seeks to obtain an understanding of life and natural world. It is a unifying thread which joins all organisms from prokaryotes to highest of eukaryotes. This course emphasizes on the development of evolutionary thought by dealing in general with the process and pattern of biological evolution. On one hand, it offers a chance to students to learn about deciphering evidences ranging from fossil records to molecular data and arranges them to establish phylogenetic relationships of species, while, on the other, it provides a platform to understand various forces which bring about variations among populations of a species and cause them to diversify into new species.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Acquire problem solving and high order analytical skills by attempting numerical problems as well as performing simulation studies of various evolutionary forces in action.
- Apply knowledge gained, on populations in real time, while studying speciation, behaviour and susceptibility to diseases.
- Gain knowledge about the relationship of the evolution of various species and the environment they live in.
- Get motivated to work towards mitigating climate change so that well adapted species do not face extinction as a result of sudden drastic changes in environment.
- Use knowledge gained from study of variations, genetic drift to ensure that conservation efforts for small threatened populations are focused in right direction.
- Predict the practical implication of various evolutionary forces acting on the human population in the field of human health, agriculture and wildlife conservation.
- Use various software to generate interest towards the field of bioinformatics and coding used in programming language

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Life's Beginning 7 hrs

Chemogeny, RNA World, Biogeny, Origin of photosynthesis, Evolution of eukaryotes

(Chapter 6- 9: Hall and Hallgrimson)

Unit 2: Historical Review of Evolutionary Concepts 4 hrs

Lamarckism, Darwinism, Neo-Darwinism

(Chapter 22: Campbell and Reece; Chapter 10 and 11: Hall and Hallgrimson)

Unit 3: Evidences of Evolution 12 hrs

Palaeontological: Fossils (formation, types and dating); Geological time scale; Study of horse

phylogeny; Molecular: neutral theory of molecular evolution, Molecular clock, Example of globin gene family, rRNA/cyt c; Phylogenetic trees: types, interpretation and applications

(Chapter 3: Hall and Hallgrimson; Chapter 18: Ridley; Chapter 7: Pevsner)

<u>Unit</u> 4: Raw material for Evolution

Variations: Heritable variations and their role in evolution

(Chapter 4: Ridley; Chapter 4: Futuyama and Kirkpatrick)

6 hrs

Unit 5: Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection. Genetic Drift (mechanism, founder's effect, bottleneck phenomenon; Role of Migration and Mutation in changing allele frequencies
(Chapter 4 and 5: Ridley; Chapter 10, 12 and 13: Futuyama and Kirkpatrick)

Unit 6:
Product of evolution: Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches **ntitative studies**

6 hrs

(Chapter 5 and 7: Ridley; Chapter 23: Campbell and Reece)

Unit 7: Extinctions, Back ground and mass extinctions (causes and effects), detailed example of K-T extinction
(Chapter 3, 13 and14: Ridley)

Unit 8: 3 hrs

Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular analysis of human origin

Unit 9:
Phylogenetic trees, Multiple sequence alignment, construction of phylogenetic trees, interpretation of trees 6 hrs
(Chapter 25: Hall and Hallgrimson; Chapter 21: Futuyama and Kirkpatric)

Practical [Credits: 2]

1. Study of fossils from models/ pictures
2. Study of homology and analogy from suitable specimens
3. Study and verification of Hardy-Weinberg Law by chi square analysis
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies
5. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.
6. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip, NJ) and its interpretation

Teaching and Learning Process:

The traditional pedagogical methods employed in the field of evolutionary biology, while building up on the information base of the students, do little to invoke a deep understanding of the various forces, mechanisms and results of evolutionary process. To inculcate a pattern of thinking which is inquisitive, scientific and focuses on seeking relationships between various cause and effects, a constructive methodology of teaching is required. While traditional lectures will be the foundation stone and walls of the teaching process, the learning process will be accentuated by providing visual stimulus through presentations which show pictorial evidence of evolution (fossils) and wildlife movies which focus on topics like sexual selection and kin selection. Regular group discussions amongst the students will enhance the learning to a great extent. Organising workshops and seminars, where eminent scientists working in the field of evolution are invited, will be a major step to draw attention of students towards the various possibilities in this field of biological science.Visits to laboratories working in the field of evolution (e.g. microbial evolution) can be very fruitful for the young

learners. The saying “Nature is the best teacher” holds truest, for the science of Evolutionary Biology. One of the most important aspects of learning will be covered when field visits are organised for students to observe and study phenomenon like adaptive mimicry. A field visit to any Natural History Museum or any Geology lab having a collection of fossils is a must to inculcate a deeper understanding of the subject. While, field visits will definitely benefit the students, equal, if not more benefit will be accrued by the use of Information and Communication Technology (ICT). On one hand, students will be able to gain information about all the studies being done in this field, while on the other, they can learn to use a number of programs for establishing phylogenetic relationship between organisms. Various computer programs which offer simulation of evolutionary forces like genetic drift, natural section etc. can be used to enhance the learningilaboratoryexercises.

Keywords:

Chemogeny, RNA World, Darwinism, Neo Darwinism, Fossils, Molecular Evolution, Phylogenetic Trees, Variations, Natural Selection, Mutation, Migration, Genetic Drift, Speciation, Isolating Mechanisms, Mass Extinctions, Human Evolution

Recommended Books:

- Ridley, M. (2004). Evolution. III Edition, Blackwell publishing
- Hall, B.K. and Hallgrimson, B. (2013). Evolution. V Edition, Jones and Barlett Publishers.
- Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.

Suggested Readings:

- Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition, Wiley-Blackwell
- Campbell, N.A. and Reece J.B. (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.

Online Tools and Web Resources

- https://www.coursera.org/learn/molecular-evolution
- https://www.coursera.org/learn/genetics-evolution

https://swayam.gov.in/courses/4062-environmental-biology-genetics-and-evolution

DSE Course-I Fish and Fisheries

Course learning Objective:

Fisheries involve study of both, capturing and culturing of fish. India is a peninsular country with a huge coastline and large inland water bodies. Assisted with such ideal geographical location our nation has outstanding accomplishments in Fish and fisheries. Globally, India is ranked second in Aquaculture and 3rd in Fisheries. In an evolutionary sense, the most successful of the larger aquatic animals are the fishes that are hunted commercially. About 64% of the global marine catch comes from the Pacific Ocean, 28% comes from the Atlantic and 8% from the Indian Ocean. Marine fisheries is a multibillion-dollar industry that is able to fulfil about 20% of the total animal protein requirement of humans, and also produce animal feeds for domestic livestock and poultry, fish oils (for paints and drugs, pet foods) and some food additives. For the increasing human population, there is continuous increase in the demand for high-quality protein. To meet these demands, it is necessary to focus attention on the current stocks from marine as well as freshwater species and create opportunities to increase or at least maintain the amount of harvest. It has become apparent that fisheries management has not always been successful in maintaining fish yields and conserving stocks. This course has been designed to equip the student with a balanced and complete scientific understanding of fisheries concepts.

Course Learning Outcome:

After completion of the course the students will be able to:

- Acquire knowledge of physiology, reproduction of fishes.
- Analyse different kinds of water and identify/differentiate different kinds of fishes.
- Procure pure fish seed by artificial procedures such as artificial and induced breeding which can learn by visiting any fish farm or demonstrated in research labs in college/Departments
- Become aware and gain knowledge of In-land and marine Fisheries in India and how it contributes to Indian economy.
- Know about different kinds of fishing methods and fish preservation which can be employed for export and storage of commercial fishes.
- Find the reasons behind the depletion of fisheries resources.
- Develop skills for entrepreneurship or self-employment in their own fisheries-related business.

Course Content:

Theory [Credits: 2] **60 hrs**

Unit 1: Introduction and Classification 6 hrs

General description of fish; Account of systematic classification of fishes (upto classes); Classification based on feeding habit, habitat and manner of reproduction.
(Chapter 1 and 8: Jhingaran; Chapter 18: Norman; Chapter 18: Shrivastava)

Unit 2: Morphology and Physiology 18 hrs

Types of fins and their modifications; Locomotion in fishes; Hydrodynamics; Types of Scales, Gills and gas exchange; Swim Bladder: Types and role in Respiration, buoyancy; Osmoregulation in Elasmobranchs; Reproductive strategies (special reference to Indian fishes); Electric organs; Bioluminiscience; Mechanoreceptors; Schooling; Parental care; Migration
(*Chapter 2, 3, 4, 5, 8, 10, 13, 14 and 15: Norman)*

Unit 3: Fisheries 12 hrs

Inland Fisheries; Marine Fisheries; Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal; Fishing crafts and Gears; Depletion of fisheries resources; Application of remote sensing and GIS in fisheries; Fisheries law and regulations

(*Chapter 4 and 21: Jhingaran; Chapter 19: Norman; Chapter 3, 13 and 14: Shrivastava)*

Unit 4: Aquaculture 20 hrs

Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of fish; Management of finfish hatcheries; Preparation and maintenance of fish aquarium; Preparation of compound diets for fish; Role of water quality in aquaculture; Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish, Fishery by-products.

(*Chapter 8, 9, 10, 12, 16, 19 and 20:Jhingaran; Chapter 20: Norman: Chapter 9, 10 and 15:*
Shrivastava)

Unit 5:Fish in Research 4 hrs

Transgenic fish, Zebra fish as a model organism in research.

(*Chapter 17 Shrivastava)*

Practical [Credits: 2]

1. Morphometric and meristic characters of fishes
2. Study of *Petromyzon*, *Myxine*, *Pristis*, *Chimaera, Exocoetus*, *Hippocampus*, *Gambusia, Labeo, Heteropneustes, Anabas*
3. Study of different types of scales (through permanent slides/ photographs).
4. Study of crafts and gears used in Fisheries
5. Water quality criteria for Aquaculture: Assessment of pH, conductivity, Total solids, Total dissolved solids
6. Study of air breathing organs in *Channa, Heteropneustes, Anabas* and *Clarias*
7. Demonstration of induced breeding in Fishes (video)
8. Demonstration of parental care in fishes (video)
9. Project Report on a visit to any fish farm/ pisciculture unit/Zebrafish rearing Lab.

Teaching and Learning Process:

There would be a teacher-centered lecture sessions, where students can take notes or absorb information and interact with the teacher. The teacher/student-based lessons would be supported by multimedia presentations (videos/animations). Visit to Field, Fisheries institutes, laboratory or Aquatic research institutes would be useful to students for better understanding of the subject.

Assessment Methods:

- Formative assessment to analyze student's performance during instruction on regular basis throughout the instruction process.
- Summative Assessment to measure a student's achievement at the end of instruction.
- Written tests to analyze their intake on taught lectures.
- Inspiringthe students to give talks through power point presentations/submit assignments with emphasis on recent studies in Fish and Fisheries.

Keywords:
Fish Classification, Fish physiology, Reproduction, Fisheries, Aquaculture, Transgenic fish

Recommended Books:
- Srivastava, C.B.L. Fish Biology. Narendra Publishing House.
- Jhingran, V.G. (1982) Fish and Fisheries in India. Hindustan publication Cooperation, India.

Suggested Readings:
- Pandey, K. and Shukla, J.P. (2013) Fish and Fisheries. Rastogi publication, India
- Norman, J.R. A History of Fishes. Hill and Wang Publishers.
- Khanna, S.S. and Singh, H.R. A text book of Fish Biology and Fisheries. Narendra Publishing House.
- Bone,Q. and Moore, R. Biology of Fishes. Talyor and Francis Group, CRC Press, U.K.

DSE Course-II: Wildlife Conservation and Management

Course Learning Objective:
The Discipline Specific Paper on Wildlife Conservation and Management is designed to acquaint students with varied aspects of wildlife conservation, including its importance, major threats, management of their habitats and populations. The emphasis will be on developing interest and invoking a sense of responsibility among students towards wildlife conservation. The course also explores different techniques, perspectives, and approaches to both identify and achieve wildlife management goals. This course will motivate students to pursue career in the field of wildlife conservation and management.

Course Learning Outcome:
Upon completion of the course, students will be able to:
- Become aware about the importance of wildlife in general, and its conservation and management in particular.
- Comprehend the application of the principles of ecology and animal behaviour to formulate strategies for the management of wildlife populations and their habitats.
- Understand the management practices required to achieve a healthy ecosystem for wildlife population along with emphasis on conservation and restoration.
- Knowthe key factors for loss of wildlife and important strategies for their *in situ* and *ex situ* conservation.
- Recognize the techniques for estimation, remote sensing and Global Position Tracking for wildlife.
- Gain knowledge about the wildlife diseases and the quarantine policies.
- Know about the Protected Area Networks in India, Ecotourism, Ecology of perturbation and Climax persistence.
- Perform critical thinking, literature review; scientific writing as well as presentations; and participation in citizen science initiatives with reference to wildlife.

Course Content:

Theory [Credits: 4] **60hrs**

Unit 1: Introduction to Wildlife 6hrs

Values of wildlife - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies: WCS, CBD, Agenda 21

(Chapter 1, 2, 3 and 10: Singh; Chapter 1 and 3: Saha and Mazumdar)

Unit 2: Evaluation and Management of Wildlife 10hrs

Habitat analysis: a) Physical parameters: Topography, Geology, Soil and water; b) Biological
Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS. *(Chapter 2, 11 & 12: Sutherland; Chapter 6: Singh; Chapter 6: Saha and Mazumdar)*

(Chapter 2, 11 & 12: Sutherland; Chapter 6: Singh; Chapter 6: Saha and Mazumdar)

Unit 3: Management of Habitats 10hrs

Setting back succession: Grazing logging; Mechanical treatment; Advancing the successional
process: Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats.
(Chapter 11 & 12: Sutherland; Chapter 6: Singh)

Unit4: Population Estimation 12 hrs

Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, and Hair identification; Pug marks and Census methods
(Chapter 2 & 4: Sutherland; Chapter 8 and 9: Singh; Chapter 6: Saha and Mazumdar)

Unit5: Management Planning of Wildlife in Protected Areas 8hrs

Estimation of carrying capacity; Human-wildlife conflict; Eco tourism / wild life tourism in forests; Climax communities: characteristics and theories; Ecology of purterbance.
(Chapter 9: Sutherland; Chapter 1: Woodroff; Chapters 8 and 11: Singh; Chapter 9: Saha and Mazumdar)

Unit6: Management of Excess Population 6hrs

Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and Mouth Disease, *Mycobacterium* TB, Bovine and Avian Flu
(Chapters 6, 7 and 11: Saha and Mazumdar)

Unit:7 Protected Areas 8hrs

National parks and sanctuaries; Biosphere reserves; Conservation and Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India and Management challenges in Tiger reserve
(Chapters 11 and 12: Singh; Chapters 3 and 9: Saha and Mazumdar)

Practical [Credits: 2]

1. Identification of mammalian fauna, avian fauna, herpeto-fauna through direct and indirect evidences seen on a field trip to a wildlife conservation site.
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System,Various types of Cameras and lenses).
3. Familiarization and study of animal evidences in the field: Identification of animals through pug marks, hoof marks, scats, nests and antlers.
4. Demonstration of different field techniques for flora and fauna: PCQM.
5. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
6. Identification of big cats: Lion, tiger, panther, cheetah, leopard and jaguar.

7. A report based on a visit to National Park/Wildlife Sanctuary/Biodiversity Park or any other wildlife conservation site.

Teaching and Learning Process:

The case study approach with real-life examples from the field will give a better understanding of the subject and its applications.The traditional chalk and talk method will be supplemented with LCD projection system and use of visualizer for theory classes. Projection of videos or short movies available on the subject will enhance the understanding of the subject. Digital collection of pictures of pugmarks, hoof marks, bird's nests, wild fauna and flora will facilitate observation of their characteristic features with ease.Group discussions, book reviews, paper presentations, videos, animations, are some methods that can be employed for effective teaching. Project based reports, assignments and E-posters can also form an important part of learning regime.Field-based research projects will develop interest in the subject and motivate students to peruse research as a career in
future.Laboratory visits to renowned institutions like WII, Dehradun and Field visits to various conservation sites like Jim Corbett National Park, Aravali Biodiversity Park and National Zoological Park will provide students a practical or hands on knowledge of the subject.Students should participate in citizen science initiatives related to wildlife such as bird counts and uploading of the data on E-bird.org.

Assessment Methods:

Students will be assessed using the following methods:

- Formative/ Continuous assessment: This will be done through problem solving exercises, oral and written examinations, closed-book and open book tests, practical assignment laboratory reports, observation of practical skills, individual project reports, seminar presentation, viva voce interviews, computerized adaptive testing, literature surveys and evaluations, outputs from collaborative work etc. to assess the retention abilities of students.
- Summative assessment: Semester-end written and practical examinations will be an indicator of student's learning throughout the semester and analyses comprehensive knowledge gained by the students.

Keywords:

Wildlife, Conservation, Management, Population, Habitat, Succession, Climax, Quarantine, Tiger Project, National Park, Wildlife Sanctuaries, Biodiversity Reserves, Wildlife Diseases, Protected Areas

Recommended Books:

- Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd. ISBN: 8120353137, 978-812035313
- Sinclair, A.R.E., Fryxell, J.M. and Caughley,G. (2006). Wildlife Ecology, Conservation and Management. Wiley-Blackwell, Oxford, UK.
- Singh, S.K. (2005). Text Book of Wildlife Management. IBDC, Lucknow.

Suggested Readings:

- Hudson, P.J., Rizzoli, A., Grenfell, B.T. Heestrbeek, H. and Dobson, A.P. (2002). The Ecology of Wildlife Diseases. Oxford University Press, Oxford.
- Banerjee, K. (2002). Biodiversity Conservation in Managed and Protected Areas. Agrobios, India.

- Sharma, B.D. (1999). Indian Wildlife Resources Ecologyand Development. Daya Publishing House, Delhi.
- Primack, R.B. (1998). Essentials of Conservation Biology. Sinauer Associates, Inc. Sunderland, MA.
- Hossetti, B. B. (1997). Concepts in Wildlife Management. Daya Publishing House, Delhi.

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4687-july-2018-wildlife-conservation
- https://swayam.gov.in/courses/5364-jan-2019-wild-life-ecology
- https://papaco.org/mooc-on-species-conservation/
- https://www.iucn.org/theme/protected-areas/our-work/capacity-development/moocs
- https://www.zsl.org/united-for-wildlife-free-conservation-courses
- https://wildlife.org/next-generation/career-development/online-courses/

https://www.openlearning.com/umtmooc/courses/wildlife-management

DSE Course-III: Immunology

Course Learning Objective:

The aim of the course in immunology is to apprise the student with the working of the immune system in normal health and how it fights the disease and may sometimes contributes to disease. The immune system is incredibly complex. This course is hence designed to enable understanding the molecular and cellular basis of the development and function of the immune system and identification of its biological, clinical and therapeutic implications.

Course Learning Outcome:

After completion of the course the students will be able to:

- Describe the basic mechanisms, distinctions and functional interplay of innate and adaptive immunity
- Define the cellular/molecular pathways of humoral/cell-mediated adaptive responses including the role of Major Histocompatibility Complex
- Explain the cellular and molecular aspects of lymphocyte activation, homeostasis, differentiation, and memory
- Understand the molecular basis of complex, humoral (Cytokines and Complement)and cellular processes involved in inflammation and immunity, in states of health and disease
- Describe basic and state-of-the-art experimental methods and technologies
- Integrate knowledge of each subsystem to see their contribution to the functioning of higher-level systems in health and disease including basis of vaccination, autoimmunity, immunodeficiency, hypersensitivity and tolerance

Course Content:

Theory [Credits: 4] **60 hrs**

Unit1: Overview of Immune System 10 hrs

Historical perspective of Immunology, Early theories of Immunology, Clonal Selection Theory, Cardinal features of vertebrate immune system, Hematopoiesis, Cells and organs of the Immune system.
(Chapter 1, 2: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit2: Innate and Adaptive Immunity 10 hrs

Anatomical barriers, Inflammation, Cell and molecules involved in innate Immunity, Adaptive Immunity (Cell-mediated and Humoral), Passive immunity; Active: Artificial and natural Immunity, Immunological Tolerance
(Chapter 1, 3 and 16: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit 3: Antigens 8 hrs

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes
(Chapter 4: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit4: Immunoglobulins 10 hrs

Structure and functions of different classes of immunoglobulins, Antigenic determinants on Immunoglobulins, Antigen-antibody interactions (Precipitation reactions, Agglutination reactions, Immunofluorescence and ELISA), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis

Chapter 4 and 6: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit 5: Major Histocompatibility Complex 4 hrs

Structure and functions of MHC molecules (MHC I and II), Endogenous and exogenous pathways of antigen processing and presentation
(Chapter 8: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit6: Cytokines 3 hrs

Properties and functions of cytokines
(Chapter 12: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit7: Complement System 4 hrs

Components and pathways of complement activation, Biological consequences of complement activation
(Chapter 7: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit8:Hypersensitivity 4 hrs

Gell and Coombs' classification and various types of hypersensitivities
Autoimmunity: Brief account with reference to Hashimoto's Thyroiditis (Organ Specific) and Rheumatoid arthritis (Systemic).Immunodeficiency: Brief account with reference to SCID (Primary) and AIDS (Secondary)

Unit9: Vaccines 7 hrs

Various types of vaccines
(Chapter 19: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

(Chapter 9: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Practical [Credits 2]

1. Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/photographs.
3. Preparation of stained blood film to study various types of blood cells.
4. ABO Blood group antigen determination by heamagglutination
5. Demonstration of:
   (a) ELISA
   (b) Immunoelectrophoresis

Teaching and Learning Process:

The course on immunology has been structured to develop the requisite knowledge, skills and learning attitude of the student. The process is extremely student-oriented and includes details of cells and organs of the system, antigens, antibodies, autoimmunity, immunodeficiency, hypersensitivity and other important aspects. The practical exercises are accordingly designed to enhance the interest of the students.A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, problem-based

learning, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this.

DSE Course-IV Biology of Insecta

Course Learning Objective:

Insects form over 70% of the faunal population on the earth. They have inhabited the earth for over 450 million years. They are the most diverse group of organisms occupying nearly all niches except for the deep sea. Learning of Morphology and Physiology of the Insects gives an overview of one of the best body designs which have survived on the earth.

Course Learning Outcome:

After completion of the course, the students will be able to:

- Appreciate the diversity of insects.
- Understand the physiology of Insects which has made them the most successful animals in terms of numbers and variety of species.
- Get a glimpse of the highly organized social life of insects.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Introduction 8 hrs

General Features of Insects; Basis of insect classification; Classification of insects up to orders; Elementary knowledge of collection, preservation and culture techniques of insects *(Chapter 1: Gullan, P. J., and Cranston, P. S.; Chapter 1 and 2: Atwal, A.S.; Vol 2; Part III: Imms, A. D.)*

Unit 2: General Morphology of Insects 8 hrs

Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits; Thorax: Wings: Typical structure of insect wing and its modifications, Types of Legs adapted to diverse habitat; Abdomen: Typical structure

(Chapter 1,8,9,10,14 and 27: Chapman RF.; Chapter 4 and 5: Imms, A. D.)

Unit 3: Physiology of Insects 30 hrs

Structure and physiology of Insect body systems (wrt cockroach)–Integumentary (structure of integument & process of moulting), digestive, excretory, circulatory, respiratory, reproductive, and nervous system; Metamorphosis: Types & hormonal control.

(Chapter 2, 9, 12, 13, 14, 15, 17 and 19: Imms, A. D. (Vol I); Chapter 3, 15, 20, 21, 22, 23, 25, 26 and 32: Chapman RF.)

Unit 4: Insect Behaviour 6 hrs

Social organization in insects – honey bees, termites, Insect Plant Interaction: Host-plant selection by phytophagous insects.

(Chapter 5 and 6: Wilson, E. O.; Chapter 4: Bernays, E. A., and Chapman, R. F.)

<u>Unit 5</u>: Insects as plant pests 6 hrs

Bionomics and control of following plant pests: Agricultural pests (*Papiliodemoleus, Leucinodes orbonalis, Spodop teralitura)*; Stored grain pests (*Calloso bruchuschinensis, Corcyra cephalonica, Sitophilus* oryzae)*(Chapter 10, 11, 18 and 19: Atwal, A.S.; Chapter 7: Dennis, S. Hill.)*

Practical [Credits: 2]

1. Study of one specimen from each insect order
2. Study of different kinds of antennae, legs and mouth parts of insects
3. Study of head and sclerites of any one insect
4. Study of insect wings and their venation
5. Study of insect spiracles
6. Methodology of collection, preservation and identification of insects
7. Morphological studies of various castes of *Apis, Camponotus* and *Odontotermes*
8. Field study of insects and submission of a project report on the insect diversity

Teaching and Learning Process:

Classroom lectures using Power point presentations enabled with related photographs of insect vectors will clarify the concepts related to insects. Group discussions on various unique physiological processes in Insects will develop interest among students to pursue higher studies in the field.Observations based on actual handling of insects and their body parts, visits to observe insects in their natural environment and entomology museum will develop curiosity among learners about insect diversity

Assessment Method:

The learners/ students can be assessed in many different ways.

- Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation.
- Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc.
- Students would be provided feedback on their work with a view to improve their academic performance.
- From time to time, learners will be given practical problems and neuroimages to test their theoretical skills and promote practical knowledge.
- They would be provided feedback on their work with a view to improve their academic performance.

Keywords:

Insect, Vector, Diseases, Mosquito, Host, Parasite

Recommend Books:

- Imms, A. D. A.General Text Book of Entomology. Chapman & Hall, UK
- Chapman, R. F. The Insects: Structure and Function. Cambridge University Press, UK
- Snodgrass, R. E. Principles of Insect Morphology. Cornell Univ. Press, USA
- Borror, D. J., Triplehorn, C. A., and Johnson, N. F.Introduction to the Study of Insects. M Saunders College Publication, USA

Suggested Readings:

- Wilson, E. O. The Insect Societies. Harvard Univ. Press, UK
- Gullan, P. J., and Cranston, P. S. The Insects, An outline of Entomology. Wiley Blackwell, UK
- Nation, J. L. Insect Physiology and Biochemistry. CRC Press, USA

DSE Course-V Animal Biotechnology

Course Learning Objective:

Biotechnology is the advanced branch of biological sciences which mostly deals with technological application on biological systems. It is basically the management of biological processes for industrial and other human welfare purposes. The present

paper on biotechnology attempts to give a wholesome idea of biotechnology at a basic level. It provides a tool kit in the form of a number of various techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine. It will equip the students with basic tools of biotechnology which are a must for everyone interested in pursuing a career in biotechnology. It makes one aware of the scope of this field which encompasses almost every field of science like engineering, research, commercialization and academics.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Use or demonstrate the basic techniques of biotechnology like DNA isolation, PCR, transformation, restriction digestion etc.
- Make a strategy to manipulate genetic structure of an organism for the improvement in any trait or its well-being based on the techniqueslearned during this course.
- Understand better the ethical and social issues regarding GMOs.
- Use the knowledge for designing a project for research and execute it.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Introduction 3 hrs

Concept and scope of biotechnology

(Chapter 1: Glick, B.R., Pasternak, J.J. and Patten, C.L.)

Unit 2: BasicTools for Gene Manipulation 12 hrs

Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics). Restriction enzymes: Nomenclature, detailed study of Type II, DNA modifying enzymes. Transformation techniques: Calcium chloride method, electroporation and biolistic method. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization

(Chapter 3: Glick, B.R., Pasternak, J.J. and Patten, C.L; Chapter 2, 4, 6, 7 and 8: Brown, T.A.)

Unit 3: Advance Tools and Techniques 18 hrs

Southern, Northern and Western blotting DNA sequencing: Sanger method, Next generation sequencing (Illumina), Polymerase Chain Reaction, DNA Finger Printing and DNA micro array, Gene Editing Tools: Zinc finger nucleases (ZFNs), transcription activator-like effector-based nucleases (TALEN) and the clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system

(Chapter : Glick, B.R., Pasternak, J.J. and Patten, C.L Chapter 9, 10 and 16, Brown, T.A.)

Unit 4: Genetically Modified Organisms

Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection; Applications of transgenic animals: Production of pharmaceuticals,

production of donor organs, knock out mice.Production of transgenic plants: Agrobacterium-mediated transformation. Applications of transgenic plants: insect and herbicide resistant plants.

(Chapter 9, 16, 18, 19 and 21: Glick, B.R., Pasternak, J.J. and Patten, C.L; Chapter 15:

Brown, T.A.)

<u>Unit</u> 5: Applications of Genetic Engineering 9 hrs

Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia), Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy *(Chapter 9: Glick, B.R., Pasternak, J.J. and Patten, C.L; Chapter 13 and 14: Brown, T.A.)*

18 hrs

Practical [Credits: 2]

1. Genomic DNA isolation from *E.coli*
2. Plasmid DNA isolation (pUC 18/19) from *E.coli*
3. Demonstration of Restriction digestion of Plasmid/Lambda DNA.
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from calcium chloride method.
6. To demonstrate following techniques:
   (Optional) Southern/ Northern/Western blotting (Any one)
   PCR
   DNA fingerprinting
   DNA Sequencing (Sanger's Method)
7. Project report on animal cell culture OR on a visit to any biotechnology Institute

Teaching and Learning Process:

The students can have hands-on experience of basic biotechnology tools and can acquire jobs and internships in pharmaceutical companies directly after graduation and can also execute research in biotechnology. A problem-solving methodology should be employed in biotechnology education, which consists of four phases: design, production, evaluation and presentation. Various methods will be employed to make learning effective like tutorials, workshops, seminar, online assignments, questionnaires, simulation exercises and presentations. Evaluation elements in these methods will also serve to direct student learning.

Assessment Methods:

- Power Point presentation on any aspect of biotechnology instead of regular assignments.
- The project work would be assessed by the visiting examiner approved by the University.
- Students should execute one project of their choice or teacher may assign the project.
- The project report should be scanned for plagiarism check by freely available software. A soft copy of report should be mandatory.
- Semester-end and term-end examinations will carry the major assessment with regular check on students in the class.

Keywords:

Biotechnology, Gene manipulation, Vectors, Restriction Enzyme, Transformation, Blotting, Sequencing, Gene Editing, Trans-genesis, Recombinant DNA medicines, Bio-nano Technology, Gene Therapy

Recommended Books:

- Brown, T.A. (2010) Gene Cloning and DNA Analysis. VI Edition,Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
- Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA. ISBN: 978-1- 55581-498-4 (HC).
- Primrose, S.B., and Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics.VIIEdition, Blackwell publishing (Oxford, UK) ISBN: 13: 978-1-4051-3544-3.

Suggested Readings:.

- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007) Recombinant DNA-Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y., USA.
- Clark, D. P. and Pazdernik, N.J. (2012) Biotechnology,,Academic Press, ISBN: 978-0-12-385063-8

Online Tools and Web Resources:

- https://swayam.gov.in/courses/5178-molecular-biology-genetic-engineering-and-plant-tissue-culture Module no.:14to 21,23&24
- https://nptel.ac.in/courses/102103041/2Gene Therapy
- https://nptel.ac.in/courses/102103013/49Genetic Engineering& Applications(Web)
- https://nptel.ac.in/courses/102107058/6Biomedical nanotechnology (Video)
- https://nptel.ac.in/courses/102107028/40Analytical Technologies in Biotechnology (Video) Electrophoresis, PCR, DNA sequencing methods
- https://www.edx.org/course?search_query=biotechnology
- https://www.coursera.org/courses?query=biotechnology&

DSE Course-VI: Basics of Neuroscience

Course Learning Objective:

'Neuroscience' is the branch of biology that deals with the scientific study of the nervous system- its anatomy, physiology and pathology. It deals with how the brain works and how the cells interact to control behaviour, physiology and psychology of a person. Neuroscience has become a buzz word in recent times, frequently making the headline for all manner of discoveries. Tremendous advances in neuroscience have occurred in the past two decades. The present course content is designed to give the learner a better understanding of the structure of the nervous system, as to how it works, how we sense, feel, get motivated, behave, learn and remember things/ events. In this course, students will learn various aspects of neural phenomena such as cellular, molecular and neural basis of brain rhythms, behaviour, cognition, sensation, and motivation; mechanisms and functions of emotion; learning and memory; and aspects of synaptic plasticity. This undergraduate course also covers aspects of clinical neuroscience with the aim of educating the learner in the breadth of the subject and to encourage critical thinking and evaluation of evidence. This will help undergraduates to decide whether they would wish to pursue higher studies and research in the field of neuroscience. This course also covers the finer details of neurotransmitter release, synaptic plasticity, activation of ligand-gated ion channels, receptor-mediated modulation of neuronal excitability, neurotransmitter clearance etc. This will equip the learner with a detailed insight into how the membrane excitability elicits functional effects in individual neurons and in neuronal networks as a whole. In the same manner, abnormal transmitter release/clearance, altered ion channel properties etc. will also be studied to understand their role in diseases of the nervous system.

Course Learning Outcome:

On completion of this course, the learner should be able to:

- Understand major advances in neuroscience, neural basis of emotions, behaviour, learning and memory, and how brain and behaviour can be trained/modified by experience.
- Discuss how the hypothalamus controls various behavioural patterns by releasing neurohormones/ neuropeptides in brain and periphery in response to various signals.
- Construct neural mechanisms of learning and memory (spatial and episodic memory etc.) and how specific circuits contribute to learning and memory.
- Develop an understanding about cognition, mechanism of our reaction to various situations and impact of neurological diseases on cognition.
- Understand cellular and molecular mechanisms that underlie cognition such as synaptic plasticity and organisation of memory, memory persistence and forgetfulness, the role of sleep in cognition etc.
- Gain knowledge about prion-like mechanisms responsible for the pathogenesis of common neurodegenerative diseases such as Alzheimer's, Parkinson's diseases etc.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: The Nervous system- An Introduction 4 hrs

Origins of Neuroscience; Neuron doctrine; Classification of nervous system.

(Chapter 1: Kandel, E.R; Chapter 1: Mark F. Bear; Chapter 2: Mark F. Bear)

Unit 2: Development and Anatomical Organization of the Nervous System 12 hrs

Neural tube induction, neurulation and embryonic brain development; Gross anatomy of human brain, Meninges, Ventricular System, Blood Brain Barrier, Cranial nerves; Spinal cord; Overview of peripheral nervous system (PNS).
(Chapter 7: Mark F. Bear; Appendix B: Kandel, E.R)

Unit 3: Cellular and Molecular Neurobiology 14 hrs

The prototypical neuron and classification of neurons; Electrophysiology of membrane potentials- resting and action potentials, generation and propagation; Types of Synapses, synaptic transmission and integration; EPSPs and IPSPs. Ion channels; Concept of neural coding
(Chapter 2,3,4, 5 and Page 350: Mark F. Bear)

Unit 4:Neurotransmitters and Rhythms of brain 9 hrs

Types of neurotransmitters; Transmitter gated channels; G-protein coupled receptors and effectors, neurotransmitter receptors; Ionotropic and metabotropic receptors. Electroencephalogram (EEG); Sleep neurophysiology, neural mechanisms of sleep; Neurophysiology of affection and depression;
(Chapter 6: Mark F. Bear; Chapter 12: Kandel, E.R; Chapter 19: Mark F. Bear)

Unit 5: Systems and Behavioural Neuroscience 14 hrs

Neurobiology of Behaviour (Example: Language, Sexual Orientation); Neurobiology of Perception (Example: Visual perception); Molecular basis of Learning and Memory: Classification of memory, amnesia, case of H.M., synaptic plasticity, long-term potentiation (LTP), long-term depression (LTD), memory consolidation.
(Chapter 20: Mark F. Bear; Chapter 12: Kandel, E.R; Chapter 24 and 25: Mark F. Bear)

Unit 6: Neurobiology of Neurodegenerative diseases 7 hrs

Molecular pathogenesis of Parkinson's, Alzheimer's, and Schizophrenia.Molecular mechanism (pathogenesis) of Pain including Placebo effect and Phantom limbs.Dopamine and alcohol addiction.Use of PET, CT and MRI imaging for disease diagnosis.
(Chapter 2: Mark F. Bear; Chapter 43:Kandel, E.R; Chapter 14: Mark F. Bear; Chapter 22:
Mark F. Bear; Chapter 12: Mark F. Bear; Chapter 51: Kandel, E.R; Chapter 7: Mark F. Bear).

Practical [Credits: 2]

1. Study of *Drosophila* nervous system.
2. Observation and quantitation of *Drosophila* photoreceptor neurons
3. Study of Anatomy of Mammalian Brain (from slaughter house or) by using brain models (Plastic or clay medical anatomical teaching models, graphics, videos etc. can used).
4. Histological study of neurons and myelin sheath (Nissl, Giemsa or Luxol Fast Blue staining.)
5. Study of olfaction in *Drosophila*.
6. Study of novelty, anxiety and spatial learning in mice.
7. Histological study of cerebellum and spinal cord by H&E stain and cerebral cortex by Nissl stain.

Teaching and Learning Process:

'Teaching and learning' involves the process of channelizing the knowledge from the one who is *beholding* to the one who is *obtaining*. Student-centric teaching-learning process shall
be the *sine qua non* of any course. To move in that direction, students will be exposed to problem solving exercises, brain puzzles, elaborative quiz-based learning. Smart

classes and ICT-based teaching, including animation clips and videos, and attractive detailed pictures will be adopted. Online learning courses and practical exercises relevant to the subject will be incorporated.Organizing conferences and seminars where the students can participate in group-based learning and poster presentations will help students to clarify their concepts. Organizing visits to brain research institutes will give a glimpse of current research and techniques in neuroscience, and they will be motivated to take up mini-project works, group discussions etc.

Assessment Methods:

The learners/ students can be assessed in many different ways.

- Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation.
- Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc.
- Students would be provided feedback on their work with a view to improve their academic performance.
- From time to time, learners will be given practical problems and neuroimages to test their theoretical skills and promote practical knowledge.
- They would be provided feedback on their work with a view to improve their academic performance.

Keywords:

Neuroscience, Neurobiology, Action potentials, Learning & memory, Synaptic plasticity, Neurotransmitters, Cognitive, Neurodegenerative diseases, Alzheimer's disease, Parkinson's disease

Recommended Books:

- Mark F. Bear, Barry W. Connors and Michael A. Paradiso (2015). Neuroscience: Exploring the Brain. IV Edition.
- Kandel, E.R., Schwartz, J.H. and Jessell, T.M. (2000). Principles of Neural Science. IV Edition, McGraw-Hill Companies.

Suggested Readings:

- Stephan M. Stahl-CUP (2000) Essential Psychopharamacology- Neuroscientific Basis and Practical Applications. II Edition.
- Vilayanur S. Ramachandran and Sandra Blakeslee (1998). Phantoms in the Brain
- Rita Carter (2009). The Human Brain Book

Online Tools and Online Resources

- Introduction to Neuroanatomy. Coursera online course https://www.coursera.org/lecture/neurobiology/introduction-to-neuroanatomy-22nRY
- General principles of sensory system part 1 and 2. Coursera online courses

  www.coursera.org%2Flecture%2Fmedical-neuroscience%2Fgeneral-principles-of-sensory-systems-part-1-nwfLG,

  www.coursera.org%2Flecture%2Fmedical-neuroscience%2Fgeneral-principles-of-sensory-systems-part-2-g7uLG

- Online lectures on Swayam (MHRD) Portal:

  Demystifying the Brain. https://swayam.gov.in/courses/5361-jan-2019-demystifying-the-brain

  How The Brain Creates Mind. https://swayam.gov.in/courses/4451-how-the-brain-creates-mind

DSE Course-VII: Computational Biology

Course Learning Objective:

This course offers an overview of fundamental concepts of Bioinformatics and Biostatistics. An interdisciplinary program, it emphasizes integration of Computer Science with Biology and introduces the students to various computational methods and software tools for understanding biological databases, gene sequence alignments, gene annotation, protein structure predictions, drug discovery, molecular phylogeny, metagenomics, etc. The broad aim of this course is to make students get basic hands-on training and develop skill-set required for computational analysis of biological data. Recently many interest groups, such as governments, universities, research institutes and industries find Bioinformatics as a crucial area of research and development due to generation of large-scale genome sequencing data.In view of above, this course is designed to motivate the undergraduate students to pursue postgraduate program in Bioinformatics and Biostatistics.

Course Learning Outcome:

After completion of the course the students will be able to:

- Explain the basic concepts of Bioinformatics and Biostatistics and its various applications in different fields of biological sciences
- Describe theoretically sources of biological data, and list various biological databases – nucleic acids, protein sequence, metabolic pathways and small molecule
- Identify various file formats of sequence data and tools for submission of data in databases as well as retrieval of gene and protein data from databases
- Annotate gene sequence and protein structure prediction
- Perform and explain the underlying mechanisms of pair-wise and multiple sequence alignments and determine phylogenetic relationships
- Describe various computational tools and methodologies and their application in structural bioinformatics, functional genomics and *in silico* drug discovery
- Measure variability (standard deviation, standard error, co-efficient of variance) and hypothesis testing (Z-test, t-Test, chi-square test)

Course Content:

Theory [Credits: 4] **60 hrs**

Unit1: Introduction to Bioinformatics 5 hrs

Goal andScope; Genomics, Transcriptomics, Systems Biology, Functional Genomics, Metabolomics, Molecular Phylogeny; Applications and Limitations of Bioinformatics *(Chapter 1: Ghosh and Mallick)*

Unit2: Biological Databases 10 hrs

Introduction to biological databases; Primary, secondary and composite databases; Nucleic acid databases (GenBank, DDBJ, EMBL and NDB); Protein databases (PIR, SWISS-PROT, TrEMBL, PDB); Metabolic pathway database (KEGG, EcoCyc, and MetaCyc); Small molecule databases (PubChem, Drug Bank, ZINC, CSD)
(Chapter 3 and 4: Ghosh and Mallick; Chapter 8: Lesk)

Unit 3: Data Generation and Data Retrieval 12 hrs

Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA,

CG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)

(Chapter 2 and 3: Ghosh and Mallick, Chapter 9: Lesk)

Unit 4: Basic Concepts of Sequence Alignment 14 hrs

Scoring Matrices (PAM, BLOSUM), Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Local and global alignment, pair wise and multiple sequence alignments; Similarity, identity and homology of sequences

(Chapter 6: Ghosh and Mallick, Chapter 5: Lesk)

Unit 5: Applications of Bioinformatics 9 hrs

Structural Bioinformatics (3-D protein, PDB), Functional genomics (genome-wide and high-throughput approaches to gene and protein functions), Human genome and genome wide associationstudies(GWAS–basicconcepts),Drugdiscovery method(basic concepts).Machine Learning in Bioinformatics (basic concepts)

(Chapter 5 and 10: Ghosh and Mallick, Chapter 2 and 6: Lesk)

Unit 6: Biostatistics 10 hrs

Introduction: Measures of Variability, calculation of standard deviation, standard error and Co-efficient of Variance,Statistical errors, Confidence Intervals, Chi-square test, Z test, t-Test *(Chapter 3, 4, 7 and 8: Zar)*

Practical [Credits: 2]

1. Accessing different biological databases
2. Retrieval of nucleotide and protein sequences from the databases.
3. To perform pair-wise alignment of sequences (BLAST) and interpret the output
4. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences
5. Predict the structure of protein from its amino acid sequence.
6. To perform a "two-sample t- test"for a given set of data
7. To learn graphical representations of statistical data with the help of computers (e.g. MS Excel).

Teaching and Learning Process:

The students will be taught theory units of this course in classrooms while practical units in Computer Laboratory/ Centres in the College. In addition to blackboard, ICT-based teaching tools, videos, animation clips, hand-outs, flow charts will be also adopted for class room teaching. Computers/laptops with high speed internet facilities will be used for practical classes. Online demonstration of each practical units will be given by the Instructor. Students will save sequence data/snapshots of the steps followed for each practical unit. Laboratory record files will be prepared for each practical unit. Students will be encouraged to participate in group discussion, seminar presentation as well as visit to Institutes of Bioinformatics or joining research internship program. Students will be trained by problem solving exercises with their computational skills.

Assessment Methods:

The students will be assessed for their performance by different means:

- Both continuous and summative assessment will be made during entire semester. Continuous assessment of students will be based on their performance in class tests, assignments.

- Students will be also assessed on the basis of power-point presentation/black-board presentation on different units of theory paper
- Summative assessment will be based on semester-end examinations of theory and practical papers.

Keywords:

Bioinformatics, Computation, Genomics, Proteomics, System Biology, Biological database, Sequence alignment, BLAST, FASTA, NCBI, EMBL, EBI, Phylogenetic tree, Drug designing, Machine Learning.

Recommended Books:

- Ghosh, Z. and Mallick, B. (2008). Bioinformatics: Principles and Applications. Oxford University Press.
- Lesk M. Arthur (2014). Introduction to Bioinformatics. Oxford University Press.
- Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition, Wiley Blackwell.
- Zar, Jerrold H. (1999). Biostatistical Analysis. IV Edition, Pearson Education Inc and Dorling Kindersley Publishing Inc. USA

Suggested Readings:

- Attwood Teressa K. and David Parry- Smith (2007). Introduction to Bioinformatics. Pearson Education.
- Mount, D. W. (2005). Bioinformatics: Sequence and Genome Analysis. CBS Publishers and Distributers Pvt. Ltd., Delhi.
- Zvelebil, Marketa and Baum O. Jeremy (2008). Understanding Bioinformatics. Garland Science, Taylor and Francis Group, USA.
- Antonisamy, B., Christopher S. and Samuel, P. P. (2010). Biostatistics: Principles and Practice. Tata McGraw Hill Education Private Limited, India.
- Pagana, M. and Gavreau, K. (2000). Principles of Biostatistics. Duxberry Press, USA
- R. Durbin, S. Eddy, A. Krogh, and G. Mitchson (1998). Biological sequence analysis: Probablistic models of proteins and nucleic acids. Cambridge University Press

Online Tools and Web Resources:

- https://www.my-mooc.com/en/categorie/bioinformatics
- https://swayam.gov.in/course/4573-bioinformatics-algorithms-and-applications
- https://www.ncbi.nlm.nih.gov/
- https://www.ebi.ac.uk/
- https://www.expasy.org/
- https://www.edx.org/course/dna-sequences-alignments-and-analysis

DSE Course-VIII: Endocrinology

Course Learning Objective:

The main goal of this Discipline Specific Elective (DSE) paper is to provide students with a basic understanding of human endocrine glands, neuro-endocrine glands and their structure, function and signalling pathways. Students will also study the influence of biological rhythm on hormones secretion. In addition, the course will facilitate the understanding of the biosynthesis and biochemistry of hormones. Also, emphasis would be laid on understanding the maintenance of homeostasis by the hormones. The course will also try to integrate the basic and clinical aspects of endocrinology to enhance the understanding of students about the consequences due to hyposecretion, hypersecretion and absence of hormones leading to various diseases and metabolic disorders.

Course Learning Outcome:

After completion of the course the students will be able to:

- Understand endocrine system and the basic properties of hormones.
- Appreciate the importance of endocrine system and the crucial role it plays along with the nervous system in maintenance of homeostasis.
- Gain insight into the molecular mechanism of hormone action and its regulation.
- Knowthe regulation of physiological process by the endocrine system and its implication in diseases.
- Gain knowledge about the prevalent endocrine disorders and critically analyze their own and their family`s health issues.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Introduction to Endocrinology 8hrs

Overview of the endocrine system, Classification of hormones and their synthesis, Transport of Hormones, Metabolism of hormones and their half-lives.

(Chapter 3 and 4: David O. Norris; Chapter 1 and 2: Anthony W. Norman and Gerald Litwack)

Unit 2: Neuroendocrinology 15 hrs

Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction.Structure of hypothalamus, Hypothalamic nuclei and their functions, Regulation of neuroendocrine glands, Feedback mechanisms, Structure of pituitary gland, Hormones and their functions, Hypothalamo-hypophyseal portal system, Disorders of pituitary gland *(Chapter 4: David O. Norris; Chapter 3: Anthony W. Norman and Gerald Litwack)*

Unit 3: Peripheral Endocrine Glands 25 hrs

Functional histology and Regulation of Thyroid, Parathyroid, Adrenal, Endocrine Pancreas, Gonads; Disorders related to hypersecretion and hyposecretion of hormones *(Chapter 5, 6, 10, 11, 12, 13: Anthony W. Norman and Gerald Litwack)*

Unit4: Molecular Endocrinology 12 hrs

Hormone receptors, Transduction and regulation Hormone action at Molecular level: Molecular mediators (GPCR Family; DAG-Calcium Signaling Systems; RTKs, Protein Kinases and Phosphatases in Cellular Signaling); Steroid Hormone Receptor Families.

(Chapter 1: Anthony W. Norman and Gerald Litwack; Chapter 2, 3, 4: Jameson and Groot)

Practical [Credits: 2]

1. Dissect and Display of Endocrine glands in laboratory bred rat*/Human model
2. Study of the permanent slides of all the endocrine glands
3. Compensatory ovarian/adrenal hypertrophy *in vivo* bioassay in laboratory bred rat*
4. Demonstration of Castration/ ovariectomy in laboratory bred rat*
5. Estimation of plasma level of any hormone using ELISA
6. Chromatographic separation of steroid hormones using paper chromatography
7. Survey based project on any prevalent endocrine disorder *Depending on availability as per UGC guidelines

Teaching and Learning Process:

Lecture using Power Point and chalk-blackboard method will clarify the concepts of endocrinology. Use of ICT facility and survey based short projects as assignments will create interest among students to explore further. Visit to Prominent endocrinology laboratory will help students to learn about basic techniques.

Assessment Methods:

- Formative assessment in the form of quizzes, multiple choice questions, fill in the blanks and short answers
- Student presentation
- Take-home Assignments
- Summative assessment in the form of end of term Theory and Practical examination

Keywords:

Endocrine glands, hormone, neuroendocrinology, hypersecretion, hyposecretion, Receptors, second messenger, signal transduction, homeostasis

Recommended Books:

- J. Larry Jameson Leslie De Groot (2010). Endocrinology. VI Edition.
- David O. Norris. Vertebrate Endocrinology. V Edition,Elsevier Academic press.
- Franklin F. Bolander. Molecular Endocrinology. III Edition, Academic Press, USA.

Suggested Readings:

- Hand Book of Physiology published by American Physiological Society by Oxford University Press, Section 7: Multiple volumes set, 1998.
- C. Donnell Turner. General Endocrinology. VI Edition,SaundersToppan.
- Stephen Nussey and Saffron Whitehead (2001). Endocrinology: An Integrated Approach.. BIOS Scientific Publishers (https://www.ncbi.nlm.nih.gov/books/NBK22/)
- Hadley, M.E. and Levine J.E. (2009). Endocrinology.VI Edition. Pearson PrenticeHall, Pearson Education Inc., New Jersey.
- Strauss and Barbieri (2013). Yen & Jaffe's-Reproductive Endocrinology- Physiology, Pathophysiology and Clinical Management. VII Edition, Elsevier

Online Tools and Web Resources:

- https://sites.google.com/site/openmeded/specialties/endocrinology
- https://www.endocrine.org/topic

DSE Course-IX: Parasitology

Course Learning Objective:

Parasites are vast menagerie. They can cause diseases without pardon. They can slip into a person's brain wrecking the biological clock turning the day into nights. They can cause livers of cattle useless and roots of plants functionless. They may cause a tourist spot an epicenter of epidemic disease. There is an enormous diversity of parasites in nature and knowing and understanding them well becomes very important in the light of controlling and managing the parasites effectively. The economic impact of these organisms is often huge and that makes it even more important to study them. Parasitology will enable us diagnose parasites correctly, understand their life cycle and control them effectively and use some of them as bio control agents.Parasitology; especially the study of life cycles of parasites;has helped in defying the stigmas and religious taboos for many societies making free many of the people from superstition and ill health. Developing countries like our country where majority of the people are engaged in agricultural activities and living in poor conditions have advantages to be harvested from the study of parasitology. The course shall surely skill the students to see, appreciate and understand the diversities of parasites in the whole spectrum of the study of life. The course shall also make the students aware about the possible scopes of the subject which include research and applied aspects including entrepreneurial works.

Course Learning Outcome:

After completion of the course the students will be able to:

- Understand the variation amongst parasites, parasitic invasion in both plants and animals;applicable to medical and agriculture aspects.
- Help to know the stages of the life cycles of the parasites and the respective infective stages.
- Develop ecological model, knowpopulation dynamics of parasite, establishment of parasite population in host body, adaptive radiations and methods adopted by parasite to combat with the host immune system
- Develop skills and realize significance of diagnosis of parasitic attackand treatment of patient or host.
- Learn important case studies to highlight interesting researches, serendipities towards the advancement and enrichment of knowledge in the field of Parasitology.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit1: Introduction to Parasitology 5 hrs

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors (mechanical and biological vector) Host parasite relationship, Ecology of parasites, Population dynamics of parasite and establishment of parasite population in host body, evolution of parasitism, evolution and co-evolution of parasite with respect to host strategy, Important case studies in the field of Parasitology including some historical events such as the role of the mosquito control and the successful completion of the construction of the Panama canal.

(Chapter 1: E.R. Noble and G.A. Noble; Community Ecology Section: Smith; Introduction Section: Baker; Introduction Section: Zimmer; Division V: General Discussion: Mala Bose)

Unit2: Parasitic Protists 14 hrs

Epidemiology, Pathogenicity, Study of Morphology, Life Cycle, Prevalence, Diagnosis,

Prophylaxis and Treatment of *Entamoeba histolytica, Giardiaintestinalis, Trypanosoma gambiense, Leishmaniadonovani, Plasmodium vivax*.

(*Chapter 1, 2, 3, 4 and 5:K. D. Chatterjee; Chapter 1: Arora and Arora; Section I and II: Parija; Ichhpujani & Bhatia.*

Unit3: Parasitic Platyhelminthes 14 hrs

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis,

Prophylaxis and Treatment of *Fasciolopsis buski, Schistosomahaematobium, Taenia solium* and *Hymenolepis nana.*

(Chapter 6 and 7: K. D. Chatterjee; Chapters 8-11: Arora and Arora; Parija.; Ichhpujani& Bhatia)

Unit4: Parasitic Nematodes 15hrs

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis,

Prophylaxis and Treatment of *Ascaris lumbricoides*, *Ancylostomaduodenale*, *Wuchereriabancrofti* and *Trichinella spiralis*. Study of structure, lifecycle and importance of *Meloidogyne* (Root knot nematode), *Pratylencus* (Lesionnematode)

(Chapter 8: K. D. Chatterjee; Chapter 11 and 12: Arora and Arora; Parija; Ichhpujani& Bhatia)

Unit5: Parasitic Arthropoda 10hrs

Biology, importance and control of ticks, mites, *Pediculus humanus* (Head andBody louse), *Xenopsylla cheopis* and *Cimex lectularius*

(Cheng; Heinz Mehlhorn, 2012 Arthropods as vectors of merging Diseases. In Parasitology Research Monographs, Vol. 3, p. 397)

Unit6: Parasitic Vertebrates 2hrs

A brief account of parasitic vertebrates; Cookicutter Shark, Candiru, HoodMockingbird and Vampire bat.

(Klimpel & Mehlhorn; Gudger)

Practical [Credits: 2]

1. Study of life stages of *Entamoeba histolytica*, *Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani* and *Plasmodium vivax*through permanentslides/micro photographs.
2. Study of adult and life stages of *Fasciolopsis buski, Schistosomahaematobium, Taenia solium* and *Hymenolepis nana* through permanentslides/microphotographs.
3. Study of adult and life stages of *Ascaris lumbricoides, Ancylostomaduodenale, Wuchereria bancrofti* and *Trichinella spiralis* throughpermanent slides/microphotographs.
4. Study of plant parasitic root knot nematode, *Meloidogyne* from the soilsample.
5. Study of *Pediculus humanus* (Head louse and Body louse), *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.
6. Study of monogenea from the gills of fresh/marine fish [Gills can beprocured from fish market as by product of the industry]

7. Study of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as by product]
8. Submission of a brief report on parasitic vertebrates.
9. Visit to rural area/hospital near rural area/NCDC/NMIR/NICD to study natural history of parasites.
10. Parasite album, photograph collection: Tissue invasion, Life cycle
11. Culturing root parasites in laboratory, field
12. DNA extraction of parasite/s and molecular identification using universal and specific markers

Teaching and Learning Process:

Classroom teaching using power point presentations enabled with related photographs of parasites their life stages and disease diagnosis will help students to understand the subject.Case studies of epidemics caused by different parasites will clarify concept and create interest in the field.Visit to local diagnostic centre will provide an overview of various medical tests conducted to detect and confirm parasitic diseases.

Assessment Methods:

The learners/ students can be assessed in many different ways.

- Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation.
- Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc.
- Students would be provided feedback on their work with a view to improve their academic performance.
- From time to time, learners will be given practical problems and neuroimages to test their theoretical skills and promote practical knowledge.
- They would be provided feedback on their work with a view to improve their academic performance.
- Discipline assessed through regularity and behaviour

Keywords:

Host, Parasites, Diseases, Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis, Treatment

Recommended Books:

- Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications and Distributors
- Noble, E.R. and Noble, G.A. (1982) Parasitology: The Biology of Animal Parasites. V Edition, Lea & Febiger

Suggested Readings:

- Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and Francis Group
- Parija, S. C. Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi

- Ichhpujani, R.L. and Bhatia, R. Medical Parasitology. III Edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi
- Murray, D. Dailey. Meyer, Olsen & Schmidt's Essentials of ParasitologyW.C. Brown Publishers
- Thomas C. Cheng (1986). General Parasitology. II Edition, Academic Press Inc
- Chatterjee, K. D. (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBS Publishers & Distributors (P) Ltd.

DSE Course-X: Reproductive Biology

Course Learning Objective:

This course is meant for making the students learn about the various aspects of reproduction in humans. It includes a detailed study of the male and female reproductive systems as well as factors that are important in maintaining reproductive health. The students are also made aware of new technologies in assisted reproduction as well as contraceptive methods. They are taught about social and public health issues related to family planning.

Course Learning Outcome:

After completion of the course the students will be able to:

- Get in-depth understanding of morphology, anatomy and histology of male and female reproductive organs.
- Know different processes in reproduction starting from germ cell formation to fertilization and consequent pregnancy, parturition and lactation.
- Compare estrous and menstrual cycles and their hormonal regulation.
- Comprehend the interplay of various hormones in the functioning and regulation of the male and female reproductive systems.
- Know about the diagnosis and management of infertility, including latest methods, technologies and infrastructure in assisted reproduction.
- Practically understand the modern methods in contraception and their use in family planning strategies.
- Translate their understanding intodevelopment of products like non-hormonal contraceptives; contribute to drug discovery programmes as well as neonatal and maternal health programmes andwork with family planning teams to understand the
  needs and preferences of individuals belonging to lower socioeconomic groups.

Course Content:

Theory [Credits 4] **60 hrs**

Unit1: Reproductive Endocrinology 12 hrs

Hypothalamo–hypophyseal–gonadal axis. Regulation of gonadotropins and gonadal steroids secretion in male and female;Steroidogenesis;Puberty; Mechanism of action of hormones related to reproduction.

(Chapters1, 2, 4 and 6: Jones, R.E. and Lopez, K.H.; Chapters 1, 2, 3, 4, 5, 6 and 7: Johnson, M.H. and Everitt, B.J.)

Unit2: Male Reproductive System 10 hrs

Functional histology and anatomy of male reproductive system: Testis, epididymis, vas deferens, prostate gland, seminal vesicle;Spermatogenesis and its regulation; Sperm transport and maturation in male genital tract

(Chapter 4: Jones, R.E. and Lopez, K.H.; *Chapters 3 and 8: Johnson, M.H. and Everitt, B.J.)*

Unit 3: Female Reproductive System 28 hrs

Functional histology and anatomy of female reproductive system:Ovary, fallopian tubes/oviducts, uterus, cervix and vagina; Folliculogenesis; Oocyte maturation and ovulation; Corpus luteum formation and regression; Reproductive cycles (estrous and menstrual) and their regulation; changes in the female tract during these cycles.Fertilization; Implantation;

Maternal recognition of pregnancy; Feto-placentalunit; Hormonal regulation of gestation; gestational adaptations; Parturition and its hormonal regulation; Lactation and its regulation

(Chapters 2, 3, 9, 10, 11, and 12: Jones, R.E. and Lopez, K.H. Chapters 4, 8-13: Johnson, M.H. and Everitt, B.J.)

Unit4: Reproductive Health and Family Planning 10 hrs

Contraceptive methods;Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technologies: sperm banks, frozen embryos, IVF, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST.

(Chapters 14 and 16: Jones, R.E. and Lopez, K.H. Chapter 14: Johnson, M.H. and Everitt, B.J.)

Practical [Credits: 2]

1. Study of animal house: Set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Examination of vaginal smear of rats (from live animals).
3. Surgical techniques: principles of surgery in endocrinology. Ovariectomy, hysterectomy, castration and vasectomy in rats.
4. Examination of histological sections from photomicrographs/permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems; Sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.
5. Human vaginal exfoliate cytology through micrographs.
6. Sperm count and sperm motility in rat.
7. Study the effect of cryptorchidism on sperm count and motility in rats.
8. Study of modern contraceptive devices.
9. Mini projects involving survey, data collection, statistical analysis and submission of a project report on reproductive health of a small human community

*All exercises requiring live animals are, at present, being performed with the help of photomicrographs/pictures.

Teaching and Learning Process:

Lecture-based learning; aided with diagrams, flow charts and models; will be interactive with simple questions for students to learn and derive logically and think analytically. Examples, wherever possible, will be given from day-to-day activities to explain the concept and make the basics clear, relevant and interesting. After every lecture students will be posed with questions to help them summarise the topic.Regular practical classes will be held to develop the practical skills of students. The topics for practical will include detailed explanations of organ systems using hands-on and digital means. Histological slides will be shown to explain the microscopic structure of various tissues. The students will be assessed on their performance after each practical class.Seminar-based learning will include by delivering seminar by students followed by a discussion to assess their understanding and grasp of the topics.Students will undertake projects for certain topics to sharpen their understanding, enhance critical thinking, reasoning and analysis, and hone their presentation skills.Students will attend in-college workshops on topics related to their study. Experts in the field will be invited to hold workshops. Students will also be taken on field trips to subject related locations/agencies for a practical understanding of skills required for their potential future workplace.Mock practical/theory examinations will be held before the university

examination. The pattern of questions would match the university question paper to better equip the students to perform with confidence in the final examination.

Assessment Methods:

Students of the reproductive biology study programme will be assessed on the basis of their course learning outcomes as well as relevant skills. A variety of assessment methods will be used:

- Time-constrained oral and written examinations
- Problem-based assignments, individual project reports
- Practical file reports
- *Viva-voce* and
- Class assessments *via* observation of practical skills and regular class tests.

Keywords:

Reproductive system, Puberty, Spermatogenesis, Oogenesis, Folliculogenesis, Menstrual cycle, Estrous cycle, Infertility, Pregnancy, Family planning, Reproductive health

RecommendedBooks:

- Jones, R.E. and Lopez, K.H. (2014) Human Reproductive Biology.IV Edition, Elsevier.
- Johnson, M.H. and Everitt, B.J. (1995) Essential reproduction. IVEdition, London, Blackwell Science (Eighth edition by Johnson, MH., 2018)

Suggested Readings:

- Austin, C.R. and Short R.V. (Eds) (2012). Reproduction in Mammals. Cambridge University Press. (online edition)
- De-Groot, L.J. and Jameson, J.L. (eds) (2001). Endocrinology. W.B. Saunders and Company.
- Franklyn F. Bolander (2012). Molecular Endocrinology. III Edition, USA, Academic Press.
- Knobil, E. and Neil, JD (eds.) (2014). The Physiology of Reproduction. IV Edition, Elsevier.
- Hatcher, R.A. et al. (1997). The Essentials of Contraceptive Technology. Population Information Programme. John Hopkins School of Public Health.
- Robert Martin (2013). How We Do It: The Evolution and Future of Human Reproduction. Basic Books.
- Peter T. Ellison (2001). On Fertile Ground: A Natural History of Human Reproduction. Harvard University Press.

DSE Course-XI: Animal Behaviour and Chronobiology

Course Learning Objective:

Animal Behaviour is the scientific study of the wild and wonderful ways in which animals interact with each other, with other living beings, and with the environment in which they live in. One important aspect pertaining to the studies on Animal Behaviour is that it can be conducted anywhere and at any time, depending on the interest of the researcher. Moreover, it is not confined to the four walls of the classroom or the laboratory. The behavioural biology has high applied value and currently linked to conservation biology, molecular biology, behavioural ecology and integrated pest management. The chronobiology addresses some periodic and cyclic nature of various life phenomena occurring in living beings in nature. They often correlate with the external environmental factors. Chronopharmacology, chronomedicine and chronotherapy are some of the direct applications of chronobiology in human health.

This course aims to provide an overview of animal behaviour and chronobiology starting from historical prospective to types of behaviours and their evolutionary significance. The course also highlights types, mechanisms and importance of the biological rhythms and biological clocks operating in the living organisms. This course will help the learners to understand and appreciate different types of animal behaviours, their adaptive, evolutionary and practical significance.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Understand types of animal behaviour and their importance to the organisms.
- Enhance their observation, analysis, interpretation and documentation skills by taking short projects pertaining to Animal behaviour and chronobiology.
- Relate animal behaviour with other subjects such as Animal biodiversity, Evolutionary biology, Ecology, Conservation biology and Genetic basis of the behaviour.
- Understand various process of chronobiology in their daily life such as jet lag.
- Learn about the biological rhythm and their application in pharmacology and modern medicine.
- Realize, appreciate and develop passion to biodiversity; andy will respect the nature and environment.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Introduction to Animal Behaviour 8 hrs

Origin and history of Ethology; Pioneers of Modern Ethology: Karl *von* Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen; Proximate and ultimate causes of behaviour; tools, techniques and methods used in studying animal behaviour
(Chapter 1, 2: Alcock; Section 2.3, 3.1, 3.2: McFarland)

Unit 2: Patterns of Behaviour 10 hrs

Stereotyped behaviours (Orientation, Reflexes); Individual behavioural patterns; Instinct *versus* Learned behaviour; Associative learning, Classical and Operant conditioning, Habituation, Imprinting
(Part 2 & 3: McFarland; Chapter 2, 5: Manning)

Unit 3: Social and Sexual Behaviour 15 hrs

Social Behaviour: Concept of Society, Communication and the senses (Chemical, Tactile, Auditory, Visual); Altruism, Inclusive fitness, Hamilton's rule; Insects' society (Example: Honey bee); Foraging in honey bee and advantages of the waggle dance.

Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Courtship behaviour; Parental care, sexual conflict in parental care.
(Chapter 2, 3, 4, 7 and 9: Alcock)

Unit 4: Introduction to Chronobiology 6 hrs

Historical developments in chronobiology, Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks

(Chapter 2: Vinod Kumar; Chapter 1, 2: Dunlap et al; Chapter 1: Saunders)

Unit 5: Biological Rhythm 13 hrs

Characteristics of biological rhythms; Short-and Long-term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non-photic zeitgebers; Circannual rhythms; Photoperiod and regulation of seasonal reproduction of vertebrates; Role of melatonin.
(Chapter 2, 3, 4: Dunlap et al; Chapter 16, 17, 20: Vinod Kumar; Chapter 9: Saunders)

Unit 6: Biological Clocks 8 hrs

Relevance of biological clocks; Chronopharmacology, Chronomedicine, Chronotherapy *(Chapter 2, 3 and 4: Dunlap et al; Chapter 16, 17, 20: Vinod Kumar; Chapter 9: Saunders)*

Practical [Credits: 2]

1. To study nests and nesting behaviour of the birds and social insects.
2. To study the behavioural responses of wood lice to dry and humid conditions.
3. To study geotaxis behaviour in earthworm/ phototaxis behaviour in insect larvae.
4. Study of courtship behaviour in birds and insects from short videos/films.
5. Visit to Forest/Wild life Sanctuary/Biodiversity Park/Zoological Park to study and record the behavioural activities of animals and prepare a short report.
6. Study and actogram construction of locomotor activity of suitable animal models.
7. To study circadian functions in humans (daily eating, sleep and temperature patterns).

Teaching and Learning Process:

Teaching learning methods for the Animal behaviour and chronobiology paper should include conventional black board teaching coupled with power point presentations and smart board. The animal behaviour in wild life can be shown to the student with the help of videos and short films. The classroom teaching should be inclusive and have opportunities for the students to participate in the class discussion. The students should be encouraged to observe various live animal behaviours in their immediate surrounding environment and interpret them. There should be ample scope for field visits and visit to the research laboratories. Seminar should be arranged at the departmental level for the student, where student can have paper presentation on various themes of animal behaviour and chronobiology. Quizzes and debates can be arranged to make the teaching learning more innovative. Students should be advised to use e resources along with standard text books and reference books. They should take short project work and case study on the animal behaviour. They should relate various concepts in chronobiology taught in the classroom with their daily life. The students should be regularly assessed.

SEC-I Sericulture

Course Learning Objective:

The course will make the students aware about the significance of sericulture as a profit-making enterprise. It will help the students to understand the biology of silkworms and its nutritional requirement to secrete quality silk. The course would clarify the techniques of silkworm rearing, reeling of silk and various measures to be taken to maximize the benefits. It would also help the students to know about various uses of silk and develop entrepreneurial skills required for self-employment in sericulture and silk production sector.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the history of sericulture and silk route.
- Recognize various species of silk moths in India, and exotic and indigenous races.
- Be aware about the opportunities and employment in sericulture industry- in public, private and government sector.
- Gain thorough knowledge about the techniques involved in silkworm rearing and silk reeling.
- Develop entrepreneurial skills necessary for self-employment in mulberry and seed production and be apprised about practicing sericulture as a profit-making enterprise.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 2] **30 hrs**

Unit 1: Introduction 4 hrs

Sericulture: Definition, history and present status; Silk route; Types of silkworms, Distribution and races; Exotic and indigenous; Mulberry sericulture; Non-mulberry Sericulture, Eri, Muga, Tassar

(Chapter 3, Section 3.1: Manual on Sericulture http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf)

Unit 2: Biology of Silkworm 3 hrs

Life cycle of *Bombyx mori;* Structure of silk gland and secretion of silk; Composition and properties of silk

(Chapter 3, Section 3.1: Manual on Sericulture http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf)

Unit 3: Rearing of Silkworms 14 hrs

Selection of mulberry variety and establishment of mulberry garden, Rearing house and rearing appliances, Disinfectants: Formalin, bleaching powder, RKO Silkworm rearing technology: Early age and Late age rearing, Types of mountages, Harvesting and storage of cocoons, Post-harvest technology- Silk reeling, Dyeing and weaving, Ahimsa silk

(Chapter 3, Section 3.3, 3.4, 3.5 and 3.6: Manual on Sericulture http://agritech.tnau.ac.in/sericulture/seri_silkworm4_lateage%20rearing.html)

Unit 4: Pests and Diseases 4 hrs

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates; Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial; Control and prevention of pests and diseases

(Chapter 4, Section 3.1: Manual on Sericulture http://silks.csb.gov.in/coochbehar/wp-content/themes/common_district/coochbehar/dpm-frame2.html http://agritech.tnau.ac.in/sericulture/disese%20mgt_silkworm.html)

Unit 5: Silk Industry and Its Importance 2 hrs

Silk usage and application in Textile and non-textile industry

(Sericulture:http://csb.gov.in/silk-sericulture/sericulture/ http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf)

Unit 6: Entrepreneurship in Sericulture 3 hrs

Prospects of Sericulture in India: Sericulture industry in different states, Employment opportunities in mulberry and non-mulberry sericulture sector, Economics in small scale and large-scale silk worm rearing, Scope for women entrepreneurs in sericulture sector (*http://csb.gov.in/services/training/entrepreneurship/ http://ministryoftextiles.gov.in/sites/default/files/note-on-sericulture-English-Jan2019.pdf http://www.researchjournal.co.in/upload/assignments/5_188-190.pdf*)

Teaching and Learning Process:

Information and concepts about benefits of silkworms in human life and how these benefits can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of silkworms in nature and study of rearing technology will be assisted through visits to various sericulture institutes, which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make students' learning more dynamic. Enquiry-based collaborative learning through presentations, debates, group discussions, and roundtables on the various aspects of silkworm biology will be promoted, to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of worms and their rearing methods. Visit to various sericulture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:
Various measures adopted will be as follows.

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones in which evaluation is held.
- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcomes will be held.
- Regular Presentations: Presentations by the students on a topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries.
- *Viva-voce: Viva-voce* is a critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of students learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Keywords:
Cocoon, Disinfectant, Eri, Flacherie, Grasserie, Moriculture, Mountages, Muga, Mulberry, Muscardine, Pebrine, Rearing, Reeling, Sericulture, Silk moth, Tasar, Textile, Uzi fly, Weaving

Recommended Books:
Manual on Sericulture (1976); Food and Agriculture Organisation, Rome
Ullal, S.R. and Narasimhanna M.N. (1987) Handbook of Practical Sericulture; 3rd Edition, CSB, Bangalore

Suggested Readings:
Yonemura, M. and Rama Rao, N. (1951) A Handbook of Sericulture. I. Rearing of silk-worms.
Government Branch Press, Mysore.
Ananthanarayanan, S. K. (2008) Silkworm Rearing. Daya Publishing
House Aruga, H. (1994). Principles of Sericulture. CRC Press
Sathe, T. V. and Jadhav, A. (2002) Sericulture and Pest Management. Daya Publishing
House Yup-Lian, L. (1991) Silkworm Diseases. Food and Agricultural Organization.

Online Tools and Web Resources:

- Silkworm crop protection (https://swayam.gov.in/courses/152-silkworm-crop-protection)
- Sericulture (http://csb.gov.in/silk-sericulture/sericulture/)
- http://csb.gov.in/publications/videos/
- http://www.fao.org/3/x2099e/x2099e02.htm

ZH SEC -II Aquarium Fish Keeping

Course Learning Objective:

The course will impart basic knowledge of ornamental fish Industry and inculcate its scope as an avenue for career development as an entrepreneur or as an aquari-culturist. It will provide a clear understanding of the basics of biology and habits of aquarium fish, so as to facilitate taking up ornamental fish keeping as an enterprise, even at the household level. The skill capacity building of students will be promoted by teaching the techniques of aquarium constructions, feed formulation and preparation, transportation, maintenance and management of the system. Students will have 'hands-on' experience by exposure to technology, production, functioning or operation of an institution through visits to public aquariums in the markets, ornamental fish farms, hatcheries, and fish feed production plant as study tours or field visits.

Course Learning Outcome:

- Upon completion of the course, students should be able to: Acquire knowledge about different kinds of fish their compatibility in aquarium.
- Become aware of Aquarium as commercial, decorative and of scientific studies.
- Develop personal skills on maintenance of aquarium.
- Know about the basic needs to set up an aquarium, i.e., dechlorinated water, reflector, filters, scavenger, aquatic plants etc. and the ways to make it cost-effective.

Course Content:

Theory [Credits: 2] **30 hrs**

Unit 1: Introduction to Aquarium Fish Keeping 2 hrs

The potential scope of Aquarium Fish Industry as a Cottage Industry; Exotic and Endemic species of Aquarium Fish
(Chapter 50 and 54: Pandey and Shukla)

Unit 2: Biology of Aquarium Fish 6 hrs

Study of different species of Aquarium fish and biology (Breeding, Feeding economic importance etc) of exotic and endemic fish. Common characters and sexual dimorphism of Fresh water and marine aquarium fish such as Guppy, Molly, Sword tail, Gold fish, Angel fish,
Blue morph, Anemone fish and Butterfly fish.
(*Chapter 3: Dawes)*

Unit 3: Food and Feeding of Aquarium Fish 8 hrs

Use of live fish feed organisms (Advantages and disadvantages of live food), Use of formulated feeds, Types of formulated feed, Formulation and preparation of feed, Advantages and disadvantages of formulated feed
(Chapter 50: Pandey and Shukla)

Unit 4: Fish Transportation 8 hrs

Live fish transport (Capture and Pre-transport maintenance, capture and handling techniques); Fish packing and transport (Closed and open transport system, Preparation for packaging, Procedure for packaging, Precautions, Post transport maintenance) General handling techniques
(Chapter 13, Jhingran)

Unit 5: Maintenance of Aquarium 6 hrs

General aquarium maintenance- budget for setting up an Aquarium Fish Farm as a cottage industry.
(Chapter 2: Dawes)

Teaching and Learning Process:

Teaching Learning must include the videos, surveys, presentation to show the significance of the course- its commercial, scientific and aesthetic prospects. Learning must include a visit to any farm or lab by students. Practical exercise with the setup of an aquarium and its maintenance; hands-on training for the formation of feeds will develop skill among students.

Assessment Methods:

- Reports
- Presentation
- Individual project reports
- Problem-solving exercises
- Observation of practical skills
- *Viva-voce*

Keywords:

Ornamental fish, Cottage industry, Endemic fish, Feed formulation, Transportation techniques.

Recommended Books:

- Dawes, J. A. (1984) The Freshwater Aquarium, Roberts RoyeeLtd.London.
- Gunther, A. (1980) An Introduction to the Study of Fishes. A and C. Black Edinburgh.

Suggested Readings:

- Jhingran, V.G. (1982) Fish and Fisheries in India. Hindustan publication Corp, India.
- Pandey, K and J.P. Shukla (2013) Fish and Fisheries. Rastogi publication

SEC-III Medical Diagnostics

Course Learning Objective:

Medical diagnostics paper is aimed to provide students a unique opportunity to study how doctors or clinicians come to a conclusion regarding disease prediction, prevention, diagnosis, and optimal treatment regimens. Students will learn about multiple diagnostic tools, techniques and technologies used in medical practices. The emphasis is on, how to select an appropriate diagnostic technique, methods and technologies to conduct analyses to understand the results and their implications in patients' diagnosis. This paper primarily focuses on clinical chemistry, hematology, diagnostic microbiology, histopathology, molecular diagnostics and diagnostic medical imaging.

Course Learning Outcome:

After completing this course, the students should be able to:

Gain knowledge about various infectious, non-infectious and lifestyle diseases, tumors and their diagnosis

- Understand the use of histology and biochemistry of clinical diagnostics and learn about the molecular diagnostic tools and their relation to precision medicine.
- Develop their skills in various types of tests and staining procedure involved in hematology, clinical biochemistry and will know the basics of instrument handling.
- Learn scientific approaches/techniques used in the clinical laboratories to investigate various diseases and will be skilled to work in research laboratories.
- Gain knowledge about common imaging technologies and their utility in the clinic to diagnose a specific disease.

Course Content:

Theory [Credits: 2] **30 hrs**

Unit 1: Introduction to Medical Diagnostics and its importance 2 hrs

(Chapter: 4 Park)

Unit 2: Medical Diagnostics of body fluids 10 hrs

Blood composition, Blood bank, Transfusion of blood, RBC, WBC and platelet count using haemocytometer, Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.), Analysis of urine, sputum, faeces and semen (sperm count)

(Chapter 9a, 9b, 9c, 12, 19, 20, 21: Prakash, G.)

Unit 3: Medical Diagnostics of Non-infectious Diseases 10 hrs

Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Diagnosis and detection of types of tumours (Benign/Malignant) and metastasis, FNAC.

(Chapter 16 and 22a: Prakash, G.; Chapter 6: Park)

Unit 4: Diagnostics Microbiology 5 hrs

Methods to diagnose and isolate infectious agents of diseases like Tuberculosis, Hepatitis and AIDS.

(Chapter5: Park)

<u>Unit 5</u>: Diagnostic Medical Imaging 3hrs

Principle of Medical imaging techniques like X-Ray of Bone fracture, PET, MRI and CT Scan *(Chapter 24: Prakash, G.)*

Teaching and Learning Process:

Different instructing strategies shall be adopted including: Lectures, interactive lectures, classroom discussions and practical based on theory papers by analyzing body fluids, tissues, blood typing, chemical analyses, cell counts of human body etc. Use of digital technologies will enable students to get a better understanding of the concepts. Hands-on experience, including diagnostic analysis in the diagnostic laboratory and student presentations will provide supplement to conventional text books. Field studies will include visits to diagnostic laboratory or a visit to a hospital having diagnostic facilities.

Assessment Methods:

- Closed-book tests to evaluate the students' knowledge and understanding of material covered in the class.
- Internal evaluation based on the experiment performed during the internal examination or class tests conducted by the internal examiners.
- Dimension of comprehension and capacity to respond to inquiries as a piece of *viva-voce*.
- Involvement in class and group discussions of individual research and contribution to fruitful discussions.
- Assignments based on the text prescribed in the syllabus.
- Power Point presentation on any aspect of medical diagnostics.
- Hospital visit/medical institute visit.
- Project work (Students should execute one project of their choice or teacher may assign the project. Project report should be scanned for plagiarism through freely available software and a soft copy of the report should be mandatory).

Keywords:

Diagnostic methods, Infectious and Non-infectious diseases, Imaging techniques

Recommended Books:

- Park, K. (2007) Preventive and Social Medicine, B.B. Publishers
- Godkar P.B. and Godkar D.P. (2005) Textbook of Medical Laboratory Technology, III Edition, Bhalani Publishing House
- Prakash, G. (2012), Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Co. Ltd.

Suggested Readings:

- Cheesbrough M., A Laboratory Manual for Rural Tropical Hospitals, A Basis For Training Courses
- Guyton A.C. and Hall J.E. Textbook of Medical Physiology, Saunders
- Robbins and Cortan, Pathologic Basis of Disease, VIII Edition, Saunders

Online Tools and Web Resources:

- https://www.skillstat.com/tools/ecg-simulator

SEC-IV: Research Methodology

Course Learning Objective:

This course offers overview of Research Methodology including quantitative and qualitative research in basic as well as applied aspects of Biological Sciences. It is designed to provide hands-on experience with collection, analysis and interpretation of data and also writing a report/thesis. Moreover, this course focusses on developing the skills necessary for pursuing a career in research. The students will be motivated to learn scientific investigation to solve problems, test hypothesis, develop or invent new products for the benefit of society.

Course Learning Outcome:

After completing this course, the students should be able to:

- Describe basic concepts of research and its methodologies
- Identify appropriate research topics and set up hypothesis
- Perform literature review using library (print) and internet (online) resources
- Design experiments/surveys, collect data and represent data in tables/figures
- Analyze data with appropriate software tools, interpret results and draw conclusion
- Write scientific report/ review/ thesis and prepare seminar/ conference presentations - oral as well as poster
- Understand the methods of citation and referencing styles, check plagiarism and get insight of intellectual property right

Course Content:

Theory [Credits: 2] **30 hrs**

Unit1: Foundations of Research 4 hrs

Meaning, Objectives, Motivation: Research Methods *vs* Methodology, Types of Research: Analytical *vs* Descriptive, Quantitative *vs* Qualitative, Basic *vs*Applied.
(Chapter 1 and 2: Kothari; Chapter 1and 2: Walliman)

Unit 2: Research Design 8 hrs

Need for research design: Features of good design, Important concepts related to good design-Observation and Facts, Prediction and Explanation, Development of Models. Developing a research plan: Problem identification, Experimentation, Determining experimental and sample designs
(Chapter 3 and 4: Kothari; Chapter 3 and 4: Walliman)

Unit 3: Data Collection, Analysis and Report Writing 12 hrs

Observation and Collection of Data-Methods of data collection- Sampling Methods, Data Processing and Analysis Strategies;Preparation of Tables and Figures; Technical Reports and Thesis writing; Bibliography/References; Data Presentation using digital tools. Seminar presentation (oral/poster)
(Chapter 6, 7 and 14: Kothari Chapter 7, 8, 9 and 10: Walliman)

Unit 4: Ethical Issues 6 hrs

Intellectual Property Rights, Copy Right, Royalty, Patent laws, Commercialization, Plagiarism, Citations, Acknowledgement, Research Grants/ Fellowships
(Chapter 4: Walliman)

Teaching and Learning Process:

Survey based data collection, graphical representation of data and compilation of report as assignments will be stressed upon. Visit to Research Laboratories will be organized to introduce and encourage usage of instruments and techniques by students. Participation in research internships/conferences/seminars will be encouraged to inculcate research skills.

Assessment Methods:

The students will be assessed on the basis of their performance in class room presentations as well as semester end examination.

Keywords:

Research methodology, Data analysis, Experimental design, Sampling, Research paper, Abstracts, Dissertation, Thesis, Citation, IPR, Plagiarism, Patent, Research grants, Fellowships

Recommended Books:

- Anthony, M, Graziano, A.M. and Raulin, M.L. (2009) Research Methods: A Process of Inquiry, Allyn and Bacon.
- Walliman, N. (2011) Research Methods- The Basics. Taylor and Francis, London, New York, USA.

Suggested Readings:

- Wadhera, B.L. (2002) Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law publishing
- Kothari, C.R. (2009) Research Methodology, New Age International.
- Coley, S.M. and Scheinberg, C.A. (1990) "Proposal writing". Stage Publications.

Online Tools and Web Resources:

- https://swayam.gov.in/course/292-introduction-to-research
- https://explorable.com/research-methodology
- https://www.coursera.org/learn/research-methods
- https://www.coursera.org/learn/sciwrite

SEC-V Apiculture

Course Learning Objective:

The course will make the student aware about the significance of beekeeping as the economically viable industry. It will help the students to understand the biology and behaviour of bees. The course would clarify the techniques of honey bee rearing, optimization of techniques based on climate and the geographical regions, and various measures to be taken to maximize the benefits. It would also help the students to develop entrepreneurial skills required for self-employment in beekeeping sector.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the various species of honey bees in India, their social organization and importance.
- Be aware about the opportunities and employment in apiculture- in public, private and government sector.

- Gain thorough knowledge about the techniques involved in bee keeping and honey production.
- Know about various products obtained from beekeeping sector and their importance.
- Develop entrepreneurial skills necessary for self-employment in beekeeping sector.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 2] **30 hrs**

Unit1: Biology of Bees 4 hrs

History, Classification and biology of Honey Bees, different species of honey bees-*Apis dorsata, Apiscerana indica, Apisflorea, Apis mellifera, Melipona* sp. Social Organization of bee colony, behavioural patterns (Bee dance, swarming)
(Chapter 1, 2 and 3: Singh, S.; Chapter 2, 3 and 5: Mishra, R.C.)

Unit 2: Rearing of Bees 14 hrs

Artificial bee rearing (Apiary), Beehives- Newton and Langstroth; Bee Pasturage; Selection of bee species for Apiculture- *Apiscerana indica, Apis mellifera*; Bee keeping equipment, Methods of extraction of Honey (Indigenous and Modern) and processing; Apiary management- Honey flow period and Lean period
(Chapter 4, 5, 6 and 7: Singh, S.; Chapter 4, 8 and 9: Mishra, R.C.)

Unit 3: Diseases and Enemies 5 hrs

Bee diseases, control and preventive measures; Enemies of bees and their control
(Chapter 10: Singh, S.; Chapter 10: Mishra, R.C, Chapter 6: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)

Unit 4: Bee Economy 3 hrs

Products of Apiculture Industry (Honey, Bees Wax, Propolis, Royal jelly, Pollen etc.) and their uses; Modern methods in employing artificial beehives for cross pollination in horticultural gardens

(Chapter 11: Singh, S.; Chapter 11 and 12: Mishra, R.C.Chapter 9: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)

Unit 5: Entrepreneurship in Apiculture 4 hrs

Bee Keeping Industries- Recent efforts, Employment opportunities, Economics in small scale and large-scale beekeeping, Scope for women entrepreneurs in beekeeping sector
(Chapter 10: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf Entrepreneurial Potential of Small-scale Beekeeping in Rural India: A Case in Kanyakumari district, Tamil Nadu. M. Esakkimuthu & VLV. Kameswari, Tropical Agricultural Research, (2017) 28: 411)

Teaching and Learning Process:

Information and concepts about benefits of honey bees in human life and how these benefits can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of bees in nature and study of rearing technology will be assisted through visits to various apiculture institutes which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make learning by

students more dynamic. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of bee biology will be promoted to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of bees and their rearing methods. Collection of plants and bee products will also help students to know the benefits of apiculture. Visit to various apiculture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

Various measures adopted will be as follows.

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones in which evaluation is held.

- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.
- Regular Presentations: Presentations by the students on a topic will enhance their learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries.
- *Viva-voce: Viva-voce* is a critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of their learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Keywords:

Apiculture, Bee, Bee hive, Beekeeping, Bees' wax, Brood, Comb sheets, Drones, Entrepreneurship, Honey, Langstroth's hive, Newton's hive, Propolis, Queen bee, Royal jelly

Recommended Books:

- Singh S. (1962) Beekeeping in India, Indian Council of Agricultural Research, New Delhi.
- Mishra, R. C. (1995) Honeybees and their Management in India. Indian Council of Agricultural Research, New Delhi.

Suggested Readings:

- Prost, P. J. (1962) Apiculture. Oxford and IBH, New Delhi.
- Rahman, A. (2017) Beekeeping in India. Indian Council of Agricultural Research, New Delhi
- Gupta, J. K. (2016) Apiculture, Indian Council of Agricultural Research, New Delhi

Online Tools and Web Resources:

- (https://www.ecornell.com/certificates/beekeeping/master-beekeeping/)
- Beekeeping (https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)
- Swayam (MHRD) Portal Vocational Beekeeping (https://swayam.gov.in/courses/5844-vocational-beekeeping

(Chapter 11: Singh, S.; Chapter 11 and 12: Mishra, R.C.Chapter 9: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)

Unit 5: Entrepreneurship in Apiculture 4 hrs

Bee Keeping Industries- Recent efforts, Employment opportunities, Economics in small scale and large-scale beekeeping, Scope for women entrepreneurs in beekeeping sector *(Chapter 10: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf Entrepreneurial Potential of Small-scale Beekeeping in Rural India: A Case in Kanyakumari district, Tamil Nadu. M. Esakkimuthu & VLV. Kameswari, Tropical Agricultural Research, (2017) 28: 411)*

Practical [Credit: 2]

1. Study of the life history of honey bee, *Apiscerana indica* and *Apis mellifera* from specimen/ photographs - Egg, larva, pupa, adult (queen, drone, worker)
2. Study of natural bee hive and identification of queen cells, drone cells and brood
3. Study of morphological structures of honey bee through permanent slides/photographs-mouth parts, antenna, wings, legs (antenna cleaner, mid leg, pollen basket), sting apparatus.
4. Permanent/temporary mount of antenna cleaner, mid leg and pollen basket OR mount of pollen grains from flowers
5. Study of artificial hive (Langstroth/Newton), its various parts and beekeeping equipment.
6. Analysis of honey- purity, biochemical analysis (Any two constituents)
7. Visit to an apiary/honey processing unit/Institute and submission of a report.
   a. Study of bee pasturage
   b. Visit to fields/gardens/orchards for studying the bee activity (role in pollination and nectar collection).
   c. Making of herbarium of nectar and pollen yielding flowering plants
8. Submission of a few products obtained from apiculture industry.

Teaching and Learning Process:

Information and concepts about benefits of honey bees in human life and how these benefits can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of bees in nature and study of rearing technology will be assisted through visits to various apiculture institutes which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make learning by students more dynamic. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of bee biology will be promoted to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of bees and their rearing methods. Collection of plants and bee products will also help students to know the benefits of apiculture. Visit to various apiculture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

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Suggested Readings:

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- Rahman, A. (2017) Beekeeping in India. Indian Council of Agricultural Research, New Delhi
- Gupta, J. K. (2016) Apiculture, Indian Council of Agricultural Research, New Delhi

Online Tools and Web Resources:

- (https://www.ecornell.com/certificates/beekeeping/master-beekeeping/)
- Beekeeping (https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)

Swayam (MHRD) Portal Vocational Beekeeping (https://swayam.gov.in/courses/5844-vocational-beekeeping

GE-I: Animal Diversity

Course Learning Objective:

Zoology is the scientific study of animal life. Animals are the most diverse creatures on this planet. This course gives a framework for understandingthe diversity within different groups, and interrelationship among different species and genera within each group. The aim of this course is to understand the importance of animal kingdom in context to hierarchy, body plan and their role in ecological development. This course provides an overview of the invertebrate and vertebrate animals, including sponges, cnidarians, flatworms, nematodes, annelids, molluscs, arthropods, echinoderms, invertebrate chordates, fishes, amphibians, reptiles, birds, and mammals. This paper comprises of 15 units. First nine units provide knowledge of coelom formation, different level of organization, different modes of living, evolutionary changes of Non-chordates and their salient features. Whereas, remaining units will impart knowledge on different

classes of chordates. After completion of this course, the learners will have a framework for understanding all of the different types of animals, and the characteristics of each.

Course Learning Outcome:
Upon completion of the course, students will be able to:

- Distinguish between major phyla of animals through a demonstrated understanding of their taxonomic classification and diversity.
- Describe the distinguishing characteristics of all major phyla.
- Understand the fundamental differences among animal body plans and relate them to function, taxonomic classification, and evolutionary relationships among phyla.
- Illustrate lifecycles, structure, function and reasons for importance of few representative organisms from different groups of animals.
- Identify anatomical structures from prepared tissues.
- Observe living animals in the environment and relate observations to theory from the course.
- Recognize major animal phyla and animals on the basis of their external characteristics.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Protista 4 hrs
General characters of Protozoa; Life cycle of *Plasmodium*
(Chapter 3: Ruppert, Fox & Barnes; Chapter 28: Campbell & Reece)

Unit 2: Porifera 4 hrs
General characters and canal system in Porifera
(Chapter 5: Ruppert, Fox &Barnes)

Unit 3: Radiata 3 hrs
General characters of Cnidarians and polymorphism
(Chapter 7: Ruppert, Fox &Barnes)

Unit 4: Aceolomates
General characters of Helminthes;
Life cycle of *Taenia solium (Chapter 10: Ruppert, Fox & Barnes)*

Unit 5: Pseudocoelomates
General characters of Nemathelminthes; Parasitic adaptations.
(Chapter 11: Barnes)

Unit 6: Coelomate Protostomes
General characters of Annelida; Metamerism.
(Chapter 13: Ruppert, Fox & Barnes; Chapter 33: Campbell & Reece)

Unit 7: Arthropoda
General characters; Social life in insects.
(Chapter 16: Ruppert, Fox & Barnes; Chapter 46: Raven) 3 hrs

Unit 8: Mollusca 4hrs

General characters of mollusca; Pearl Formation.
(Chapter 12: Ruppert, Fox & Barnes)

Unit 9: Coelomate Deuterostomes 5 hrs

General characters of Echinodermata, Water Vascular system in Starfish.
(Chapter 28: Ruppert, Fox & Barnes; Chapter 47: Raven)

Unit 10: Protochordata 3hrs

Salient features of protochordata
(Chapter 2 and 3: Young)

Unit 11: Pisces 5hrs

General characters of Pisces, Osmoregulation in Fishes.
(Chapter5: Young; Chapter 14: Kardong)

Unit 12: Amphibia 5hrs

General characters, Adaptations for terrestrial life, Parental care in Amphibia.
(Chapter12: Young)

Unit 13: Reptilia 4hrs

General characters, Terrestrial adaptations inreptiles, Poisonous and Non-poisonous snakes *(Chapter34: Campbell & Reece; Chapter14, Young)*

Unit 14: Aves

General Characters, Flight adaptations.
(Chapter34: Campbell & Reece; Chapter 15 and 17: Young)

Unit 15: Mammalia

General Characters; Primates; Dentition in mammals
(Chapter: 22 and 24: Young)

Practical [Credits: 2]

1. Study of specimens

- Non-chordates**:** *Euglena, Noctiluca, Paramecium, Sycon,Physalia, Tubipora, Metridium,*

  Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus, Hermitcrab*, Daphnia,* Millipede, Centipede, Beetle*, Chiton, Dentalium, Octopus, Asterias and Antedon.*

- Chordates*: Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Icthyophis/Uraeotyphlus, Salamandra, Rhacophorus Draco, Uromastix, Naja, Viper,*

  Model of *Archaeopteryx,* Any three common birds- (Crow, duck, Owl), Squirrel and Bat.

2. Study of Permanent Slides:
   - Cross section of *Sycon*, Sea anemone and *Ascaris (*male and female*).*
   - T. S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine.
   - Bipinnaria and Pluteus larva.
3. Study of:
   - Septal & pharyngeal nephridia of earthworm.
   - Placoid, Cycloid and ctenoid scales.
4. Study of following organ systems:
   - Digestive System of Cockroach.
   - Urinogenital system of Rat

Teaching and Learning Process:

Teaching-Learning process will include delivery of lectures using boards, Multimedia presentation, short documentaries on animal diversity, imparting practical based knowledge through specimens, live demonstration of diversity in surroundings.

Assessment Methods:

Assessment methods are:

- Course examination
- Multiple choice questions quiz at the end of each lecture
- Case studies
- Oral presentation by students
- Report or essay writing
- Project based to assess the skills of scientific enquiry and problem-solving

Keywords:

Invertebrates, Vertebrates, Protozoa, Parazoa, Metazoa, Protochordates, Parasitic adaptations, Migration, Parental care, Biting mechanism, Osmoregulation, Canal system, Water vascular system

Recommended Books:

- Campbell and Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
- Raven, P. H. and Johnson, G. B. (2004). Biology, VIEdition, Tata McGraw Hill Publications. New Delhi.

Suggested Readings:

- Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
- Ruppert, Fox and Barnes (2006). Invertebrate Zoology. A functional Evolutionary Approach,VII Edition, Thomson Books/Cole
- Kardong, K. V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. Tata McGraw Hill Publishing Company. New Delhi.

. **Online Tools and Web Resources:**

- http://vle.du.ac.in
- Animal Diversity Web (ADW); an online database of animal natural history, distribution, classification, and conservation biology. Web resource https://animaldiversity.org/
- Online Zoo;https://www.activewild.com/online-zoo/

GE-II: Aquatic Biology

Course Learning Objective:

Aquatic biology is a scientific discipline that investigates study of all life forms like plants, animals and chemicals prevalent in the waters from different sources such as lakes, rivers, streams, wetlands, marine environments etc. It is a modern area of academic study and research-oriented program. This program helps students to study about aquatic life and equip students with skills that can later lead into a profession in aquatic biology. Aquatic biology at undergraduate level works as an entry point for future aquatic biologist. Two major aspects of Aquatic biology are study of the organisms in the freshwater (Limnology) and saline waters (Marine biology). This paper focuses on research and explains processes, structures and pathways in most aquatic and wet ecosystems. Geographically, aquatic ecosystems in temperate, tropical and arctic regions, and both basic and applied science will be covered.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Know the physico-chemical environment, and its role in aquatic ecosystem.
- Learn about adaptations exhibited by organisms to survive in these typical conditions.
- Realize how human activities influence the physicochemical environment of water bodies, and devastating impact it has on aquatic organisms.
- Learn about the laws governing the use of freshwater systems, as well as the local, state, federal, and international agencies that enforce these laws to protect endangered and vulnerable species.
- Understand and apply relevant scientific principles in the area of aquatic biology and educate others or work to conserve our natural resources.

Course Content:

Theory [Credits: 4] **60hrs**

Unit 1: Aquatic Biomes 6 hrs

Brief introduction of the aquatic biomes: Freshwater ecosystem (lakes, wetlands, streams and rivers), Estuaries, Intertidal zones, Oceanic pelagic zone, Marine benthic zone and Coral reefs.
(Chapter 10: Odum; Chapter 8: Wetzel)

Unit 2: Aquatic Resources 10 hrs

Important fin and shellfish resources of Inland (major carps, Catfish & prawn), Brackish water (Hilsa), Marine (demersal and pelagic), Ornamental and sport fishes.
(Chapter 3: Odum)

Unit 3: Freshwater Biology 24hrs

Lakes: Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico–chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.
(Chapter 4, 5 and 10: Odum; Chapter 2, 5, 6 and 19: Golterman; Chapter 3, 5, 7, 12, 13 and 24: Wetzel)

Unit 4: Marine Biology 10hrs

Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.
(Chapter 10: Odum)

Unit 5: Management of Aquatic Resources 10hrs

Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation (legislations), Sewage treatment Water quality assessment-BOD and COD.
(Chapter 3: Odum; Chapter 17and 19: Golterman; Chapter 13: Wetzel)

Practical [Credits: 2]

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.
3. Determine the amount of turbidity/transparency, dissolved oxygen, free carbon dioxide, alkalinity (carbonates & bicarbonates) in water collected from a nearby lake/ water body.
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.
5. A Project Report on a visit to a Sewage treatment plant/Marine bio-reserve/Fisheries Institutes.

Teaching and Learning Process:

In addition to the traditional way of chalk and board teaching, teaching would be supplemented withVideo/animations to help better understanding of the subject. For enhanced practical/field driven knowledge of students, they would be taken to laboratories or Aquatic research institutes/industries.

Assessment Methods:

- Power point presentations
- Assignments with emphasis on recent studies in the Aquatic Biology
- Written examination.

Keywords:

Fresh water, Marine Biology, Aquatic resources, Management of resources

Recommended Books:

Goldman. Limnology.II Edition
Odum and Barrett. Fundamentals of Ecology.V Edition

Suggested Readings:

Pawlowski. Physicochemical Methods for Water and Wastewater Treatmen.I Edition Wetzel. Limnology. III edition
Trivedi and Goyal. Chemical and Biological Methods for Water Pollution Studies

Online Tools and Web Resources:

- MOOC https://swayam.gov.in/courses/5686-animal-diversity

GE III: Environment and Public Health

Course Learning Objective:

Health is wealth but this wealth is directly affected by the environment. Environmental issue that affects human health is the most important trigger that has led to the urgency of conservation of environment. All the aspects of human health, including quality of life are determined by physical, chemical, biological, social and psychological factors in environment. The sustenance of environment is the key to development of future of mankind.This courseaims to create awareness among students about the necessity conservation of Mother Nature. The main objective of the syllabus is to assess, correct, control and prevent those factors that can adversely affect environment and hence health of present and future generation.

Course Learning Outcome:

Upon completion of course, students will be able to:

- Get familiarizedwith various aspects of environmental risks and hazards.
- Recognize the climate change due to human activities.
- Be aware about the various impacts of environmental degradation on human health through case studies and how it can be prevented.
- Learn about the nuclear and chemical disaster;s and their after effects through cases studies.
- Know various waste management technologies and their utility.
- Understand the diagnostic methods of various diseases and ways to prevent them.
- Realize the importance of nature conservation for betterment of human race and all living beings.

Course Content:

Theory [Credits: 4] **60hrs**

Unit1: Introduction 10hrs

Sources of Environmental hazards, Hazard identification and accounting, Bioaccumulation, Biomagnification, Dose Response Evaluation, exposure Assessment. (*Chapter 18, 22, 23: Chirac)*

Unit 2: Climate Change 10hrs

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, *El Nino La Nina,* Southern Oscillation (ENSO), Effect of climate change on public health
(Chapter 9: Vasudevan; Chapter 26: Subhramaniam; Chapter 12: Park; Chapter 33: MishraandPandey)

Unit 3: Pollution 15hrs

Air, water, noise pollution: Sources, effects and control

Smog: Causes and its effect on human health, Effect of noise on Human health, Water borne diseases, Respiratory ailments (Asthma). Nuclear accidents and holocaust. Case Histories and their aftermath of: Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident.

(Chapter 7, 9 and 10: Vasudevan; Chapter 26: Subhramaniam; Chapter 12: Park; Chapter 3,
5: Bullard and Filborn; Chapter 1: Crowland. Louvar

Unit 4: Waste Management Technologies *15hrs*

Classification and Characteristics of solid and hazardous waste, Sewage treatment and its management, Solid waste management, Handling and disposal: Biomedical waste and Nuclear waste, Health risk due to hazardous waste (Minamata disease)

(Chapter 7 and 11, Vasudevan; Chapter 12: Park; Chapter 33: Mishra and Pandey)

Unit 5: Diseases 10hrs

Causes, symptoms and control of tuberculosis,Vector borne diseases (Dengue, Malaria), Typhoid, Cholera, Cancer, Infectious diseases

(Chapter 5 and 6: Park)

Practical [Credits: 2]

1. To determine pH, Cl, SO_4, NO_3 in soil samples from different locations.
2. To determine pH, Cl, SO_4, NO_3 in water samples from different locations.
3. To determine dissolved oxygen in water samples collected from different water bodies by Winkler's Method
4. To measure the COD of water sample from various sources
5. To study the methods adopted for segregation of domestic and hospital wastes into different categories.
6. A report based on a visit to thermal power plant/ solid waste management site/ Sewage Treatment Plant/ Nuclear Power Plant

Teaching and Learning Process:

Generic Elective papers are interdisciplinary in nature. This paper has been revised for better understanding of the subject by the students even from unrelated disciplines. For an effective teaching learning process instead of teaching in a complete lecture mode, there should be interactive teaching for better understanding of the topic. The topics under Waste management can be understood through visits to waste treatment plants.There can be extended practical other than the ones included in the syllabus which may include collection of data, data analysis and preparing report.Incorporation of media and multimedia andscreening of documentaries/movies relevant to the current scenario of environmental degradation will create awareness among students.Students can present case studies or Government's initiative relevant to the topics related to the paper. Quizzes and debates can be used for better understanding of the topics. Continuous evaluation through tests, presentation, assignments and project work will inculcate in-depth understanding of the subject.

Assessment Methods:

The various methods can be adopted for continuous evaluation of the students:

- Regular class test
- Oral presentation as part of assignment

- Participation in discussion
- Project work with viva
- Performance in regular and extended practical

Keywords:

Environment, Pollution, Environmental hazards, Public Health, Climate Change, Waste management technologies

Unit 4: Marine Biology 10hrs

Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.
(Chapter 10: Odum)

Unit 5: Management of Aquatic Resources 10hrs

Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation (legislations), Sewage treatment Water quality assessment-BOD and COD.
(Chapter 3: Odum; Chapter 17and 19: Golterman; Chapter 13: Wetzel)

Practical [Credits: 2]

6. Determine the area of a lake using graphimetric and gravimetric method.
7. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.
8. Determine the amount of turbidity/transparency, dissolved oxygen, free carbon dioxide, alkalinity (carbonates & bicarbonates) in water collected from a nearby lake/ water body.
9. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.
10. A Project Report on a visit to a Sewage treatment plant/Marine bio-reserve/Fisheries Institutes.

Teaching and Learning Process:

In addition to the traditional way of chalk and board teaching, teaching would be supplemented withVideo/animations to help better understanding of the subject. For enhanced practical/field driven knowledge of students, they would be taken to laboratories or Aquatic research institutes/industries.

Assessment Methods:

- Power point presentations
- Assignments with emphasis on recent studies in the Aquatic Biology
- Written examination.

Keywords:

Fresh water, Marine Biology, Aquatic resources, Management of resources

Recommended Books:

Goldman. Limnology.II Edition
Odum and Barrett. Fundamentals of Ecology.V Edition

Suggested Readings:

Pawlowski. Physicochemical Methods for Water and Wastewater Treatmen.I Edition Wetzel. Limnology. III edition
Trivedi and Goyal. Chemical and Biological Methods for Water Pollution Studies

Online Tools and Web Resources:

- MOOC https://swayam.gov.in/courses/5686-animal-diversity

GE IV: Environment and Public Health

Course Learning Objective:

Health is wealth but this wealth is directly affected by the environment. Environmental issue that affects human health is the most important trigger that has led to the urgency of conservation of environment. All the aspects of human health, including quality of life are determined by physical, chemical, biological, social and psychological factors in environment. The sustenance of environment is the key to development of future of mankind.This courseaims to create awareness among students about the necessity conservation of Mother Nature. The main objective of the syllabus is to assess, correct, control and prevent those factors that can adversely affect environment and hence health of present and future generation.

Course Learning Outcome:

Upon completion of course, students will be able to:

- Get familiarizedwith various aspects of environmental risks and hazards.
- Recognize the climate change due to human activities.
- Be aware about the various impacts of environmental degradation on human health through case studies and how it can be prevented.
- Learn about the nuclear and chemical disaster;s and their after effects through cases studies.
- Know various waste management technologies and their utility.
- Understand the diagnostic methods of various diseases and ways to prevent them.
- Realize the importance of nature conservation for betterment of human race and all living beings.

Course Content:

Theory [Credits: 4] **60hrs**

Unit1: Introduction 10hrs

Sources of Environmental hazards, Hazard identification and accounting, Bioaccumulation, Biomagnification, Dose Response Evaluation, exposure Assessment. (*Chapter 18, 22, 23: Chirac)*

Unit 2: Climate Change 10hrs

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, *El Nino La Nina,* Southern Oscillation (ENSO), Effect of climate change on public health

(Chapter 9: Vasudevan; Chapter 26: Subhramaniam; Chapter 12: Park; Chapter 33: MishraandPandey) **ZH GE IV: Environment and Public Health**

Course Learning Objective:

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Course Learning Outcome:

Upon completion of course, students will be able to:

- Get familiarizedwith various aspects of environmental risks and hazards.

- Recognize the climate change due to human activities.
- Be aware about the various impacts of environmental degradation on human health through case studies and how it can be prevented.
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Course Content:

Theory [Credits: 4] **60hrs**

Unit1: Introduction 10hrs

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Unit 2: Climate Change 10hrs

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, *El Nino La Nina,* Southern Oscillation (ENSO), Effect of climate change on public health
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Upon completion of course, students will be able to:
- Get familiarizedwith various aspects of environmental risks and hazards.
- Recognize the climate change due to human activities.
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- Learn about the nuclear and chemical disaster;s and their after effects through cases studies.
- Know various waste management technologies and their utility.
- Understand the diagnostic methods of various diseases and ways to prevent them.
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Course Content:

Theory [Credits: 4] **60hrs**

Unit1: Introduction 10hrs

Sources of Environmental hazards, Hazard identification and accounting, Bioaccumulation, Biomagnification, Dose Response Evaluation, exposure Assessment. (*Chapter 18, 22, 23: Chirac)*

Unit 2: Climate Change 10hrs

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, *El Nino La Nina,* Southern Oscillation (ENSO), Effect of climate change on public health

(Chapter 9: Vasudevan; Chapter 26: Subhramaniam; Chapter 12: Park; Chapter 33: MishraandPandey

Unit3: Air, water, noise pollution: Sources, effects and control

Smog: Causes and its effect on human health, Effect of noise on Human health, Water borne diseases, Respiratory ailments (Asthma). Nuclear accidents and holocaust. Case Histories and their aftermath of: Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident.

(Chapter 7, 9 and 10: Vasudevan; Chapter 26: Subhramaniam; Chapter 12: Park; Chapter 3, 5: Bullard and Filborn; Chapter 1: Crowland. Louvar)

Unit 4: Marine Biology 10hrs

Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.

(Chapter 10: Odum)

Unit 5: Management of Aquatic Resources 10hrs

Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation (legislations), Sewage treatment Water quality assessment-BOD and COD.

(Chapter 3: Odum; Chapter 17and 19: Golterman; Chapter 13: Wetzel)

Practical [Credits: 2]

1.Determine the area of a lake using graphimetric and gravimetric method.

2.Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.

3.Determine the amount of turbidity/transparency, dissolved oxygen, free carbon dioxide, alkalinity (carbonates & bicarbonates) in water collected from a nearby lake/ water body.

4.Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.

5.A Project Report on a visit to a Sewage treatment plant/Marine bio-reserve/Fisheries Institutes.

Teaching and Learning Process:

In addition to the traditional way of chalk and board teaching, teaching would be supplemented withVideo/animations to help better understanding of the subject. For enhanced practical/field driven knowledge of students, they would be taken to laboratories or Aquatic research institutes/industries.

Assessment Methods:

- Power point presentations
- Assignments with emphasis on recent studies in the Aquatic Biology
- Written examination.

Keywords:

Fresh water, Marine Biology, Aquatic resources, Management of resources

Recommended Books:
Goldman. Limnology.II Edition
Odum and Barrett. Fundamentals of Ecology.V Edition

Suggested Readings:
Pawlowski. Physicochemical Methods for Water and Wastewater Treatmen.I Edition Wetzel. Limnology. III edition
Trivedi and Goyal. Chemical and Biological Methods for Water Pollution Studies

Online Tools and Web Resources:
- MOOC https://swayam.gov.in/courses/5686-animal-diversity

GE IV: Environment and Public Health

Course Learning Objective:
Health is wealth but this wealth is directly affected by the environment. Environmental issue that affects human health is the most important trigger that has led to the urgency of conservation of environment. All the aspects of human health, including quality of life are determined by physical, chemical, biological, social and psychological factors in environment. The sustenance of environment is the key to development of future of mankind.This courseaims to create awareness among students about the necessity conservation of Mother Nature. The main objective of the syllabus is to assess, correct, control and prevent those factors that can adversely affect environment and hence health of present and future generation.

Course Learning Outcome:
Upon completion of course, students will be able to:
- Get familiarizedwith various aspects of environmental risks and hazards.
- Recognize the climate change due to human activities.
- Be aware about the various impacts of environmental degradation on human health through case studies and how it can be prevented.
- Learn about the nuclear and chemical disaster;s and their after effects through cases studies.
- Know various waste management technologies and their utility.
- Understand the diagnostic methods of various diseases and ways to prevent them.
- Realize the importance of nature conservation for betterment of human race and all living beings.

Course Content:

Theory [Credits: 4] **60hrs**

Unit1: Introduction 10hrs

Sources of Environmental hazards, Hazard identification and accounting, Bioaccumulation, Biomagnification, Dose Response Evaluation, exposure Assessment. (*Chapter 18, 22, 23: Chirac)*

Unit 2: Climate Change 10hrs

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, *El Nino La Nina,* Southern Oscillation (ENSO), Effect of climate change on public health
(Chapter 9: Vasudevan; Chapter 26: Subhramaniam; Chapter 12: Park; Chapter 33: MishraandPandey)

Unit3: Air, water, noise pollution: Sources, effects and control

Smog: Causes and its effect on human health, Effect of noise on Human health, Water borne diseases, Respiratory ailments (Asthma). Nuclear accidents and holocaust. Case Histories and their aftermath of: Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident.

(Chapter 7, 9 and 10: Vasudevan; Chapter 26: Subhramaniam; Chapter 12: Park; Chapter 3,
5: Bullard and Filborn; Chapter 1: Crowland. Louvar)

Unit 4: Waste Management Technologies *15hrs*

Classification and Characteristics of solid and hazardous waste, Sewage treatment and its management, Solid waste management, Handling and disposal: Biomedical waste and Nuclear waste, Health risk due to hazardous waste (Minamata disease)

(Chapter 7 and 11, Vasudevan; Chapter 12: Park; Chapter 33: Mishra and Pandey)

Unit 5: Diseases 10hrs

Causes, symptoms and control of tuberculosis,Vector borne diseases (Dengue, Malaria), Typhoid, Cholera, Cancer, Infectious diseases

(Chapter 5 and 6: Park)

Practical [Credits: 2]

1. To determine pH, Cl, SO_4, NO_3 in soil samples from different locations.

Teaching and Learning Process:

Generic Elective papers are interdisciplinary in nature. This paper has been revised for better understanding of the subject by the students even from unrelated disciplines. For an effective teaching learning process instead of teaching in a complete lecture mode, there should be interactive teaching for better understanding of the topic. The topics under Waste management can be understood through visits to waste treatment plants.There can be extended practical other than the ones included in the syllabus which may include collection of data, data analysis and preparing report.Incorporation of media and multimedia andscreening of documentaries/movies relevant to the current scenario of environmental degradation will create awareness among students.Students can present case studies or Government's initiative relevant to the topics related to the paper. Quizzes and debates can be used for better understanding of the topics. Continuous evaluation through tests, presentation, assignments and project work will inculcate in-depth understanding of the subject.

Assessment Methods:

The various methods can be adopted for continuous evaluation of the students:

- Regular class test
- Oral presentation as part of assignment
- Participation in discussion
- Project work with viva
- Performance in regular and extended practical

Keywords:

Environment, Pollution, Environmental hazards, Public Health, Climate Change, Waste management technologies

GE-IV: Human Physiology

Course Learning Objective:

The students will be introduced to the principles of normal biological function in human body. Basic human physiology will be outlined and correlated with histological structures. Students will be exposed to the concept of how animals maintain an internal

homeostatic state in response to changes in their external environment. Hands-on practical skills useful in routine life will be inculcated among students. Students will be encouraged for subsequent biological courses that require an understanding of the physiology of organisms.

Course Learning Outcome:
Upon completion of the course, students will be able to:

- Know the principles of normal biological function in human body.
- Outline basic human physiology and correlate with histological structures.
- Understand how animals maintain an internal homeostatic state in response to changes in their external environment.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Digestion and Absorption of Food 12 hrs

Structure and function of digestive system; Digestion and absorption of carbohydrates, fats and proteins; Nervous and hormonal control of digestion (in brief)
(Chapter 24: Tortora & Derrickson)

Unit 2: Functioning of Excitable Tissue (Nerve and Muscle) 10 hrs

Structure of neuron and brief introduction of neuroglia; Propagation of nerve impulse (myelinated and non-myelinated nerve fibre); Structure of skeletal muscle; Mechanism of muscle contraction (Sliding filament theory); Neuromuscular junction
(Chapter 12 and 10: Tortora & Derrickson)

Unit 3: Respiratory Physiology 8 hrs

Structure and function of respiratory tract and Lungs; Ventilation, External and internal respiration; Transport of oxygen and carbon dioxide in blood; Factors affecting transport of gases
(Chapter 23: Tortora & Derrickson)

Unit 4: Renal Physiology 8 hrs

Functional anatomy of kidney; Mechanism and regulation of urine formation
(Chapter 26: Tortora & Derrickson)

Unit 5: Cardiovascular System 8 hrs

Structure of heart; Coordination of heartbeat; Cardiac cycle and ECG
(Chapter 20: Tortora & Derrickson)

Unit 6: Endocrine and Reproductive Physiology 14 hrs

Structure and function of endocrine glands and related disorders (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes); Brief account of spermatogenesis and oogenesis; Menstrual cycle
(Chapter 18 and 28: Tortora & Derrickson)

Practical [Credits: 2]

1. Preparation of temporary mounts: Neurons and Blood film.
2. Preparation of haemin and haemochromogen crystals.
3. Demonstration of haemoglobin using Sahli's haemoglobinometer.
4. Examination of permanent histological sections of mammalian, stomach, lung, kidney, thyroid, pancreas, testis, ovary.

Teaching and Learning Process:

Interactive learning using classic lecture mode, Power Point Presentations, Discussion, Audio Visual aids, etc. will be used to create awareness and interest among students.

Assessment Methods:

- Diagnostic assessment- to check the knowledge base. It is desired, as being a Generic Elective paper, students would come from diverse streams (science, commerce and arts).
- Formative assessment- written test/*viva-voce* to check the retention of the topic.
- At the end, summative assessment could be done and students to be rewarded on the basis of presentations, test, project reports, theory and practical examination.

Keywords:

Physiology, Histology, Anatomy, Physiological pathways, Feed-back loops, Control and coordination.

Recommended Books:

- Widmaier E, Raff H and Strang K. (2013) Vander's Human Physiology: The Mechanism of Body Function**s**. McGraw-hill Education XIIIth Edition.
- Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology. XII Edition, John Wiley and Sons, Inc.

Suggested Readings:

- Guyton, A.C. and Hall, J.E. (2011) Textbook of Medical Physiology. XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
- Kesar, S. and Vashisht, N. (2007) Experimental Physiology. Heritage Publishers.
- Prakash, G. (2012) Lab Manual on Blood Analysis and Medical Diagnostics. S. Chand and Company Ltd.

Online Tools and Web Resources:

- e portals like SWAYAM
- http://nsdl.niscair.res.in

ZH GE V Exploring The Brain: Structure And Function

Course Learning Objective:

Exploring the Brain Structure and function is designed for science undergraduates with the aim to provide them an understanding of neural structures as well as its functions which are prerequisites for higher studies in neurology and psychiatry courses. This introductory course will lead students to explore the nervous system on multiple levels. They will learn about the structure of human brain as well as cellular & molecular components of nervous system which come together in neuronal circuits for conducting signals and memory consolidation. This course is also designed to familiarize students with different neurological disorders, neuro-physiological as well as neuro-imaging techniques used for its diagnosis. Overall, this course will provide students basic knowledge and awareness about field of neuroscience. The course content is mapped to provide an overview of brain anatomy and various aspect of nervous system to our

undergraduates who wish to pursue higher studies or research in the field of neuroscience.

Course Learning Outcome:
Upon completion of the course, students will be able to:

- Define the cellular- and anatomical-level organisation of the brain.
- Understand the properties of neuronal and non-neuronal cells that make up the brain including the propagation of electrical signals used for cellular communication.
- Comprehend how the interaction of cells and neural circuits leads to various higher level activities like cognition and behaviour.
- Identify principles /mechanism underlying various neurological disorders.
- Learn about neuroimaging methods used for disease diagnosis; and neurophysiological methods for sleep and epilepsy analysis.

Course Content

Theory [Credits: 4] **60 hrs**

Unit 1: Introduction 3 hrs

Historical views of the Brain; Neuron doctrine; Organisation and Classification of nervous system.
(Chapter 1 and 2: Mark F. Bear)

Unit 2: Evolution and Adaptation of Brain 6 hrs

Brain evolution and behavioral adaptation; Theories of brain evolution – involving addition of structure or areas, involving new formation and reorganisation of circuits.
(Chapter 16 and 17: Kent and Carr)

Unit 3: Cellular Neurobiology 8hrs

Neurons and Glia: Neurons - Soma, Axon, Classification of Neurons; Glia Dendrite; -

Astrocytes, Oligodendrocytes and other non-neuronal cells. Action potential: its generation and propagation. Synapse: Types of synaptic transmission, Principles of synaptic transmission and synaptic integration.
(Chapter 7: Mark F. Bear)

Unit 4: Understanding Brain Structure through Development

Formation of neural tube, Primary brain vesicles; Differentiation of forebrain, midbrain and hindbrain.Cerebral cortex - neocortical evolution and structure-function relationship.Gross anatomy of human brain, Spinal cord; Cranial nerves, Meninges, ventricular system.
(Chapter 4, 5: Mark F. Bear; Chapter 4- 13: ER Kandel)

14 hrs

Unit 5: Chemical Control of Brain, Behaviour, Learning& Memory 18 hrs

Structure and functions of hypothalamus, pituitary and pineal glands. Diffuse modulatory systems of the brain - noradrenergic, serotonergic, dopaminergic and cholinergic system.Neurotransmitters, Ionotropic and metabotropic receptors. Molecular basis of learning and memory formation: role of the cortex, and hippocampus. Synaptic plasticity and memory consolidation

(Chapter 6, 15, 20: Mark F. Bear; Chapter 65: ER Kandel; Chapter 7, 8, 10: JH Byrne)

Unit 6: Rhythms of the Brain 4 hrs

Biological Rhythms: Circadian Rhythms and Zeitgebers, Role of the suprachiasmatic nucleus in regulating circadian rhythms, Electroencephalogram; Sleep rhythms, neural mechanisms of sleep.

(Chapter 20: JH Byrne; Chapter 51: ER Kandel)

Unit 7: Neurological Disorders 7 hrs

Molecular neurodegeneration in Alzheimer and Parkinson disease. Psychosocial and biological approaches to mental illness like Obsessive-Compulsive Disorder (OCD); Attention-Deficit/Hyperactivity Disorder (ADHD) and Schizophrenia.Neuroimaging techniques: PET,CT and MRI imaging for disease diagnosis.

(Chapter 21: Mark F. Bear; Chapter 63: ER Kandel)

Practical [Credits: 2]

1. Dissection and study of *Drosophila* nervous system.
2. Observation and quantitation of *Drosophila* photoreceptor neurons.
3. Perform histochemistry of spinal cord and brain to identify neurons and subcortical structures.
4. Action potential: simulations under normal conditions and in presence of toxins.
5. Prepare a brief project on electrophysiological hallmark of sleep-wake staging or epileptogenesis.

Teaching and Learning Process:

Knowledge will be shared between teacher and students through two-way communication. Learning among students will be facilitated by using problem solving exercises, elaborative quiz-based learning, smart class-based teaching, using multimedia and animation videos as well as interactive sessions.They will be motivated to take up mini-project works, prepare models and participate in group discussions for increasing their awareness about experimental neuroscience.

Assessment Methods:

The learners/ students can be assessed in the following ways:

- Continuous assessment will be made during entire semester. Summative assessment will be collected through as mid semester and semester end evaluations.
- Students will be asked to give powerpoint or black-board presentation on related topics to increase their basic presentation skills and knowledge.
- Students will be provided feedback on assignments to improve their writing skills and academic performance.
- From time to time learners will be given theoretical and practical problems to test their theoretical skills and promote practical knowledge.

Keywords:

Neuroscience, Neuroanatomy, Circadian rhythms, Sleep, Neurochemistry, Action potentials, Learning and memory, Synaptic plasticity, Neurotransmitters, Cognitive, Neurodegenerative diseases, Alzheimer, Parkinson disease.

Recommended Books:

- Mark F. Bear, Barry W. Connors, Michael A. Paradiso (2015). Neuroscience: Exploring the brain. IV Edition.
- ER Kandel, JH Schwartz and TM Jessell (2010). Principles of Neural Science.IV Edition, , McGraw-Hill Companies.
- John H. Byrne. Ruth Heidelberg and M. Neal Waxham. From Molecules to Networks: An Introduction to Cellular and Molecular Neuroscience.

Suggested Readings:

- Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P (eds). (2002). Molecular Biology of the Cell.IV Edition, New York: Garland.
- Kelly R.B. (1993). Storage and release of neurotransmitters. Cell 72:43–53.
- Kimelberg H.K. (2010). Functions of mature mammalian astrocytes: A current view. The Neuroscientist 16:79–106.
- Bezanilla F. (2008). Ion channels: from conductance to structure. Neuron 60:456–468.
- Goedert M. and Spillantini M.G. (2006). A century of Alzheimer's disease. Science 314:777–781. Peter J Simmons and David Young-CUP-2003, Nerve Cells and Animal Behaviour. II Edition.
- Stephan M. Stahl-CUP-2000, Essential Psychopharamacology- Neuroscientific Basis and Practical Applications, II Edition.
- Vilayanur S. Ramachandran and Sandra Blakeslee (1998). Phantoms in the Brain
- Rita Carter (2009). The Human Brain Book

Online Tools and Web Resources:

- Learn Medical Neuroscience. Virtual Lab. https://www.learnmedicalneuroscience.nl/virtual-lab/sensory-systems/
- Allen Brain Atlases:http://portal.brain-map.org
- Human Brain project:https://www.humanbrainproject.eu/en/
- Neuroscience learning resource: https://www.hhmi.org/biointeractive/neuroscience-collection
- JoVE Science Education. https://www.jove.com/science-education-library
- Coursera- Introduction to Neuroanatomy.
- Coursera- General principles of sensory system part 1 and 2.
- Swayam (MHRD) Portal:

  Demystifying The Brain online course –Neuroscience of Human Movement online How The Brain Creates Mind online course

  Learning about Learning: A Course on Neurobiology of Learning and Memory Cognitive Science online course

GE-VI Food, Nutrition and Health

Course Learning Objective:

The prime focus is to provide the students with a basic understanding of the relationship between food, nutrition and health. It is imperative that focus should be on realistic issues faced by people with respect to nourishment at all stages of life.Unhealthy eating habits particularly the shift from fresh food consumption to packaged foods with added salts and preservatives have contributed to the obesity epidemic in nearly all parts of the world. It is important to understand this link and change eating habits in accordance to one`s age, pregnancy, lactation and physical activity.By taking steps to eat healthy, one can obtain the nutrients required by the body to stay healthy, active, and strong. Mental health is also affected largely by our lifestyle. Apart from physical activity, the intake of the required vitamins, minerals and antioxidants alsonourish the brain. Malnutrition is the main cause of impairment of growth in young children and infants and leads to diseases like Marasmus. Moreover, food hygiene includingfood and water borne infections along with food spoilage has also been covered in this course.

Course Learning Outcome:

Upon the completion of the course, students will be able to:

- Have a better understanding of the association of food and nutrition in promoting healthy living.
- Think more holistically about the relationship between nutrition science, social and health issues.
- Move on to do post-graduation studies and can apply for jobs as food safety officers, food analysts, food inspectors, food safety commissioners or controllers for jobs in organizations like FSSAI.
- Specialize in various fields of nutrition.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Basic concept of food and nutrition 13hrs

Food Components and food-nutrients, Concept of a balanced diet, nutrient needs and dietary pattern for various groups- adults, pregnant and nursing mothers, infants, school children, adolescents and elderly. Food Pyramid, Nutritional anthropometry- BMI, waist-to-hip ratio, skin-fold test and bioelectrical impedance; interpretation of these measurements.
(Part 1, 5 and 6: Mann and Truswell; Chapter 1, 7 and 11: Gibney)

Unit 2: Nutritional Biochemistry 15hrs

Carbohydrates, Lipids, Proteins, their dietary source and role Vitamins- their dietary source and importance Minerals- their biological functions.Dietary Fibres - Definition, their dietary source and nutritional importance. Elementary idea of Probiotics, Prebiotics, Organic Food.

(*Part 1 and 2: Mann and Truswell; Chapter 8 and 9: Gibney; Chapter 1, 2, 4, 5 and 7: Lee and Salminen)*

Unit 3: Health 17hrs

Definition and concept of health, Major nutritional Deficiency diseases- (kwashiorkor and marasmus), Deficiency disorders, their causes, symptoms, treatment, prevention and government programmes, if any. Life style related diseases- hypertension, diabetes mellitus, Atherosclerosis and obesity- their causes and prevention through dietary and

lifestyle modifications, Social health problems- smoking, alcoholism, drug dependence and Common ailments- cold, cough, and fevers, their causes and treatment.
(Chapter 1 and 2: Robinson; Chapter 8: Gibney; Chapter 4, 6, 7, 13 and 18: Elia)

Unit 4: Food hygiene 15 hrs

Food and Water borne infections;Bacterial infection: Cholera, typhoid fever, dysentery; Viral infection: Hepatitis, Poliomyelitis;Protozoaninfection: amoebiasis, giardiasis; Parasitic infection: taeniasis and ascariasis their transmission, causative agent, sources of infection, symptoms and prevention; Brief account of food spoilage: Causes of food spoilage and their preventive measures.

(Chapter 14 and 15: Gibney; Chapters 2, 3 and 5: Hawker; Part I and II: Clive de W Blackburn)

Practical [Credits: 2]

1. To detect adulteration in a) Ghee b) Sugars c) Tea leaves and d) Turmeric
2. Estimation of Lactose in milk and diagnosis of lactose intolerance by measuring hydrogen gas during expiration.
3. Ascorbic acid estimation in food by titrimetry
4. Estimation of Calcium in foods by titrimetry
5. Study of the stored grain pests from slides/photographs (*Sitophilus oryzae, Trogoderma granarium, Callosobruchus chinensis*and *Tribolium castaneum*): their identification, habitat and food sources, damage caused and control. Preparation of temporary mounts of the above stored grain pests.
6. Visit to food testing lab /or any agency of food standards
7. Project work
8. Undertake computer aided diet analysis and nutrition counselling for different age groups.
9. Identify nutrient rich sources of foods (fruits and vegetables), their seasonal availability and price.
10. Study of nutrition labelling on selected foods

Teaching and Learning Process:

Lectures using PowerPoint and chalk-blackboard method & RBPT will be used to impart knowledge. Use of IT-CT facility will be integrated in the learning. Survey based short projects as assignments will help students to gain insight in the subject. Visit to prominent food and nutrition laboratories to learn about basic techniques will arouse interest among students.

Assessment Methods:

- Quizzes, multiple choice questions, fill in the blanks and short answers
- Student presentation
- Take-home Assignments
- End of term theory and Practical examination

Keywords:

Food, Nutrition, Health, Food Pyramid, Diseases

Recommended Books:

- Shashi Goyal & Pooja Gupta. Food, Nutrition and Health (ISBN: 9788121940924)
- Linda Tapsell. Food, Nutrition and Health. I Edition, Oxford (ISBN: 978-0195518344)
- Gibney MJ et al. (eds) (2009) Introduction to Human Nutrition. Wiley-Blackwell A John Wiley & Sons Ltd, Nutritional Society.
- Mann J and Truswell SA, Essentials of Human Nutrition, Oxford University Press
- Yuan Kun Lee and Seppo Salminen: Handbook of Probiotics and Prebiotics, second ed., John Viley & Sons, Inc.
- James Robinson, Deborah J McCornick, Concepts in Health and Wellness, Delmar Cenage Learning, 1st ed

- Jeremy Hawker, Norman Begg, Iain Blair, Ralf Reintjes, Julius Weinberg, Communicable Disease Control Handbook, 2nd ed
- Clive de W Blackburn, Food Spoilage Microorganisms, Woodhead Publishing Limited, cambridge

Suggested Readings:

- Avantina Sharma. Principles of Therapeutic Nutrition and Dietetics.. CBS Publishers and Distributors Pvt. Ltd.
- Elia M et al. (eds) Clinical Nutrition. Wiley-Blackwell A John Wiley & Sons Ltd.

GE-VII: Animal Cell Biotechnology

Course Learning Objective:

The syllabus of Generic elective course/ paper on "Animal Cell Biotechnology" is revised to cater to the needs of Choice Based Credit System (CBCS). The changing scenario of higher education in India and abroad is taken into consideration to make this syllabus more oriented towards current need of modern research and industrial sectors. The revised and updated syllabus is based on a basic and applied approach with vigor and depth. Empowerment of students to face research and industrial outlets by nurturing independent thinking, initiating scientific enquiry and developing their entrepreneurship skills is at the centre of this syllabus. The units of the syllabus are well defined, taking into consideration the level and capacity of students.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Get a clear concept of the basic principles and applications of biotechnology.
- ☐ Know the basic techniques used in genetic manipulation helping them continue with higher studies in this field.
- Acquire knowledge of the basic principles, preparations and handling required for animal cell culture.
- Understand principles underlying the design of fermenter and fermentation process and its immense use in the industry.
- ☐ Design small experiments for successful implementation of the ideas and develop solutions to solve problems related to biotechnology keeping in mind safety factor for environment and society.
- Apply knowledge and skills gained in the course to develop new diagnostic kits and to innovate new technologies further in their career.
- Enhance their understanding of the various aspects and applications of biotechnology as well as the importance of bio-safety and ethical issues related to it.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit1: Introduction 2 hrs

Concept and Scope of Biotechnology
(Chapter 1: Glick)

Unit2: Techniques in Gene Manipulation 20hrs

Outline process of genetic engineering and recombinant DNA technology, Isolation of genes, Concept of restriction and modification: Restriction endonucleases, DNA modifying enzymes, Cloning Vectors: Plasmids, Phage vectors, Cosmids, Phagemids (lambda & M13), BAC, YAC, HAC. Shuttle and Expression Vectors. Construction and screening of Genomic libraries and cDNA libraries. Transformation techniques: Electroporation and Calcium Chloride method.Agarose and Polyacrylamide Gel Electrophoresis, Southern, Northern and Western blotting, DNA sequencing: Sanger method, Polymerase chain reaction, DNA Fingerprinting and DNA microarrays.

(Chapter 3, 4, 5 and 9: Glick; Chapter 4: Watson)

Unit 3: Fermentation

Different types of Fermentation: Submerged & Solid state; batch, Fed batch & Continuous; Stirred tank, Air Lift, Downstream Processing: Filtration, centrifugation, extraction, chromatography (Only Principles: Adsorption, Ion exchange, gel filtration, hydrophobic, affinity and size exclusion and lyophilization.

(Chapter 17: Glick; Chapter 14: S

Unit 4: Transgenic Animal Technology 5 hrs

Production of transgenic animals: Retroviral method, DNA microinjection method, Nuclear Transplantation: Dolly and Polly.

(Chapter 21: Glickingh)

Unit 5: Animal Cell Culture and rDNA Application in Health 18 hrs

Basic techniques in animal cell culture, Primary Culture and Cell lines, Culture media- Natural and Synthetic, Cryopreservation of cultures, Recombinant Vaccines, Gene Therapy (*in-vivo* and *ex-vivo*), Production of recombinant Proteins: Monoclonal Antibodies, Insulin and growth hormones, Bio safety: Physical and Biological containment.

(Chapter 10 and 11 Glick; Chapter 5 and 20: Singh)

Practical [Credits: 2]

1. Packing and sterilization of glass and plastic wares for cell culture.
2. Preparation and sterilization of culture media.
3. Preparation of genomic DNA from *E. coli.*
4. Plasmid DNA isolation (pUC 18/19) and its detection on agarose gel.
5. Calculation of transformation efficiency from the data provided
6. Restriction digestion of lambda ( ) DNA using *Eco*R1 and *Hind* III.
7. Techniques:
    a) Western Blot
    b) Southern Hybridization
    c) DNA Fingerprinting
    d) PCR
    e) DNA Microarrays

15hrs

Teaching and Learning Process:

As the students of Generic Elective papers are from different and unrelated discipline (s) the revised syllabus is framed with a basic introduction to the concept of genetic engineering, scientific techniques and applications. Effective teaching involves aligning the three major components of instruction: learning objectives, assessments, and instructional activities. To increase the participation of students and in turn develop their interest in the topic; more discussions/ Quizzes will be included.Brain storming sessions will be held to help students march towards scientific excellence, the recent research activities/trends.Open Learning Resourceslike SWAYAM, MOOC etc. will be shown.Field trips/visits to Institute/Industry will be plannedto provide better exposure and more practical view of studying science and applying it judiciously. Students understanding will be assessed at frequent intervals throughout the learning process. Continuous evaluation of learning will be carried out and efforts will be made to measure cognitive as well as applied learning. Project work, quiz, problem solving exercise, classroom assessment methods, end-semester examination, etc. will constitute the different components of the overall assessment. Extra efforts and time slots will be given to students facing difficulty in understanding any topic/concept etc.

Assessment Methods:

- Regular class tests with objective/subjective questions.
- Oral presentation on regular basis by students.
- Group discussion: Dividing the class into groups and assign each group a topic or latest
- development/scientific finding in the field of biotechnology.
- Small projects can be designed by students (a group of 3 students) to enhance their critical thinking, improving scientific writing and honing their skills.
- Assignment work.

Keywords:

Restriction enzymes, Vector, Transformation, Fermentation, Transgenic, Gene Therapy

Recommended Books:

- Mathur, J.P. and Barnes, D. (1998). Methods in Cell Biology:. Animal Cell Culture Methods. Academic Press
- Brown, T.A. (1998). Molecular Biology Labfax II: Gene Cloning and DNA Analysis. II Edition, Academic Press, California, USA.
- Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology- Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.

Suggested Readings:

- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C.and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA-Genes and Genomes-A Short Course. III Edition, Freeman and Co., N.Y., USA.

Online Tools and Web Resources:

- https://epgp.inflibnet.ac.in/
- https://swayam.gov.in/Home

GE-VIII Insect Vector and Disease

Course Learning Objective:

Insect vectors cause many diseases which lead to millions of deaths across the world every year especially in developing countries. The rate of pathogen transmission by insects is increasing at an alarming rate posing a growing threat to the human population. Disease transmission by these insects can be prevented only by studying their biology, modes of transmission of pathogens by them, evaluation of associated risk factors, devise effective methods to control these insects and resolve the challenges posed.

Course Learning Outcome:

Upon completion of the course, the students will be able to:

- Identify different insects and classify them based on their morphology and behaviour
- Describe the host-pathogen relationships and the role of the host reservoir on transmission of parasite
- Explain various modes of transmission of parasite by insect vectors
- Recognize various possible modern tools and methodologies for laboratory diagnosis, surveillance and treatment of diseases
- Define various terms related to insect transmitted diseases such as vectorial capacity, mechanical and biological transmission, host specificity etc.
- Identify the risk groups and characterize them on the basis of exposure risk
- Explain control methods of insect vector diseases including spreading awareness on public health programs and mitigating insect borne diseases
- Employ the use of advanced management strategies in disease control with respect to parasite evolution

Course Content:

Theory [Credits:4] **60 hrs**

Unit 1: Introduction to Insects 10 hrs

General Features of Insects, Classification of insects up to Orders- key identification features; Morphological features: Head- Eyes, Types of antennae, Types of Mouth parts *w.r.t.* feeding habits: siphoning type (butterfly), sponging type (housefly), biting and chewing type (cockroach), piercing and sucking type (mosquito), chewing and lapping type (honey bee); thorax: types of legs.

(Chapters 2 and 3: Service, M.W.; Chapters 1 and 2: Richard P. Lane & Roger W. Crosskey)

Unit 2: Concept of Vectors 4 hrs

Brief introduction to carriers and vectors (mechanical and biological vector); Insect reservoirs; Host-vector relationship; Vectorial capacity; Adaptations in insects to act as vectors; Host Specificity; Modes of disease transmission- vertical and horizontal transmission.

(Chapters 1 and 2: Service, M.W.; Chapter 1: Richard P. Lane & Roger W. Crosskey)

Unit 3: Insects as Vectors 10 hrs

Features of Orders with insects as vectors (Diptera, Siphonaptera, Siphunculata, Hemiptera) *w.r.t.* evolutionary, anatomical, physiological, cellular and molecular adaptations towards their role as vectors; Management strategies to control insect vectors- quarantine, cultural, mechanical, chemical, biological, behavioural.

(Chapters 1 and 2: Service, M.W.; Chapter 2: Richard P. Lane & Roger W. Crosskey)

Unit 4: Dipterans as Disease Vectors 20 hrs

Dipterans as important insect vectors- Mosquitoes, Sand flies, Houseflies; Study of mosquito borne diseases- Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis; Control of mosquitoes; Study of sand-fly borne diseases- Leishmaniasis, phlebotomus fever; Control of sand flies. Study of house fly as important mechanical vector; Myiasis; Control of housefly.

(Chapters 4, 5, 6, 8 and 12: Service, M.W.; Chapters3, 4,5 and 11: Richard P. Lane & Roger W. Crosske)

Unit 5: Siphonapterans as Disease Vectors 5 hrs

Fleas as insect vectors; Host-specificity; Study of flea borne diseases- Plague, typhus fever; Control of sand flies.

(Chapter 15: Service, M.W.; Chapter 16: Richard P. Lane & Roger W. Crosskey)

Unit 6: Siphunculata as Disease Vectors 6 hrs

Human louse (head, body and pubic louse) as disease vectors; study of louse borne diseases-Typhus fever, relapsing fever, trench fever, vagabond's disease, phthiriasis; Control of human louse.

(Chapter 16: Service, M.W.; Chapter 15: Richard P. Lane & Roger W. Crosskey)

Unit 7: Hemipterans as Disease Vectors 5 hrs

Bugs as insect vectors; Blood sucking bugs; Chagas disease; Bed bugs as mechanical vectors; Control and prevention methods.

(Chapter 17 and 18: Service, M.W.; Chapter 14: Richard P. Lane & Roger W. Crosskey)

Practical [Credits: 2]

1. Study of different kinds of mouth parts of insects through slides/specimens
2. Study of insect vectors through permanent slides or photographs: *Aedes, Culex, Anopheles,* lice (head, body, pubic), bed bug*, Phlebotomus* (sand fly), *Musca domestica* (house fly)
3. Study of different diseases transmitted by above insect vectors.
4. Project report on any one disease transmitted by insect vector

Teaching and Learning Process:

Classroom teaching using Power point presentations enabled with related photographs of insect vectors, their life stages and disease diagnosis will be employed to clarify concepts. Case studies of epidemics caused by insects as vectors will be discussed to make the students aware about their importance. Visit to local diagnostic centre will provide an overview of various medical tests conducted to detect and confirm vector transmitted diseases.

Assessment Methods:

- Continuous and Comprehensive Formative assessment (attendance, assignment and test)
- *Viva-voce: Viva-voce* is a critical component of assessment of the practical component of a course. Inquiry-based learning
- Summative Assessment
- Term-end Theory exam
- Term-end Practical exam

Keywords:

Insect, Vector, Diseases, Mosquito, Host, Parasite

Recommended Books:

- Service, M.W. (1980) A Guide to Medical Entomology. Macmillan Press.
- Ricard P. Lane and Crosskey R. W. (1993) Medical insects and Arachnids. Springer Science and Business Media, B. V.
- Burgess, N.R.H and Cowan, G.O. (1993) A Colour Atlas of Medical Entomology. Springer Science and Business Media, B. V.

Suggested Readings:

- Kenneth G. V. Smith. (1973) Insects and other Arthropods of Medical Importance. John Wiley and Sons.
- Nicholas R. H. Burgess. (1981) Arthropods of Medical Importance. Noble Books Ltd. Hampshire

Discipline Core Courses: Zoology
: Animal Diversity

Course Learning Objective:

Zoology is the scientific study of animal life. Animals are the most diverse creatures on this planet. This course gives a framework for understandingthe diversity within different groups, and interrelationship among different species and genera within each group. The aim of this course is to understand the importance of animal kingdom in context to hierarchy, body plan and their role in ecological development. This course provides an overview of the invertebrate and vertebrate animals, including sponges, cnidarians, flatworms, nematodes, annelids, molluscs, arthropods, echinoderms, invertebrate chordates, fishes, amphibians, reptiles, birds, and mammals. This paper comprises of 15 units. First nine units provide knowledge of coelom formation, different level of organization, different modes of living, evolutionary changes of Non-chordates and their salient features. Whereas, remaining units will impart knowledge on different classes of chordates. After completion of this course, the learners will have a framework for understanding all of the different types of animals, and the characteristics of each.

Course Learning Outcome:
Upon completion of the course, students will be able to:

- Distinguish between major phyla of animals through a demonstrated understanding of their taxonomic classification and diversity.
- Describe the distinguishing characteristics of all major phyla.
- Understand the fundamental differences among animal body plans and relate them to function, taxonomic classification, and evolutionary relationships among phyla.
- Illustrate lifecycles, structure, function and reasons for importance of few representative organisms from different groups of animals.
- Identify anatomical structures from prepared tissues.
- Observe living animals in the environment and relate observations to theory from the course.
- Recognize major animal phyla and animals on the basis of their external characteristics.

Course Content: **60 hrs**

(CREDITS 4)

Unit 1: Kingdom Protista **4**

General characters and classification up to classes; Locomotory Organelles and locomotion in Protozoa (Amoeba & Paramoecium)

Unit 2: Phylum Porifera **3**

General characters and classification up to classes; Canal System in *Sycon*

Unit 3: Phylum Cnidaria **3**

General characters and classification up to classes; Polymorphism in Hydrozoa

Unit 4: Phylum Platyhelminthes **3**

General characters and classification up to classes; Life history of *Taenia solium*

Unit 5: Phylum Nemathelminthes **5**

General characters and classification up to classes; Life history of *Ascaris lumbricoides* and its parasitic adaptations

Unit 6: Phylum Annelida **3**

General characters and classification up to classes; Metamerism in Annelida

Unit 7: Phylum Arthropoda **5**

General characters and classification up to classes; Vision in Arthropoda, Metamorphosis in Insects

Unit 8: Phylum Mollusca **4**

General characters and classification up to classes; Torsion in gastropods

Unit 9: Phylum Echinodermata **4**

General characters and classification up to classes; Water-vascular system in Asteroidea

Unit 10: Protochordates **2**

General features and Phylogeny of Protochordata

Unit 11: Agnatha **2**

General features of Agnatha and classification of cyclostomes up to classes

Unit 12: Pisces **4**

Unit 13: Amphibia **4**

General features and Classification up to orders; Parental care

Unit 14: Reptiles **4**

General features and Classification up to orders; Poisonous and non-poisonous snakes, Biting mechanism in snakes

Unit 15: Aves **5**

General features and Classification up to orders; Flight adaptations in birds

Unit 17: Mammals **5**

Classification up to orders; Origin of mammals

Note: Classification of Unit 1-9 to be followed from "Barnes, R.D. (1982). *Invertebrate Zoology*, V Edition"

General features and Classification up to orders; Osmoregulation in Fishes

PRACTICAL **(CREDITS 2)**

1. Study of the following specimens:

Amoeba, *Euglena, Plasmodium, Paramecium, Sycon*, *Obelia, Physalia, Aurelia, Metridium, Taenia solium,* Male and female *Ascaris lumbricoides, Aphrodite, Nereis, Pheretima, Hirudinaria, Palaemon, Cancer*, *Limulus*, *Palamnaeus, Scolopendra*, *Julus*, *Periplaneta, Apis, Chiton, Pila, Unio, Loligo, Sepia, Octopus, Pentaceros, Ophiura, Echinus, Cucumaria* and *Antedon, Balanoglossus, Ascidia, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo, Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla, Chelone, Hemidactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gavialis,* Any six common birds from different orders, *Sorex*, Bat, *Loris*

2. Study of the following permanent slides:

T.S. and L.S. of *Sycon*, Study of life history stages of *Taenia,* T.S. of Male and female *Ascaris*

3. Key for Identification of poisonous and non-poisonous snakes

An "**animal album**" containing photographs, cut outs, with appropriate write up about the above mentioned taxa. Different taxa/ topics may be given to different sets of students for this purpose.

Teaching and Learning Process:

Teaching-Learning process will include delivery of lectures using boards, Multimedia presentation, short documentaries on animal diversity, imparting practical based knowledge through specimens, live demonstration of diversity in surroundings.

Assessment Methods:
Assessment methods are:

- Course examination
- Multiple choice questions quiz at the end of each lecture
- Case studies
- Oral presentation by students
- Report or essay writing
- Project based to assess the skills of scientific enquiry and problem-solving

Keywords:

Invertebrates, Vertebrates, Protozoa, Parazoa, Metazoa, Protochordates, Parasitic adaptations, Migration, Parental care, Biting mechanism, Osmoregulation, Canal system, Water vascular system

Recommended Books:

- Campbell and Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
- Raven, P. H. and Johnson, G. B. (2004). Biology, VIEdition, Tata McGraw Hill Publications. New Delhi.

Suggested Readings:

- Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
- Ruppert, Fox and Barnes (2006). Invertebrate Zoology. A functional Evolutionary Approach,VII Edition, Thomson Books/Cole
- Kardong, K. V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. Tata McGraw Hill Publishing Company. New Delhi.

Discipline Core Courses: Zoology

Genetics and Evolutionary Biology

Course Learning Objective:

Unknown to them, human beings had been applying the principles of genetics by engaging in selective breeding of domesticated animals for many centuries. However, it was only with the work of Mendel and advent of 20th century, that basic principles of the science of genetics were formulated. In about a century of its existence, this field has generated tremendous amount of knowledge through observational and experimental research. The information amassed in the last century has laid the

foundation for more discoveries in this important field of life science. This course aims to provide an overview of genetics starting from the work of Mendel to the current understanding of various phenomena like recombination, transposition, sex determination and mutations. The course will help in building sound fundamental knowledge of the principles of genetics, to be used as a stepping stone for higher studies and research in this field.

Course Learning Outcome:
Upon completion of the course, students will be able to:

- Have a deeper understanding of the varied branches of the biological sciences like microbiology, evolutionary biology, genomics and metagenomics.
- Gain knowledge of the basic principles of inheritance.
- Analyse pedigree leading to development of analytical skills and critical thinking enabling the students to present the conclusion of their findings in a scientific manner.
- Know the mechanisms of mutations, the causative agents and the harmful impact of various chemicals and drugs being used in day to day life.
- Find out the effects of indiscriminate use of various chemicals, drugs or insecticides in nature by studying their effect on various bacterial species in soil and water samples from different industrial or polluted areas.

CORE COURSE II

GENETICS AND EVOLUTIONARY BIOLOGY

THEORY
(CREDITS 4)

Unit 1: Introduction to Genetics 3

Mendel's work on transmission of traits, Genetic Variation, Molecular basis of Genetic Information

Unit 2: Mendelian Genetics and its Extension 8

Principles of Inheritance, Chromosome theory of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, sex linked inheritance, extra-chromosomal inheritance

Unit 3: Linkage, Crossing Over and Chromosomal Mapping 9

Linkage and crossing over, Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and coincidence, Somatic cell genetics - an alternative approach to gene mapping

Unit 4: Mutations 7

Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy; Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations,

Unit 5: Sex Determination **4**

Chromosomal mechanisms, dosage compensation

Unit 6: History of Life **2**

Major Events in History of Life

Unit 7: Introduction to Evolutionary Theories **5**

Lamarckism, Darwinism, Neo-Darwinism

Unit 8: Direct Evidences of Evolution **5**

Types of fossils, Incompleteness of fossil record, Dating of fossils, Phylogeny of horse

Unit 9: Processes of Evolutionary Change **9**

Organic variations; Isolating Mechanisms; Natural selection (Example: Industrial melanism); Types of natural selection (Directional, Stabilizing, Disruptive), Artificial selection

Unit 10: Species Concept **6**

Biological species concept (Advantages and Limitations); Modes of speciation (Allopatric, Sympatric)

Unit 11: Macro-evolution **5**

Macro-evolutionary Principles (example: Darwin's Finches)

Unit 12: Extinction **6**

Mass extinction (Causes, Names of five major extinctions, K-T extinction in detail), Role of extinction in evolution

GENETICS AND EVOLUTIONARY BIOLOGY

PRACTICAL **(CREDITS 2)**

1. Study of Mendelian Inheritance and gene interactions (Non Mendelian Inheritance) using suitable examples. Verify the results using Chi-square test.
2. Study of Linkage, recombination, gene mapping using the data.
3. Study of Human Karyotypes (normal and abnormal).
4. Study of fossil evidences from plaster cast models and pictures
5. Study of homology and analogy from suitable specimens/ pictures

6. Charts:

a) Phylogeny of horse with diagrams/ cut outs of limbs and teeth of horse ancestors

b) Darwin's Finches with diagrams/ cut outs of beaks of different species

7. Visit to Natural History Museum and submission of report

SUGGESTED READINGS

- ☐ Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India.
- ☐ Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons Inc.
- ☐ Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*. X Edition. Benjamin Cummings.
- ☐ Russell, P. J. (2009). *Genetics- A Molecular Approach*. III Edition. Benjamin Cummings.
- ☐ Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. *Introduction to Genetic Analysis*. IX Edition. W. H. Freeman and Co.
- ☐ Ridley, M. (2004). *Evolution*. III Edition. Blackwell Publishing
- ☐ Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). *Evolution*. Cold Spring, Harbour Laboratory Press.
- ☐ Hall, B. K. and Hallgrimsson, B. (2008). *Evolution*. IV Edition. Jones and Bartlett Publishers
- ☐ Campbell, N. A. and Reece J. B. (2011). *Biology*. IX Edition, Pearson, Benjamin, Cummings.
- ☐ Douglas, J. Futuyma (1997). *Evolutionary Biology*. Sinauer Associates.

Teaching and Learning Process:

Lectures, using blackboard and power-point presentations will be delivered by the teachers and the queries of students will be addressed after they have revised the topic. Concepts can be clarified by giving assignments e.g. constructing linkage maps, pedigree analysis, probability calculations etc. As a part of peer learning, regular group discussions will be held
amongst the students to enhance their knowledge. In order to develop scientific temperament and hone communication skills of students, power point presentations, paper presentations and debates can be organized on various themes as prescribed in the syllabi, while focusing on the latest development in them. An essential part of learning is through observation and experimentation. Thus, visit of students to laboratories working in the field of Genetics (e.g. *Drosophila*, microbial genetics) can be organized. Also, students can be encouraged to undertake internships in these labs so as to deepen their interest in this field. Lectures of researchers can be organized to update students about the latest developments in this field, so that they get motivation to make a career in this highly versatile field of biological sciences.

Assessment Methods:
Students can be assessed by following methods for proper understanding of the subject.

- Problem solving assignments.
- Assessment of case history projects to prepare pedigrees and find out the probabilities of occurrence of diseases in next generations.
- Power point presentation evaluation on different topics.
- Holding debates and assessment for understanding of the subject.
- Multiple choice questions (Test) for assessing grasping of the topics.
- Laboratory visits to understand the research going on in the field of Genetics and to submit reports.

Keywords:

Mendelian inheritance, Multiple alleles, Penetrance, Epistasis, Pleiotropy, Gene, Chromosomal mapping, Recombination, Interference, Mutagens, chromosomal aberrations, Sex determination, Dosage compensation, Nuclear inheritance, Mitochondrial inheritance, Polygenic inheritance, Complementation, Transposons, Ty elements, Ac-Ds elements.

Recommended Books:

- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons In.
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cumming
- Pierce B. A. (2012). Genetics-A Conceptual Approach. IV Edition. W. H. Freeman and Company

Discipline Core Courses: Zoology
Physiology and Biochemistry

Course Learning Objective:

Biochemistry is to understand the core biological phenomena at the molecular level. The aim of the course is to comprehend the fundamental principles of chemistry that govern complex biological systems.The program is designed to enable a student acquire sound knowledge of biochemistry and its practicable applicability. To make the study relevant, interesting, encouraging to the students to join the industry or to prepare

them for higher studies including research. The new and updated syllabus is based on a basic and applied approach to ensure that students develop problem solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics.

Course Learning Outcome:

- Upon completion of the course, students should be able to: Gain knowledge and skill in the fundamentals of biochemical sciences, interactions and interdependence of physiological and biochemical processes.
- Get exposed to various processes used in industries and gain skills in techniques of chromatography and spectroscopy.
- Demonstrate foundation knowledge in biochemistry; synthesis of proteins, lipids, nucleic acids, and carbohydrates; and their role in metabolic pathways along with their regulation.
- Know about classical laboratory techniques, use modern instrumentation, design and conduct scientific experiments, and analyze the resulting data.
- Be knowledgeable in proper procedures and regulations in handling and disposal of chemicals.

CORE COURSE III

PHYSIOLOGY AND BIOCHEMISTRY

THEORY
(CREDITS 4)

Unit 1: Nerve and muscle
Structure of a neuron, Resting membrane potential, Graded potential, Origin of Action potential and its propagation in myelinated and non-myelinated nerve fibres, Ultra-structure of skeletal muscle, Molecular and chemical basis of muscle contraction

Unit 2: Digestion **5**

Physiology of digestion in the alimentary canal; Absorption of carbohydrates, proteins, lipids

Unit 3: Respiration **5**

Pulmonary ventilation, Respiratory volumes and capacities, Transport of Oxygen and carbon dioxide in blood

Unit 4: Excretion **5**

Structure of nephron, Mechanism of Urine formation, Counter-current Mechanism

Unit 5: Cardiovascular system **6**

Composition of blood, Hemostasis, Structure of Heart, Origin and conduction of the cardiac impulse, Cardiac cycle

Unit 6: Reproduction and Endocrine Glands **7**

Physiology of male reproduction: hormonal control of spermatogenesis; Physiology of

female reproduction: hormonal control of menstrual cycle

Structure and function of pituitary, thyroid, Parathyroid, pancreas and adrenal

Unit 7: Carbohydrate Metabolism **8**

Glycolysis, Krebs Cycle, Pentose phosphate pathway, Gluconeogenesis, Glycogen metabolism, Review of electron transport chain

Unit 8: Lipid Metabolism **5**

Biosynthesis and β oxidation of palmitic acid

Unit 9: Protein metabolism **5**

Transamination, Deamination and Urea Cycle

Unit 10: Enzymes **6**

Introduction, Mechanism of action, Enzyme Kinetics, Inhibition and Regulation

PRACTICAL **(CREDITS 2)**

1. Preparation of hemin and hemochromogen crystals

2. Study of permanent histological sections of mammalian pituitary, thyroid, pancreas, adrenal gland
3. Study of permanent slides of spinal cord, duodenum, liver, lung, kidney, bone, cartilage

4. Qualitative tests to identify functional groups of carbohydrates in given solutions (Glucose,

2. Estimation of total protein in given solutions by Lowry's method.

3. Study of activity of salivary amylase under optimum conditions

SUGGESTED READINGS

- ☐ Tortora, G.J. and Derrickson, B.H. (2009). *Principles of Anatomy and Physiology*, XII Edition, John Wiley & Sons, Inc.
- ☐ Widmaier, E.P., Raff, H. and Strang, K.T. (2008) *Vander's Human Physiology*, XI Edition., McGraw Hill
- ☐ Guyton, A.C. and Hall, J.E. (2011). T*extbook of Medical Physiology*, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company
- ☐ Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). *Biochemistry*. VI Edition. W.H Freeman and Co.

- ☐ Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). *Principles of Biochemistry*. IV Edition. W.H. Freeman and Co.
- ☐ Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009). *Harper's Illustrated Biochemistry*. XXVIII Edition. Lange Medical Books/Mc Graw3Hill.

- **DISCIPLINE CENTRIC ELECTIVE COURSES**
  CORE COURSE IV

- **COMPARATIVE ANATOMY AND DEVELOPMENTAL BIOLOGY OF VERTEBRATES**

Teaching and Learning Process:

At the end of the IV Semester, the UG student is expected to demonstrate clear understanding of general concepts and fundamental biochemical principles; such as structure/function of biomolecules metabolic pathways, regulation of biological and biochemical processes through class room lectures and encourage interactive learning with simulation studies including animations, presentations. Principles of various biochemical techniques will be explained through advanced instrumentations. The data will be analysed and interpreted with computer-assisted software.Project-based studies will help students devise experiments independently.

Assessment Methods:

- Continuous Assessment by regular class tests; Projects and Assignments both individual/group projects to inculcate independent thinking as well as team work among the students. Regular Presentationsto be assessed based on the content, novelty, explanation and response to queries.

- Online Assignment/Project Submission; Self-assessment through Quiz.

- Concept maps (Diagram with hierarchical nodes, labeled with concepts), Concept (The instructor presents one or more questions during class along with several possible answers), Oral/Poster Presentation.

- Use of free video recording tool and online video platform (such as PresentationTube; http://presentationtube.com/). It helps to connect and train teachers and students to record, publish, and share quality video tutorials.

Keywords:

Carbohydrates, Lipids, Proteins, Enzymes, Amino acids, Nucleic acids, DNA, RNA, Conjugates, Steroids

Course Learning Objective:

This course aims to provide the undergraduate students a thorough knowledge of structural details and comparative account of the different organ systems of the body from lower to higher vertebrates, and protochordates, thus enabling them to appreciate the incredible vertebrate diversity. The course furnishes an understanding of evolutionary basis of morphological and anatomical differences as well as similarities that occur among vertebrates. It helps students propose possible homology between structures, and understand how they evolved as the vertebrates dwelled different habitats. The structural modifications of digestive, circulatory, respiratory and skeletal system relates to the distribution of animals in their different comfort zones of habitat and ecological niches. The understanding of anatomical details of organ systems of mammals like rat and mice aims to gives the basic information for their use in experimental and research studies in different branches of Zoology like Immunology, Medical Zoology and Reproductive Biology etc.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Explain comparative account of the different vertebrate systems

- Understand the pattern of vertebrate evolution, organisation and functions of various systems.

- Learn the comparative account of integument, skeletal components, their functions and modifications in different vertebrates.

- Understand the evolution of heart, modification in aortic arches, structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and digestive system and its anatomical specializations with respect to different diets and feeding habits.
- Learn the evolution of brain, sense organs and excretory organsto a complex, highly evolved form in mammals;
- Learn to analyze and critically evaluate the structure and functions of vertebrate systems, which helps them to discern the developmental, functional and evolutionary history of vertebrate species.
- Understand the importance of comparative vertebrate anatomy to discriminate human biology.

THEORY

Unit 1: Integumentary System **4**
Derivatives of integument w.r.t. glands and digital tips

Unit 2: Skeletal System **3**
Evolution of visceral arches

Unit 3: Digestive System **4**
Brief account of alimentary canal and digestive glands

Unit 4: Respiratory System **5**
Brief account of Gills, lungs, air sacs and swim bladder

Unit 5: Circulatory System **4**
Evolution of heart and aortic arches

Unit 6: Urinogenital System **4**
Succession of kidney, Evolution of urinogenital ducts

Unit 7: Nervous System **3**
Comparative account of brain

Unit 8: Sense Organs **3**
Types of receptors

Unit 9: Early Embryonic Development **12**

Gametogenesis: Spermatogenesis and oogenesis w.r.t. mammals, vitellogenesis in birds; Fertilization: external (amphibians), internal (mammals), blocks to polyspermy; Early development of frog and humans (structure of mature egg and its membranes, patterns of cleavage, fate map, up to formation of gastrula);types of morphogenetic movements; Fate of germ layers; Neurulation in frog embryo.

Unit 10: Late Embryonic Development **10**

Implantation of embryo in humans, Formation of human placenta and functions, other types of placenta on the basis of histology; Metamorphic events in frog life cycle and its hormonal regulation.

Unit 11: Control of Development **8**

Fundamental processes in development (brief idea) – Gene activation, determination, induction, Differentiation, morphogenesis, intercellular communication, cell movements and cell death

PRACTICAL **(CREDITS 2)**

1. Osteology:

   a) Disarticulated skeleton of pigeon and rabbit

   b) Carapace and plastron of turtle /tortoise

   c) Mammalian skulls: One herbivorous and one carnivorous animal.

2. Frog - Study of developmental stages - whole mounts and sections through permanent slides – cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages.
3. Study of the different types of placenta- histological sections through permanent slides or photomicrographs.
4. Study of placental development in humans by ultrasound scans.

5. Examination of gametes - frog/rat - sperm and ova through permanent slides or photomicrographs.

SUGGESTED READINGS

- ☐ Kardong, K.V. (2005) *Vertebrates' Comparative Anatomy, Function and Evolution*. IV Edition. McGraw-Hill Higher Education.

- ☐ Kent, G.C. and Carr R.K. (2000). *Comparative Anatomy of the Vertebrates*. IX Edition. The McGraw-Hill Companies.

☐ Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate Structure*, John Wiley and Sons.

☐ Walter, H.E. and Sayles, L.P; *Biology of Vertebrates*, Khosla Publishing House.

☐ Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.

☐ Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.

☐ Carlson, Bruce M (1996). Patten's Foundations of Embryology, McGraw Hill, Inc.

Assessment Methods:

- Formative assessment on regular basis: This includes putting up questions in order to monitor students' learning. Students are marked on the basis of continuous assessment and end term exam.
- Continuous assessment: includes class test, assignment and attendance.
- Marks for the attendance: to maintain regularity in the class.
- Practical: provide a great opportunity to assess students for their understanding about a concept lectured, and demonstrate activity in small groups. Additionally, regular assessment of the practical skills gained by students can also be done.
- Summative assessment: includes project reports, assignments, oral presentations, *viva-voce*, evaluation of practical records, regular tests.

Keywords:

Anatomy, integument, axial, appendicular, cranium, jaw suspensorium, pectoral and pelvic girdle, visceral arches, dentition, air sacs, accessory respiratory receptors, visual,cranial, spinal nerves,

RecommendedBooks:

- Kardong, K.V. (2005). Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
- Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
- Leiem C.F., Bermis W.E, Walker, W.F, Grande, L. (2001). Functional anatomy of the vertebrates, An evolutionary perspective. III Edition, Brookes/Cole, Cengage Learning.

Suggested Readings:

- C.K Weichert and W. Presch (1970). Elements of Chordate Anatomy, IV Edition, McGraw-Hill.
- Pough.H. (2018). Vertebrate Life.X Edition. Pearson International.

Online Tools and Web Resources:

- SWAYAM (Functional anatomy and regulation of vision, hearing, taste, smell and touch, Link - https://www.swayamprabha.gov.in/index.php/program/upcoming/9).
- SWAYAM (Structure of heart), Link- https://www.swayamprabha.gov.in/index.php/program/archive/9.
- COURSERA (PALEONTOLOGY: Early vertebrate evolution, Link – https://www.coursera.org/learn/early-vertebrate-evolution).

DISCIPLINE SPECIFIC ELECTIVES

DSE 1

AQUATIC BIOLOGY

Course Learning Objective:

The primary aim of the syllabus is to sensitize the students about the paramount role and importance of nature. The study of Ecology imparts us the knowledge about the judicious use of existing ecological resources for sustainable development. Ecology is the only branch of science which briefs us on the ways and means of living with nature for mutual benefit. Study of ecology will provide students opportunity to understand its practical aspects and helps them to solve many contemporary ecological issues such as global warming, land degradation, habitat loss, desertification and pollution etc. The hands-on experiences of laboratory will also enable students to understand the ecosystem and ecology in a better way.

Course Learning Outcome:
Upon completion of the course, students should be able to:

- Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors.
- Comprehend the population characteristics, dynamics, growth models and interactions.
- Understand the community characteristics, ecosystem development and climax theories.
- Know about the types of ecosystems, food chains, food webs, energy models, and ecological efficiencies.
- Apply the basic principles of ecology in wildlife conservation and management.

- Inculcate scientific quantitative skills, evaluate experimental design, read graphs, and analyse and use information available in scientific literature.

THEORY (Credits 4)

UNIT 1: Aquatic Biomes

Brief introduction of the aquatic biomes: Freshwater ecosystem (lakes, wetlands, streams and rivers), estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs.

UNIT 2: Freshwater Biology

Lakes: Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico–chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Nutrient Cycles in Lakes-Nitrogen, Sulphur and Phosphorous.

Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.

UNIT 3: Marine Biology

Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.

UNIT 4: Management of Aquatic Resources

Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation (legislations), Sewage treatment Water quality assessment- BOD and COD.

PRACTICAL (Credits 2)

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.
3. Determine the amount of Turbidity/transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collected from a nearby lake/ water body.
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.
5. A Project Report on a visit to a Sewage treatment plant/Marine bio-reserve/Fisheries Institutes.

SUGGESTED READINGS

- ☐ **Anathakrishnan** : Bioresources Ecology 3rd Edition
- ☐ **Goldman** : Limnology, 2nd Edition
- ☐ **Odum and Barrett** : Fundamentals of Ecology, 5th Edition
- ☐ **Pawlowski** : Physicochemical Methods for Water and Wastewater Treatment, 1st Edition
- ☐ **Wetzel** : Limnology, 3rd edition
- ☐ **Trivedi and Goyal** : Chemical and biological methods for water pollution studies
- ☐ **Welch** : Limnology Vols. I-II

Teaching and Learning Process:

The course involves four hours each of classroom teaching and laboratory activity per week. Classroom work would include lectures based on textbook and scientific journal readings. Lectures will consist of traditional board teaching as well as power point presentations. Learning process will also include participatory activities like focused group discussions, presentations by students, experience sharing, brainstorming and project writing. Field trip activities to National parks and Eco-parks would complement and enhance understanding of the course concepts and information about the wildlife and its conservation. Laboratory work will provide students the first hands-on experience for better understanding of the subject.

Assessment Methods:

- Evaluation will determine the extent to which the students demonstrate desired learning outcomes.

- Multiple assessment methods will be used as evaluation criteria which include continuous assessment, assignments, tests, class presentations and mock tests.

- Project writing based on leanings from field trips will also be held for comparative evaluation of students.

Teaching and Learning Process:

The course involves four hours each of classroom teaching and laboratory activity per week. Classroom work would include lectures based on textbook and scientific journal readings. Lectures will consist of traditional board teaching as well as power point presentations. Learning process will also include participatory activities like focused group discussions, presentations by students, experience sharing, brainstorming and project writing. Field trip activities to National parks and Eco-parks would complement and enhance understanding of the course concepts and information about the wildlife and its conservation. Laboratory work will provide students the first hands-on experience for better understanding of the subject.

Assessment Methods:

- Evaluation will determine the extent to which the students demonstrate desired learning outcomes.

- Multiple assessment methods will be used as evaluation criteria which include continuous assessment, assignments, tests, class presentations and mock tests.

- Project writing based on leanings from field trips will also be held for comparative evaluation of students.

DSE 2

INSECT, VECTORS AND DISEASES

Course Learning Objective:

The coursewould provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organisation of the animals based on their evolutionary relationships, structural and functional affinities. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- Appreciate the diversity of non-chordates living in varied habit and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically analyse the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

THEORY **(Credits 4)**

Unit I: Introduction to Insects **6**

General Features of Insects, Morphological features, Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits

Unit II: Concept of Vectors **6**

Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host-vector relationship, Vectorial capacity, Adaptations as vectors, Host Specificity

Unit III: Insects as Vectors **8**

Classification of insects up to orders, detailed features of orders with insects as vectors – Diptera, Siphonaptera, Siphunculata, Hemiptera

Unit IV: Dipteran as Disease Vectors **24**

Dipterans as important insect vectors – Mosquitoes, Sand fly, Houseflies;

Study of mosquito-borne diseases – Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis; Control of mosquitoes

Study of sand fly-borne diseases – Visceral Leishmaniasis, Cutaneous Leishmaniasis, Phlebotomus fever; Control of Sand fly

Study of house fly as important mechanical vector, Myiasis, Control of house fly

Unit IV: Siphonaptera as Disease Vectors **6**

Fleas as important insect vectors; Host-specificity, Study of Flea-borne diseases –

Plague, Typhus fever; Control of fleas

Unit V: Siphunculata as Disease Vectors **4**

Human louse (Head, Body and Pubic louse) as important insect vectors; Study of louse-borne diseases –Typhus fever, Relapsing fever, Trench fever, Vagabond's disease, Phthiriasis; Control of human louse

Unit VI: Hempitera as Disease Vectors **6**

Bugs as insect vectors; Blood-sucking bugs; Chagas disease, Bed bugs as mechanical vectors, Control and prevention measures

INSECT VECTORS AND DISEASES

PRACTICAL (CREDITS 2)

1. Study of different kinds of mouth parts of insects

2. Study of following insect vectors through permanent slides/ photographs: *Aedes, Culex, Anopheles*, *Pediculus humanus capitis, Pediculus humanus corporis, Phithirus pubis, Xenopsylla cheopis, Cimex lectularius, Phlebotomus argentipes, Musca domestica,* through permanent slides/ photographs

3. Study of different diseases transmitted by above insect vectors

Submission of a project report on any one of the insect vectors and disease transmitted

SUGGESTED READINGS

- ☐ Imms, A.D. (1977). *A General Text Book of Entomology*. Chapman & Hall, UK
- ☐ Chapman, R.F. (1998). *The Insects: Structure and Function*. IV Edition, Cambridge University Press, UK
- ☐ Pedigo L.P. (2002). *Entomology and Pest Management*. Prentice Hall Publication
- ☐ Mathews, G. (2011). *Integrated Vector Management: Controlling Vectors of Malaria and Other Insect Vector Borne Diseases*. Wiley-Blackwell

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the

students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and round tables on the various aspects of non-chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of Classification.Curriculum related assignments would improve the reading ,writing and abstracting skills and enhance the critical thinking of the students.

Assessment Methods:
Various measures adopted will be as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones during which students will be evaluated.

- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.

- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.

- ***VIVA-VOCE:*** *Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.

- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Keywords:

Acoelomates, Classification, Cnidaria, Ctenophora, Diploblastic, Helminths, Metazoa, Parazoa, Porifera, Protista, Protostomia, Pseudocoelomates, Structural organization, Symmetry, Triploblastic

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.

- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education

*Note: Classification to be followed from "Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India"

Suggested Readings:

- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis. III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

- Swayam (MHRD) Portal
- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity)
- Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology)
- ePG Pathshala (MHRD)Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35

SKILL ENHANCEMENT COURSES

SEC 1

APICULTURE

Course Learning Objective:

The coursewould provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organisation of the animals based on their evolutionary relationships, structural and functional affinities. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Course Learning Outcome:
Upon completion of the course, students should be able to:

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- Appreciate the diversity of non-chordates living in diverse habit and habitats.

- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically think about the organization, complexity and characteristic features of non-chordates.
- Getting familiarized with the morphology and anatomy of representatives of various animal phyla.
- Comprehendthe economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

APICULTURE

(CREDITS 2)

Unit 1: Biology of Bees **(4)**

History, Classification and Biology of Honey Bees

Social Organization of Bee Colony

Unit 2: Rearing of Bees **(10)**

Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth

Bee Pasturage

Selection of Bee Species for Apiculture

Bee Keeping Equipment

Methods of Extraction of Honey (Indigenous and Modern)

Unit 3: Diseases and Enemies **(5)**

Bee Diseases and Enemies

Control and Preventive measures

Unit 4: Bee Economy **(2)**

Products of Apiculture Industry and its Uses (Honey, Bees Wax, Propolis), Pollen

etc

Unit 5: Entrepreneurship in Apiculture **(4)**

Bee Keeping Industry – Recent Efforts, Modern Methods in employing artificial

Beehives for cross pollination in horticultural gardens

8. Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted not only through classroom lectures to inculcate a conceptual base among the students about the subject but also through observations in nature and through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of non-chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:
Various measures adopted will be as follows:

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones during which students will be evaluated.

- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.

- Regular Presentations: Presentations by the students on a particular topic will enhance students' learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.

- *Viva-voce: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.

- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

SUGGESTED READINGS

- ☐ Prost, P. J. (1962). *Apiculture*. Oxford and IBH, New Delhi.

- ☐ Bisht D.S., *Apiculture*, ICAR Publication.

Singh S., *Beekeeping in India*, Indian council of Agricultural Research, NewDelhi

Teaching and Learning Process

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted not only through classroom lectures to inculcate a conceptual base among the students about the subject but also through observations in nature and through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of non-chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:

Various measures adopted will be as follows:

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones during which students will be evaluated.

- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.

- Regular Presentations: Presentations by the students on a particular topic will enhance students' learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.

- *Viva-voce: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.

- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

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SEC – 2

AQUARIUM FISH KEEPING

(CREDITS 2)

Course Learning Objective:

The coursewould provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organisation of the animals based on their evolutionary relationships, structural and functional affinities. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- Appreciate the diversity of non-chordates living in varied habit and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically analyse the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Unit1: Introduction to Aquarium Fish Keeping

The potential scope of Aquarium Fish Industry as a Cottage Industry, Exotic andEndemic species of Aquarium Fishes

Unit 2: Biology of Aquarium Fishes

Common characters and sexual dimorphism of Fresh water and Marine Aquariumfishes such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish

Unit 3: Food and feeding of Aquarium fishes

Use of live fish feed organisms. Preparation and composition of formulated fish feeds

Unit 4: Fish Transportation

Live fish transport - Fish handling, packing and forwarding techniques.

Unit 5: Maintenance of Aquarium

General Aquarium maintenance – budget for setting up an Aquarium Fish Farm as a Cottage Industry

Teaching and Learning Process

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted not only through classroom lectures to inculcate a conceptual base among the students about the subject but also through observations in nature and through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of non-chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:

Various measures adopted will be as follows:

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones during which students will be evaluated.

- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.

- Regular Presentations: Presentations by the students on a particular topic will enhance students' learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.

- *Viva-voce: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.

- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Keywords:

Annelida, Arthropoda, Coelomates, Classification, Deuterostomia, Echinodermata, Insecta, Metamerism, Metazoa, Mollusca, Onychophora, Structural organization, Symmetry, Triploblastic

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education

  *Note: Classification to be followed from "Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition, Cengage Learning, India"

Suggested Readings:

- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

- Swayam (MHRD) Portal
- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity)
- Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology)

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CC-III	Non-chordates II: Coelomates	SUBRATA MAITY
CC-IV	Cell Biology	AVISHEK SAMANTA
CC-V	Diversity of Chordates	BISWAJIT PAUL
CC-VI	Physiology: Controlling and Coordinating system	SOMA BERA

CC-VII	Fundamentals of Biochemistry	SUBRATA PAYRA
CC-VIII	Comparative Anatomy of Vertebrates	BISWAJIT PAUL
CC-IX	Physiology: Life Sustaining Systems	DR. MRINMAY GHORAI
CC-X	Biochemistry of Metabolic Processes	SUBRAT PAYRA SUBRATA MAITY
CC-XI	Molecular Biology	DR. MRINMAY GHORAI
CC-XII	Principles of Genetics	AVISHEK SAMANTA

CC-XIII	Developmental Biology	DR. MRINMAY GHORAI
CC-XIV	Evolutionary Biology	AVISHEK SAMANTA
DSE-I	Animal Behavior and Chronobiology	BISWAJIT PAUL
DSE-II	Animal Biotechnology	AVISHEK SAMANTA
DSE-III	Basic of Neuroscience	SOMA BERA
DSE-IV	Biology of Insecta	SUBRATA MAITY
DSE-V	Computational Biology	SUBRATA PAYRA
DSE-VI	Endocrinology	SUBRATA MAITY
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DSE-IX	Parasitology	SUBRATA PAYRA
DSE-X	Reproductive Biology	BISWAJIT PAUL
DSE-XI	Wild Life Conservation and Management	SUBRATA MAITY
GE-I	Animal Cell Biotechnology	SOMA BERA
GE-II	Animal Diversity	BISWAJIT PAUL
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GE-IV	Environment and Public Health	SOMA BERA

GE-V	Exploring the Brain: Structure and Function	DR. MRINMAY GHORAI
GE-VI	Food Nutrition and Health	AVISHEK SAMANTA
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GE-VIII	Insect Vectors and Diseases	BISWAJIT PAUL
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SEC-II	Aquarium Fish Keeping	AVISHEK SAMANTA SOMA BERA
SEC-III	Medical Diagnostics	SUBRATA MAITY
SEC-IV	Research Methodology	SUBRATA MAITY
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