

**Learning Outcomes based Curriculum Framework
(LOCF)
for
(ZOOLOGY)
Undergraduate Programme: A template
2019**



**UNIVERSITY GRANTS COMMISSION
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Preamble

Institutional infrastructures of colleges and universities within the country are incomparable and uneven, and they function with an additional variation of adopting different road maps for teaching and learning process. Thus, we have different syllabi, teaching methods, hands-on-training, and different learning outcomes. Introducing uniformity, whenever and wherever tried, has obviously not worked with the desired outcome. Added to this, failure to keep pace with the advancing knowledge base, half-hearted engagement and integration with other disciplines, and poor-transfer of skill sets to the students to negotiate efficiently with the changing needs, have made it essential to graduate from incremental inputs to syllabi revisions alone, to the use of disruptive approaches to reshape the subject-specific course structures, with measurable learning outcomes. The approach, if adopted, is bound to generate opinions of teachers and students alike to resist the change. However, the intention is to understand the subject of Zoology in the evolving biological paradigm in modern times; where, living beings need to be understood at the level of atomic interactions; and comparative systems of organisms need to be studied through the prism of integrated chemical, physical, mathematical and molecular entities to appreciate the inner working of different organisms at morphological, cellular, molecular, interactive and evolutionary levels. The syllabi could be shaped with a customised approach depending on the institutional infrastructure and geographical location, yet it should cater, in principle, to the expected learning outcomes more or less uniformly. For example, in diverse geographical domains with diverse skill sets, examples illustrated in detail for teaching and hands on exposure and field work could differ by involving the study of available species across the ladder of evolution, yet the comparative biology taught should provide a uniform level of understanding of the subject. After all, the purpose is to understand inner working of living-beings by comparing various systems within invertebrates and vertebrates i.e., from a single cell protozoan to multicellular humans, and develop a comprehensive understanding and appreciation of the differences through ICT tools and well-designed hands on practical exposures along with the field work. Added to this, if the same principle is followed to understand different phyla through the ladder of evolution and compare cardinal features for classification involving both morphological and molecular tools, along with associated field and lab work, the final product would be better trained without rote learning. Diversity in the life forms need to be understood by a Zoologist for its socio-economic capital, in case a student is interested in entrepreneurship, through applied aspects of Zoology; and by a career-

researcher as a ladder towards multiscale hierarchical systems, where chemical and physical principles would apply from molecules to self-assembled and organized organisms. The vibrancy to synthesize out of the knowledge gained and come out with disruptive outcomes, would define the learning outcomes of the future UG and PG students.

Apart from the above mentioned attributes expected of a UG/PG student related to the subject area of Zoology to be studied in an integrated and cross-disciplinary manner with a comprehensive understanding of all living systems, their relationship with the eco-system, and unravelling of their application value; the scale, character and rigour of which may vary from one institution to the other, it would, however, be mandatory to bring in uniformity in the learning outcomes with respect to the 'broad-range skill sets' related-to-the-discipline of the study and the 'Social skills'. Within the broad-range skill sets related to the discipline, what would be required is to impart and assess the quality of critical thinking, analytical and scientific reasoning, reflective thinking, information and digital literacy, and problem-solving capacity. These are part of the defined characteristic attributes to be demonstrated by a UG/PG in any discipline, as defined by the Core Committee on LOCF of UGC. On similar lines, what is expected of the social skills is to imbibe values for cooperative team work, moral and ethical awareness and reasoning, multicultural competence, leadership readiness and qualities and self- directed and lifelong learning attitude. Again, this has been a general guideline defined by the UGC Core Committee. It is obvious all of us together need to meet the challenge to bring in these attributes within each subject area of study, in the present case the subject of Zoology.

As regards the fine nuances of how to organize the course structure in Zoology and Aquaculture (the latter being a part of the subject of Applied Zoology, may not necessarily require separate emphasis) within the framework of expectations of the learning outcome, I provide a few steps of specific details for general debate and course corrections, wherever required.

Specific Details:

Background: Students should be equipped to identify the major groups of organisms, discuss the basis of their biodiversity and draw parallels with their phylogenetic relationship, using well thought cardinal features of classification on the basis of morphology and molecular information wherever available. This principle of comparative biology should be followed in understanding comparative anatomy, physiology and other functions for all in the hierarchy of animal evolution, instead of dealing with each phylum/order/species and each system as a stand-alone. This shall allow the student to gain comprehensive knowledge about different animal species in one go, appreciating the differences and similarities, thereby achieving proficiency in handling them experimentally or for research purposes. This would also reduce the burden of teaching on mentors, though initially a little hard work to shape the contents of the curriculum is required. Teachers would need to be trained for the same as well for a uniform approach to deliver and communicate.

A comprehensive knowledge of structure-function relationship at the level of gene, genome, cell, tissue, organ, and systems, through development would further add to the knowledge base and the learning outcome in terms of editing of genes and genomes for industrial application and research purposes. Short dissertations could be designed around these problems to give them hands-on-training and equip them with skill sets of use in future, in the areas of applied aspects of Zoology, including Aquaculture.

Details of the course content in an integrated fashion to cut down on some of the individual lectures would be designed by the members of the committee for further feedback to shape the syllabi better for both UG and PG students, so as to be monitored for the outcomes through the innovative processes of learning efficiently and effectively.

FOREWORD

1. Introduction

Zoology deals with the study of animal kingdom specially the structural diversity, biology, embryology, evolution, habits and distribution of animals, both living and extinct. As it covers a fascinating range of topics, the modern zoologists need to have insight into many disciplines. The learning outcomes-based curriculum framework for a B.Sc. degree in Zoology is designed to cater to the needs of students in view of the evolving nature of animal science as a subject. The framework is expected to assist in the maintenance of the standard of Zoology degrees/programmes across the country by reviewing and revising a broad framework of agreed expected graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes. The framework, however, does not seek to bring about uniformity in syllabi for a programme of study in Zoology, or in teaching-learning process and learning assessment procedures. Instead, the framework is intended to allow for flexibility and innovation in programme design and syllabi development, teaching-learning process, assessment of student learning levels.

2. Learning Outcomes based approach to Curriculum Planning

The courses should be delivered in terms of concepts, mechanisms, biological designs & functions and evolutionary significance cutting across organisms at B.Sc. level. These courses should be studied by students of all branches of biology. Both chalk and board, and PowerPoint presentations can be used for teaching the course. The students should do the dissertation/ project work under practical of different courses, wherever possible.

The students are expected to learn the courses with excitements of biology along with the universal molecular mechanisms of biological designs and their functions. They should be able to appreciate shifting their orientation of learning from a descriptive explanation of biology to a unique style of learning through graphic designs and quantitative parameters to realize how contributions from research and innovation have made the subjects modern, interdisciplinary and applied and laid the foundations of Zoology, Animal Sciences, Life Sciences, Molecular Biology and Biotechnology. These courses and their practical exercises will help the students to apply their knowledge in future course of their career development in higher education and research. In addition, they may get interested to look for engagements in industry and commercial activities employing Life Sciences, Molecular Biology and Biotechnology. They may also be interested in entrepreneurship and start some small business based on their interest and experience.

2.1 Nature and extent of the B.Sc. degree Programme in Zoology

B.Sc. Zoology course will help to understand the behaviour, structure and evolution of animals. Zoologists use a wide range of approaches to do this, from genetics to molecular and cellular biology, as well as physiological processes and anatomy, whole animals, populations, and their ecology. The scope of Zoology as a subject is very broad. The intention is to understand the subject of Zoology in the evolving biological paradigm in modern times; where, living beings need to be understood at the level of atomic interactions; and comparative systems of organisms need to be studied through the prism of integrated chemical, physical, mathematical and molecular entities to appreciate the inner working of different organisms at morphological, cellular, molecular, interactive and evolutionary levels. The key areas of study within the disciplinary/subject area of Zoology comprise: animal diversity, principles of ecology, comparative anatomy and developmental biology of vertebrates, physiology and biochemistry, genetics and evolutionary biology, animal biotechnology, applied zoology, behaviour, immunology, reproductive biology, and insect, vectors and diseases. B.Sc. degree programme in Zoology also deals with skill enhancement courses such as apiculture, aquarium fish keeping, medical diagnostics, sericulture etc. The depth and breadth of study of individual topics dealt with would vary with the nature of specific Zoology programmes. As a part of the efforts to enhance the interest and employability of graduates of Zoology programmes, the curricula for these programmes are expected to include learning experiences that offer opportunities for higher studies and research at reputed laboratories.

2.2 Aims of Bachelor's degree programme in Zoology

Zoology is the study of all animal life; from primitive microscopic malaria-causing protozoa to large advanced mammals, across all environmental spheres from red deer in mountain forests to dolphins in deep oceans, and from underground burrowing voles to golden eagles in the skies. Some of these animals are useful to us and we nurture them as pets or livestock; some are serious pests or disease-causing; and some are simply splendid and awe-inspiring. No matter what our relation with the animals is, we need to understand their behaviour, population dynamics, physiology and the way they interact with other species and their environments. It provides students with the knowledge and skill base that would enable them to undertake further studies in Zoology and related

areas or in multidisciplinary areas that involve advanced or modern biology and help develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

The modern era requires a classical zoologist with a modern approach to master many subjects of Zoology. There is a need for the students to compete with the globe, therefore, the main focus of this curriculum is to enable the student to be professionally competent and successful in a career. Having Zoology as backbone of the curriculum, this course, with the department centric electives will enhance the skills required to perform research in laboratory and experimental research. The students can choose to focus on a “whole animal” or a “bits of animals” approach. The “whole animal” pathway makes the students proficient in the identification and study of animals while the latter approach provides the skills required to pursue laboratory and experimental work such as disease research, DNA technologies, wildlife forensics etc. The curriculum can be modified to such extent that a student at B.Sc. level can be a specialist in immunology, ornithology, animal behaviour or entomology. For such specializations, the curriculum needs to focus on special skills to maximise the students’ employment probability; for example few skills needed by industry may include the species-specific monitoring for key species, handling of dangerous/ poisonous/ wild animals and the use of Geographic Information Systems (GIS) for data collection.

3. Graduate Attributes in Zoology

- ***Disciplinary knowledge and skills:*** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, theoretical principles and experimental findings in Zoology and its different subfields (animal diversity, principles of ecology, comparative anatomy and developmental biology of vertebrates, physiology and biochemistry, genetics and evolutionary biology, animal biotechnology, applied Zoology, aquatic biology, immunology, reproductive biology, and insect, vectors and diseases), and other related fields of study, including broader interdisciplinary subfields such as chemistry, physics and mathematics; (ii) ability to use modern instrumentation for advanced genomic and proteomic technology.
- ***Skilled communicator:*** Ability to impart complex technical knowledge relating to Zoology in a clear and concise manner in writing and oral skills.

- ***Critical thinker and problem solver:*** Ability to have critical thinking and efficient problem solving skills in the basic areas of Zoology (animal diversity, principles of ecology, comparative anatomy and developmental biology of vertebrates, physiology and biochemistry, genetics and evolutionary biology, animal biotechnology, applied Zoology, aquatic biology, immunology, reproductive biology, insect, vectors and diseases etc.).
- ***Sense of inquiry:*** Capability for asking relevant/appropriate questions relating to issues and problems in the field of Zoology, and planning, executing and reporting the results of an experiment or investigation.
- ***Team player/worker:*** Capable of working effectively in diverse teams in both classroom, laboratory and in industry and field-based situations.
- ***Skilled project manager:*** Capable of identifying/mobilizing appropriate resources required for a project, and manage a project to completion, while observing responsible and ethical scientific conduct; and safety and chemical hygiene regulations and practices.
- ***Digitally literate:*** Capable of using computers for Bioinformatics and computation and appropriate software for analysis of genomics and proteomics data, and employing modern bioinformatics search tools to locate, retrieve, and evaluate location and biological annotation genes of different species.
- ***Ethical awareness/reasoning:*** Capable of conducting their work with honesty and precision thus avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and appreciating environmental and sustainability issues. Research ethics committee expects them to declare any type of conflict of interest that may affect the research. Any plan to withhold information from researchers should be properly explained with justification in the application for ethical approval.
- ***Lifelong learners:*** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling.

4. Qualification Descriptors for a Bachelor's Degree programme in Zoology

The qualification descriptors for a Bachelor's Degree programme in Zoology may include the following:

- Demonstrate (i) a fundamental/systematic or coherent understanding of the academic field of Zoology, its different learning areas and applications, and its linkages with related disciplinary areas/subjects; (ii) procedural knowledge that creates different types of professionals related to Zoology area of study, including research and development, teaching and government and public service; (iii) skills in areas related to specialization area relating the subfields and current developments in the academic field of Zoology.
- Use knowledge, understanding and skills required for identifying problems and issues relating to Zoology. A keen interest in research and the study of living organisms.
- Communicate the results of studies undertaken accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s);
- Meet one's own learning needs, drawing on a range of current research and development work and professional materials;
- Apply one's subject knowledge and transferable skills to new/unfamiliar contexts to identify and analyse problems and issues and solve complex problems with well-defined solutions.
- Demonstrate subject-related and transferable skills that are relevant to Zoology-related job trades and employment opportunities
- Good observation skills
- Able to work precisely
- A logical approach to problem-solving
- Good oral and written communication abilities
- Able to work independently or with team members

5. Learning Outcomes in Bachelor's Degree programme in Zoology

5.1 Knowledge and Understanding

- Demonstrate (i) in-depth knowledge and understanding about the fundamental concepts, principles and processes underlying the academic field of Zoology and its different subfields (animal diversity, principles of ecology, comparative anatomy and developmental biology of vertebrates, physiology and biochemistry, genetics and evolutionary biology, animal biotechnology, applied Zoology, aquatic biology, immunology, reproductive biology, and insect, vectors and diseases, apiculture, aquarium fish keeping, medical diagnostics, and sericulture) (ii) procedural knowledge that creates different types of professionals in the field of Zoology and related fields such as, apiculture, aquarium fish keeping, medical diagnostics, and sericulture, etc.(iii) skills related to specialization areas within Zoology as well as within subfields of Zoology, including broader interdisciplinary subfields (Chemistry, Physics and Mathematics).
- Over the years, Zoologists were able to find many differences within the same breed of an animal species. As a Zoology professional one can study extinct animals by specializing in Paleozoology, on the different types of birds in Ornithology; opt for studying
- Herpetology and Arachnology, the branches dealing with the study of snakes and spiders, respectively or
- Appreciate the complexity of life processes, their molecular, cellular and physiological processes, their genetics, evolution and behaviour and their interrelationships with the environment.
- Study concepts, principles and theories related with animal behaviour and welfare.
- Understand and interpret data to reach a conclusion
- Design and conduct experiments to test a hypothesis.
- Understand scientific principles underlying animal health, management and welfare.
- Accept the legal restrictions & ethical considerations placed for animal welfare.
- Understand fundamental aspects of animal science relating to management of animals.

- Assess problems and identify constraints in management of livestock.

5.2 Subject Specific Intellectual and Practical Skills

The students will be able to

- Understand how organisms are classified and full and identified
- Demonstrate knowledge of basic zoological principles
- Use appropriate information with a critical understanding
- Learn basic laboratory and analytical skills
- Use effective methods for modifying animal behaviour
- Participate in animal management programmes in an effective manner
- Work safely and effectively in the field, in laboratories and in animal facilities
- Demonstrate competence in handling and statistical analysis of data gained from practical
- Learn communication and IT skills, including the collation and statistical analysis of data, citing & referencing work appropriately, communicating using a range of formats

In course learning outcomes, the student will attain subject knowledge in terms of individual course as well as holistically. The example related to core courses and their linkage with each other is stated below:

5.3 Learning Outcomes of different types of courses for B.Sc. Zoology

Core Courses (CC)

Programme Outcomes	CC 1	CC 2	CC 3	CC 4	CC 5	CC 6	CC 7	CC 8	CC 9	CC 10	CC 11	CC 12	CC 13	CC 14
Core competency	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Critical thinking	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Analytical reasoning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Research-skills	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Teamwork	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Discipline Specific Elective Courses (DSE)

Programme Outcomes	DSE 1	DSE 2	DSE 3	DSE 4	DSE 5	DSE 6	DSE 7	DSE 8	DSE 9	DSE 10	DSE 11
Additional Academic Knowledge	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Problem-solving	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Additional analytical skills	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Additional Research-skills	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Generic Elective Courses (GEC)

Programme Outcomes	GEC 1	GEC 2	GEC 3	GEC 4	GEC 5	GEC 6	GEC 7	GEC 8	GEC 9	GEC 10	GEC 11	GEC 12	GEC 13
Additional Academic Knowledge	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Exposure beyond discipline	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Problem-solving	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Analytical reasoning	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Ability Enhancement Course (AEC)

Programme Outcomes	AEC 1	AEC 2	AEC 3	AEC 4	AEC 5	AEC 6	AEC 7	AEC 8	AEC 9
Additional Academic Knowledge	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Psychological skills	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Problem-solving	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Skill Enhancement Course (SEC)

Programme Outcomes	SEC 1	SEC 2	SEC 3	SEC 4	SEC 5	SEC 6	SEC 7	SEC 8	SEC 9	SEC 10	SEC 11	SEC 12	SEC 13	SEC 14
Additional Knowledge enhancement	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Exposure beyond discipline	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Analytical reasoning	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Digital Literacy	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Moral and ethical awareness	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

The core courses would fortify the students with in-depth subject knowledge concurrently; the discipline specific electives will add additional knowledge about applied aspects of the program as well as its applicability in both academia and industry. Generic electives will introduce integration among various interdisciplinary courses. The skill enhancement courses would further add additional skills related to the subject as well as other than subject. In brief, the students graduated with this type of curriculum would be able to disseminate subject knowledge along with necessary skills to suffice their capabilities for academia, entrepreneurship and Industry.

For each syllabus, the course content has been divided into four units with a breakup of the topics to be covered to provide the students better understanding of the main theme represented in the title of each unit. Such type of design is to indicate the breadth of content to be taught thus ensuring more or less uniform coverage of information on a certain theme. The teacher has to take up the contents in such a manner by asking questions and answering them that the whole process appears to be an interesting narrative with topics falling in line rather than appearing as unrelated complex terms. Learning will be more enjoyable and imbibing if appropriate examples are cited from our daily lives.

6. Distribution of different courses with their credits for B.Sc. Zoology

6.1 Distribution of different types of courses with their credits for B.Sc. Zoology (Regular/ Pass Course)

Semester	Core Courses (CC) (6x12=72) Note: 14 CC are available. Choose 12 as compulsory. 6 credits (4T+2P) each	Ability Enhancement Electives (AEC) (2x4=8) Note: 9 AEC are available. Choose any 2; 4 credits each	Skill Enhancement Electives (SEC) (4x4=16) Note: 14 SEC are available. Choose any 4; 4 credits each	Discipline Specific Electives (DSE) (3x6=18) Note: 11 DSE are available. Choose any 3 6 credits (4T+2P) each	Generic Elective (GEC) (3x6=18) Note: 13 GEC are available. Choose any 3; 6 credits (4T+2P) each	Credit hour load
1.	CC-I CC-II	AEC			GEC	22
2.	CC-III CC-IV	AEC			GEC	22
3.	CC-V CC-VI		SEC		GEC	22
4.	CC-VII CC-VIII		SEC	DSE		22
5.	CC-IX CC-X		SEC	DSE		22
6.	CC-XI CC-XII		SEC	DSE		22
Credits	48(T)+24(P)=72	8(T)	16(T)	12(T)+6(P)=18	12(T)+6(P)=18	132
% Courses	54.6	6.0	12.2	13.6	13.6	100

6.2 Distribution of different types of courses with their credits for B.Sc. Zoology (Honours)

Semester	Core Courses (CC) (6x14=84) Note: 14 CC are available. All courses are compulsory. 6 credits (4T+2P) each	Ability Enhancement Electives (AEC) (2x4=8) Note: 9 AEC are available. Choose any 2; 4 credits each	Skill Enhancement Electives (SEC) (2x4=8) Note: 14 SEC are available. Choose any 2; 4 credits each	Discipline Specific Electives (DSE) (4x6=24) Note: 11 DSE are available. Choose any 4; 6 credits (4T+2P) each	Generic Elective (GEC) (4x6=24) Note: 13 GEC are available. Choose any 4; 6 credits (4T+2P) each	Seminar/Project/group discussion (2x 10=20) Choose any 2; 10 credits each	Credit hour load
1.	CC-I CC-II	AEC			GEC		22
2.	CC-III CC-IV	AEC			GEC		22
3.	CC-V CC-VI		SEC		GEC		22
4.	CC-VII CC-VIII		SEC		GEC		22
5.	CC-IX CC-X CC-XI			DSE DSE		SMR	30
6.	CC-XII CC-XIII CC-XIV			DSE DSE		SMR	30
Credits	56(T)+28(P)=84	8(T)	8(T)	16(T)+8(P)=24	16(T)+8(P)=24	20*	148
% Courses	56.80	5.40	5.40	16.20	16.20	13.5 ^{1*}	100

*optional

7. Course Structure for Bachelor's Programme in Zoology with details

7.1 Core Courses

These courses provide an in depth understanding of relevant theories, concepts, and principles of zoology besides having an insight into the philosophy of the subject. The students are likely to have a strong foundation in Zoology.

S.N.	Name of course	Theory	Practical	Credits
1.	Systematics & Diversity of Life - Protists to Chordates	4	2	6
2.	Developmental Biology & Evolution	4	2	6
3.	Comparative Anatomy & Physiology of Non-chordates	4	2	6
4.	Cell Biology and Histology	4	2	6
5.	Comparative Anatomy & Physiology of Chordates	4	2	6
6.	Genetics	4	2	6
7.	Biochemistry	4	2	6
8.	Behaviour and Chronobiology	4	2	6
9.	Ecology	4	2	6
10.	Molecular Biology	4	2	6
11.	Biotechniques	4	2	6
12.	Microbiology, Parasitology & Immunology	4	2	6
13.	Biostatistics & Bioinformatics	4	2	6
14.	Applied Zoology	4	2	6

7.2 Discipline Specific Elective Courses

With the course content largely subject specific, the first aim of these courses is to engage all students in enriching, enjoyable and intellectually stimulating learning experiences. Methods are designed to support independent learning. The courses are likely to help students acquire subject-specific, cognitive and transferable skills to solve complex problems.

S.N.	Name of course	Theory	Practical	Credits
1.	Neuroscience	4	2	6
2.	Endocrinology	4	2	6
3.	Nanobiology	4	2	6

4.	Evolutionary Biology	4	2	6
5.	Mammalian Physiology	4	2	6
6.	Human Reproductive Biology	4	2	6
7.	Genetic Engineering and Biotechnology	4	2	6
8.	Agrochemicals and Pest management	4	2	6
9.	Wild Life Conservation and Management	4	2	6
10.	Aquatic Zoology	4	2	6
11.	Livestock Management and Animal Husbandry	4	2	6

7.3 Generic Elective Courses

These courses enable the students to apply knowledge and understanding to address not only the core issues but also the issues of general importance where the knowledge of Zoology can be an added advantage. The courses will facilitate the students to develop all-round knowledge and skills on the integrated subjects in life sciences.

S.N.	Name of course	Theory	Practical	Credits
1.	Exploring the Brain: Structure and Function	4	2	6
2.	Human Physiology	4	2	6
3.	Vectors, Diseases and Control	4	2	6
4.	Food, Nutrition and Health	4	2	6
5.	Global Climate change	4	2	6
6.	Environmental Microbiology	4	2	6
7.	Environmental Biotechnology	4	2	6
8.	Biodiversity Conservation and Sustainable Development	4	2	6
9.	Bioeconomics	4	2	6
10.	Systematics and Evolutionary Biology	4	2	6
11.	Global Environmental Issues	4	2	6
12.	Environmental Monitoring and Management	4	2	6
13.	Basics of Systematics and Classification	4	2	6

7.4 Ability Enhancement Courses

These courses will mainly enhance the ability and personal skills of the students and help in personality development besides making them aware about the latest happenings or trends and facilitating effective communication with correct usage of technical language in order to present complex concepts and information. The students will learn to express in competitive and professional environments, orally and in writing in a clear and concise manner.

S.N.	Name of course	Theory	Practical	Credits
1.	Science Communication and Popularization	4		4
2.	Good Laboratory Practices	4		4
3.	Basic mathematics for Zoologists	4		4
4.	Research Methodology	4		4
5.	History of Indian Science	4		4
6.	Personality Development	4		4
7.	Human health and Sex Education	4		4
8.	Human Nutrition	4		4
9.	Intellectual Property Right			

7.5 Skill Enhancement Courses

These courses will encourage and enhance the investigative and analytical skills of students resulting in their ability to formulate problems clearly, identify key issues and reach the solution with logical arguments. The classroom sessions are aimed to provide industry-standard skills and can be helpful in fetching jobs.

S.N.	Name of course	Theory	Practical	Credits
1.	Reproductive Technologies	4		4
2.	Public Health and Hygiene	4		4
3.	Dairy Production and Technology	4		4
4.	Computer Applications	4		4
5.	Biofertilizers	4		4
6.	Environmental Impact Analysis	4		4
7.	Insect pest, vector biology and management	4		4

8.	Preventive medicine	4		4
9.	Ornamental freshwater fish production	4		4
10.	Aquaculture	4		4
11.	Toxicology	4		4
12.	Beekeeping	4		4
13.	Sericulture	4		4
14.	Ecotourism	4		4

The experiments involving animals will be performed through permanent slides/photographs/ video recording/ as per UGC guidelines.

8. Assessment and Evaluation

8.1 Assessment methods

Students' performance in core, discipline electives, generic electives and skill enhancement courses are to be assessed in various ways viz.,

- The oral and written scheduled or surprise tests,
- Problem-solving exercises,
- Closed-book and open-book tests,
- Practical skills and laboratory reports,
- Individual and group project reports,
- Seminar presentations,
- Group discussions
- *Viva voce* examinations.
- The computerized learning, literature surveys and evaluations, peers and self-assessment can be the additional methods used.
- Regular reading habits in the students need to be inculcated through continuous monitoring and observation about weaker aspect of the students.

8.2 List of Topics Suggested for Seminar and Group Discussion

1. Origin of life
2. Molecular systematics vs traditional taxonomy
3. Molecular system of classification
4. Living fossils
5. Animal connecting links
6. Reliability of taxonomic characters
7. Scope of evo-devo (Evolutionary developmental biology)
8. Mass extinction phenomenon
9. Pleuripotency and its relevance
10. Latest trends in developmental biology
11. Evolution of major animal lineages
12. Relevance of Palaeontology in current scenario
13. Parthenogenesis in animals
14. Polymorphism
15. Parasitic adaptations
16. Metamorphosis
17. Freshwater sponges
18. Molluscs of industrial value
19. Coral reefs and their role in ecosystem generation
20. Biochemical pathways, their evolutionary background and regulation
21. Water regulation in marine animals
22. Were dinosaurs warm blooded?
23. Evolution of terrestrial animals
24. Blood groups and their importance
25. Role of DNA sequencing in evolutionary history.
26. Genetic control of sex determination.
27. Bone marrow transplant
28. Recent advances in tissue culture and engineering.
29. Somatic hybridization
30. Neurodegenerative disorders
31. Popular cell lines and their importance
32. Apoptosis

33. Mutations and cancer
34. Epithelial tissue and its importance
35. Genome modification/ editing
36. Recent advances in gene cloning
37. Epigenetic disorders in humans
38. Diseases due to chromosomal anomalies
39. Stem cell technology
40. Genetic counseling
41. RNA interference
42. DNA barcoding
43. Stem cells & IPS cells
44. Current trends in DNA sequencing
45. DNA markers and Genetic diversity
46. Comparative genomics in understanding of gene function
47. Biodiversity and climate change
48. Biotechnology: Past, present and Future.
49. Molecular Taxonomy, New Classification systems
50. Tree of Life.
51. Marine zooplanktons and their ecological importance including oxygen evolution
52. Bioprospecting and Biopiracy

53. Molecular systematics vs. traditional taxonomy
54. Biochemical Pathways and their evolutionary background, Regulation
55. Biodiversity Hotspots.
56. Biotechnology; Past present and Future
57. Climate change: threat to food security
58. Stratospheric Ozone depletion and marine productivity
59. Good ozone vs. bad ozone
60. Air pollution and climate change
61. Biodiversity under climate changing scenario
62. Preparing healthy/ fit animal stock for tomorrow ; Conventional Breeding
63. Hybrids or transgenic animals
64. Vital body enzymes
65. Hormonal disorders

66. The process of Transcription
67. Advances in DNA hybridization
68. Essential and non essential amino acids
69. Important body lipids
70. Parental care in animals
71. Learning in birds
72. Instinctive behaviour invertebrates
73. Social behaviour in primates
74. Application of animal behaviour studies
75. Behaviour in captivity
76. Circadian rhythm
77. Environmental ethics
78. Biodiversity hotspots
79. Biodiversity mapping
80. Population explosion
81. Ecological indices
82. Niche segregation
83. Carrying capacity
84. Eukaryotic genome
85. Regulation of gene expression
86. RNA editing and splicing
87. DNA damage and repair
88. Central dogma of molecular biology
89. Molecular cloning
90. Monoclonal and polyclonal antibodies production techniques
91. Immunological techniques in disease diagnosis
92. Basic principles of light microscopy
93. Using SEM and TEM
94. Principles of Florescence and confocal microscopes
95. Applications of calorimetry and spectrophotometry
96. Techniques involving separation of biomolecules.
97. Diseases caused by viruses
98. Common bacterial diseases
99. Autoimmune diseases

100. Hybridoma technology and its applications
101. Zoonotic diseases
102. Helminth infections in humans
103. Concept of Immunity
104. Graphical representation of biological results
105. Statistical methods of hypothesis testing
106. Information technology in data acquisition and retrieval
107. Database management
108. Use of bioinformatics in biological research
109. Basics of information technology
110. Fish culture
111. Dairy management
112. Cattle diseases and their management
113. Apiculture and Sericulture
114. Pearl culture industry
115. Vermiculture
116. Prawn culture, a good source of revenue generation
117. In vitro fertilization techniques
118. Phenoplasticity and its relevance

8.3 Suggested List of Supplementary Web Resources for Laboratory Exercises

1. Anatomy of Frog: Pro Dissector (CD)- www.prodissector.com
2. Physiology of Frog: Physio Ex 4.0 (CD)- www.physioex.com
3. Anatomy of Chordates: The Vertebrate Dissection Guide Series (CD)–Learning Development Centre, University of Portsmouth
4. Anatomy of earthworm: The dissection works (CD); Source – www.scienclass.com; www.neosci.com
5. Anatomy of shark: Shark dissection and anatomy (video)- www.neosci.com
6. Cockroach dissection- www.ento.vt.edu
7. Mammalian Physiology– www.biopac.com

8.4 Guidelines for Individual/ Team Projects and Field Reports

The aim of the individual/ team project/s is to develop an aptitude for research in Zoology and to inculcate proficiency to identify appropriate research topic and presentation.

The topics of biological interest and significance can be selected for the project. Project is to be done by a group not exceeding 5 students. The project report should be submitted on typed A4 paper, 12 Font, 1.5 Space in spirally bound form and duly attested by the supervising teacher and the Head of the Department on the day of practical examination before a board of two Examiners for End Semester. The viva-voce based on the project is conducted individually. Project topic once chosen shall not be repeated by any later batches of students.

The project report may have the following sections:

1. Preliminary (Title page, declaration, certificate of the supervising teacher, content etc.)
2. Introduction with relevant literature review and objective
3. Materials and Methods
4. Result
5. Discussion
6. Conclusion / Summary
7. References.

Field Study/ Study tour

Students have to visit one research institute and one wild life sanctuary / museum / zoo. Scientifically prepared hand-written study tour report along with photographs of candidate at the places of visit must be submitted by each student for End Semester on the day of the examination of project.

B.Sc. Zoology
Core Courses (CC)

Semester	Core course	Course Title	Credit
I	CC-1	Systematics and Diversity of Life- Protists to Chordates	Theory:04 Practical: 02 Total: 06

About the course

The course is a walk for the Bachelor's entrant through the amazing diversity of living forms from simple to complex one. It enlightens how each group of organisms arose and how did they establish themselves in the environment with their special characteristics. It also deals with the differences and similarities between organisms on the basis of their morphology and anatomy which led to their grouping into taxa and clades.

Learning outcomes

After successfully completing this course, the students will be able to:

- Develop understanding on the diversity of life with regard to protists, non chordates and chordates.
- Group animals on the basis of their morphological characteristics/ structures.
- Develop critical understanding how animals changed from a primitive cell to a collection of simple cells to form a complex body plan.
- Examine the diversity and evolutionary history of a taxon through the construction of a basic phylogenetic/ cladistics tree.
- Understand how morphological change due to change in environment helps drive evolution over a long period of time.
- The project assignment will also give them a flavour of research to find the process involved in studying biodiversity and taxonomy besides improving their writing skills. It will further enable the students to think and interpret individually due to different animal species chosen.

Theory

UNIT I: Origin of Life on Earth, Products of evolutionary process **13 Lectures**

Origin of life on Earth: Arrival of simple form from primordial chemicals. Multicellularity: from simple collections of poorly differentiated cells to complex body plans. Biological diversity. Systematics and taxonomy. Species concept, clades. Nomenclature and utility of scientific names. Classification: morphological and evolutionary (molecular). Relationship of taxa: phylogenetics and cladistics with special reference to paraphyly, monophyly, apomorphy, plesiomorphy and phenoplasticity

UNIT II: Diversity in Protists and acoelomate Metazoa **13 Lectures**

Structure and diversity in Protists. Origin of Metazoans: Diploblastic and triploblastic organization; symmetries; body cavities; protostomes and deuterostomes. Special features and structural diversity in sponges. Cnidarians: Special features; transition of third germ layer; polymorphism and division of labour; coral reef forming Cnidarians. The Bilateria: Basic characteristics. The acoelomates: Basic organization and adaptive radiations in flatworms.

UNIT III: Diversity in pseudocoelomate and coelomate Non chordates **13 Lectures**

The Ecdysozoa: characteristics of the representative taxa. Pseudo coelomates; Basic organization and adaptive radiations in roundworms. The coelomates: Basic organization and adaptive radiations in Arthropods- Ancestors/ fossil arthropods. Adaptive radiations in Crustaceans, Myriapods, Chelicerates, Insects, etc. Basic organization and diversity in Annelids. Basic organization and diversity in Molluscs. Disruption of bilateral symmetry and its significance. Basic organization of Echinoderms; their affinity to Chordates.

UNIT IV: Diversity in Protochordates and Chordates **13 Lectures**

Chordates – Primitive Chordates and their affinities. Hemichordates, Urochordates and Cephalochordates. Advent of vertebrates: Cyclostomes, their evolutionary status and affinities. Basic organization and diversity of fishes, their evolutionary transitions. From Water to Land invasion - Early Tetrapodes. Amphibians diversity and adaptability to dual mode of life. Amniotes: the amniotic egg, adaptive radiations in reptiles; the avian ancestors. Birds: Adaptation from terrestrial to aerial mode of life. Origin of Mammals- Special features

of Monotremes and Marsupials. Characteristics of other mammalian groups with special reference to primates

Recommended readings

- Barnes, R. S. K.; Calow, P.; Olive, P. J. W.; Golding, D. W.; Spicer, J. I. (2002) *The Invertebrates: a Synthesis*, Blackwell Publishing.
- Hickman, C.; Roberts, L.S.; Keen, S.L.; Larson, A. and Eisenhour, D. (2018) *Animal Diversity*, McGraw-Hill.
- Holland, P. (2011) *The Animal Kingdom: A Very Short Introduction*, Oxford University Press.
- Kardong, K.V. (2006) *Vertebrates: Comparative Anatomy, Function, Evolution* (4th edition), McGraw- Hill.
- Barrington, E.J.W. (1979) *Invertebrate Structure and Functions*. II Edition. E.L.B.S. and Nelson.
- Boradale, L.A. and Potts, E.A. (1961) *Invertebrates: A Manual for the use of Students*. Asia Publishing Home.
- Bushbaum, R. (1964) *Animals without Backbones*. University of Chicago Press.

Practical

1. Study of animals through slides and museum specimens in the laboratory with details on their classification, biogeography and diagnostic features (record book).
2. Study of animals in nature during a survey of a National Park or Forest area.
3. Collection of five species (preferably invertebrates, insects) belonging to a clade. A project work on their generic identification, description and illustration with a note on their locality. Also the assessment of their relationship by constructing a cladogram using characters and character states.
4. Comparison of two species of birds belonging to same genus (Interspecific difference).
5. Comparison and weighting of characters of two birds belonging to same family but dissimilar genera.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28)

Semester	Core course	Course Title	Credit
I	CC-2	Developmental Biology & Evolution	Theory:04 Practical: 02 Total: 06

About the course

The course explains the sequence of events starting with a single cell to the production of a very complex organism. The course not only describes how embryos develop (embryology), but also highlights how the processes of development are brought about by changing individual cells into specialized cells with specific functions (the cellular level), and how genes within the genome of the organism drive and guide these changes (the molecular level). It also deals with a comparative account of development in some select groups of animals.

Learning outcomes

After successfully completing the course, the students will be able to

- Develop critical understanding how a single-celled fertilized egg becomes an embryo and then a fully formed adult by going through three important processes of cell division, cell differentiation and morphogenesis.
- Understand how developmental processes and gene functions within a particular tissue or organism can provide insight into functions of other tissues and organisms.
- Realize that very similar mechanisms are used in very diverse organisms; and development is controlled through molecular changes resulting in variation in the expression and function of gene networks.
- Understand how the field of developmental biology has changed since the beginning of the 19th century with different phases of developmental research predominating at different times.
- Examine the evolutionary history of the taxa based on developmental affinities.
- Understand the relevance of developmental biology in medicine or its role in development of diseases.

Theory

UNIT I: How does reproduction start, commence and modify in living system?

13 Lectures

Reproduction: a basis of species sustenance. Asexual and sexual reproduction and their relevance in corresponding environments. How are germ cells “special”? Gamete formation, types, their diversity and competence, external and internal fertilization; causes of Infertility. Structural and biochemical changes in gametes during and after fertilization, block to polyspermy. Establishment of the major embryonic axes, polarity, morphogen gradients and their interpretation. Fate maps, their relevance. *In vitro* fertilization; Amniocentesis; Artificial insemination (AI); Gamete intra-fallopian transfer (GIFT). Intra-cytoplasmic sperm injection (ICSI); Test tube baby.

UNIT II: How does development affect organization of phenotypes and their variation?

12 Lectures

Developmental commitment. Mosaic and regulative development. Direct and indirect development. Cleavage: types and patterns. Body plan and symmetries. Germ layer differentiation. Tubulation. Morphogenesis: Epiboly, emboly/ invagination, involution and ingression. Cell-cell interactions (cell signaling, cell adhesion etc.) during tissue organization, lateral inhibition, induction, and recruitment. Organogenesis: formation of gut, heart, kidney and muscles. Concept of competence, determination and differentiation and growth, molecular mechanism involved. Pleuropotency. Stem cell biology and tissue repair

UNIT III: Tracing the evolutionary biology of development

12 Lectures

Role of extra embryonic membranes in development, Placenta: types, structure and functions. Metamorphosis in insect and frog. Regeneration: epimorphosis, morphallaxis and compensatory regeneration. Development, ageing and apoptosis. Developmental mechanisms of evolutionary change (Evo-devo). Ecological Developmental Biology. Developmental biology in understanding of disorders. Teratogenesis; wound healing, birth defects, developmental brain disorders. Neurodegeneration. Endocrine Disruptors & Cancer.

UNIT IV: Understanding evolution through natural selection, adaptation and optimal models tradeoffs

15 Lectures

Early life on Earth and its indirect evidences, direct evidence of early life; great oxygenation and its relationship with life. Evolution and radiation of metazoans, major evolutionary transitions, Mass extinctions, Anthropocene and its uniqueness. Evidences of evolution: Hardy-Weinberg Equilibrium, Selection, Migration. Nonrandom mating, Cost/ benefit of sex, Sexual conflict, Evolution in asexual systems Life-history adaptations, Trade-offs, Number and size of offspring; Parent-offspring conflict. Genetic drift, Neutral evolution; Theories of evolution. Linkage disequilibrium; Epistasis. Heritability; Breeding value. Sources of variation: mutation, recombination, epigenetic variation. Evolution of mutation rates. Phenotypic plasticity, Genome evolution: Mobile genetic elements; gene duplication. Evolution and Health: Evolution of antibiotic Resistance, Virulence, Evolutionary medicine.

Recommended readings

1. Gerhart, J. *et al.* (1997) *Cells, Embryos and Evolution*. Blackwell Science
2. Gilbert, S.F. (2010) *Developmental Biology* (9th edition). Sinauer
3. Wolpert, L. (2007) *Principles of Developmental Biology* (3rd edition). Oxford University Press
4. Campbell, N. and Reece, J. (2014) *Biology* (10th edition). Benjamin Cummings
5. Ridley, M. (2004). *Evolution*. III Edition. Blackwell Publishing.
6. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). *Evolution*. Cold Spring, Harbour Laboratory Press.
7. Hall, B. K. and Hallgrímsson, B. (2008). *Evolution*. IV Edition. Jones and Bartlett Publishers

Practical

1. Types of eggs based on quantity and distribution of yolk: sea urchin, insect, frog, Chick.
2. Comparative study of cleavage patterns in Frog and Amphioxus models.
3. How do cells move, change shape and size during morphogenetic movement of Blastulation, Gastrulation in Frog, Amphioxus, Chick?
4. Study of development of chick embryo through incubated chick eggs up to 96 h.
5. Extra embryonic membranes of chick through permanent slides.

6. Some videos to develop understanding on the process of development.
7. Study of adaptive radiations in feet of birds and mouth parts of insects.
8. Understanding embryological evidence of evolution (through charts and videos).
9. Study of types of fossils.
10. Analogy and homology (wings of birds and insects, forelimbs of bat and rabbit).
11. Serial homology in appendages of *Palaemon*.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
II	CC-3	Comparative Anatomy and Physiology of Non-chordates	Theory:04 Practical: 02 Total: 06

About the course

The course makes a detailed comparison of the anatomy of the different taxa of non chordates. It also highlights how in the taxonomic hierarchy, there is an increase in the complexity of structure and function. The course thus gives an overview of the intricate life processes and adaptive radiations in non chordates.

Learning outcomes

After successfully completing this course, the students will be able to

- Develop an understanding of the characters used to classify besides being able to differentiate the organisms belonging to different taxa.
- Acquire knowledge of the coordinated functioning of complex human body machine.
- Have hands on experience of materials demonstrating the diversity of protists and non-chordates.
- Understand the relative position of individual organs and associated structures through dissection of the invertebrate representatives.
- Realize that very similar physiological mechanisms are used in very diverse organisms.
- Get a flavor of research by working on project besides improving their writing skills. It will further enable the students to think and interpret individually.
- Undertake research in any aspect of animal physiology in future.

Theory

UNIT I: Diversity of Tegument and Digestive system

13 Lectures

Basic affinities and differences between prokaryotes and eukaryotes; protists and the non-chordate animals. Symmetry, Coelom development and diversity. Cell membrane in protists and its derivatives. Tegument in non-chordates and its derivatives. Nutrition and feeding modes in protists. Digestive system & feeding mechanism in non-chordates): Process of digestion from food vacuoles to complex digestive organs.

UNIT II: Diversity of Locomotory, Respiratory, Circulatory and Excretory systems

13 Lectures

Locomotion and diversity of locomotory organs in protists and non-chordates, muscle and locomotion, Structure and diversity of skeletal elements in protists and non-chordates. Respiration: diversity of respiratory organs, modes of respiration. Respiratory pigments and oxygen consumption rates of different organisms. Circulation and the diversity of circulatory system. Excretion (protists): endocytosis, exocytosis; Excretion and diversity of excretory organs in non chordates.

UNIT III: Diversity of Nervous and Reproductive systems

13 Lectures

Nervous system with special reference to diversity in brain and nerve chord. Neuroendocrine systems, pheromones. Sense organs: Mechanoreceptors and their diversity in different taxa. Sense organs: photoreceptors, chemoreceptors, thigmoreceptors, rheoreceptors and proprioceptors in different taxa. olfaction and sound perception in insects, etc. Diversity of the reproductive organs and accessory sex organs; modes of reproduction- asexual and sexual reproduction. Metamorphosis. Diversity of larval forms in non-chordates

UNIT IV: Evolution and characteristics of important Non Chordate taxa

13 Lectures

Organization and affinities in fossils (such as trilobites). Affinities of living fossils, *Limulus* and *Peripatus*. Polymorphism and colony formation. Parasitic adaptations and life cycle patterns in parasites belonging to different taxa. The parasites listed by World Health Organization under preventive programmes. Structure and diversity of the pest organisms. Invertebrate model organisms and their importance. Taxa with special characteristics: Types of canal systems in sponges and their significance. Torsion and detorsion in Mollusca. Components of water vascular system in echinoderms.

Recommended readings

1. Barrington, E J W. (1967) Invertebrate structure and function, Nelson, London.

2. Barnes, R. D. (1968) Invertebrate Zoology, 2nd Ed. Saunders, Philadelphia.
3. Hyman, L H. (1940-67). The Invertebrates, Vol. I-VI. McGraw-Hill, New York.
4. 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.
5. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
6. Marshall, A.J and Williams, W.D. (1995) Text book of Zoology-Invertebrates. VII Ed., Vol. I, A.L.T.B.S. Publishers.
7. <http://abacus.bates.edu/acad/depts/biobook/AnimPhyl.pdf>

Practical

1. Study of models, permanent slides and museum specimens representing different protists and non-chordate taxa.
2. Some additional slides/specimens of
Protozoans of agricultural importance.
Coral-reef forming Cnidarians
Plant parasitic nematodes
Nematodes used as models in experimental biological research
3. Dissection of *Pheretima* to expose circumpharyngeal ganglia
4. Dissection of *Periplaneta* to expose the digestive system and salivary glands
5. Dissection of *Palaemon* to expose appendages and statocyst
6. Dissection of *Pila*
7. Study of larval forms: *Ephyra*, *Planula*, *Trochophore*, *Pluteus*, *Velliger*, **Zoea**, Metazoea, Bipinnaria
8. Some videos to develop understanding on the animals of different taxa.
9. Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
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II	CC-4	Cell Biology and Histology	Theory:04 Practical: 02 Total: 06
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About the course

The course provides a detailed insight into basic concepts of cellular structure and function. It also gives an account of the complex regulatory mechanisms that control cell function.

Learning outcomes

After successfully completing this course, the students will be able to

- Understand the functioning of nucleus and extra nuclear organelles and understand the intricate cellular mechanisms involved.
- Acquire the detailed knowledge of different pathways related to cell signaling and apoptosis thus enabling them to understand the anomalies in cancer.
- Develop an understanding how cells work in healthy and diseased states and to give a 'health forecast' by analyzing the genetic database and cell information.
- Get new avenues of joining research in areas such as genetic engineering of cells, cloning, vaccines development, human fertility programme, organ transplant, etc.
- Understand how tissues are produced from cells in a normal course and about any malfunctioning which may lead to benign or malignant tumor.

Theory

UNIT-I: The structure and organelles of prokaryotic and eukaryotic cells. 13 Lectures

Cell biology, its scope in modern perspective. Cell theory and its modern version and interpretation. General structure of prokaryotes, bacteria, archaea and eukaryotes. Extra nuclear cell organelles: Ultrastructure and functions of endoplasmic reticulum, ribosome, Golgi apparatus, lysosome, peroxisomes. Mitochondria: Origin, structure, composition, genome organization and function. Cytoskeleton: composition and functions; microtubules and microfilaments. MT vs Actin - their organization, association with membrane. Nucleus: size, shape, structure and functions of interphase nucleus. Ultrastructure of nuclear membrane and pore complex. Nucleolus: general organization, chemical composition and functions, nuclear sap/ nuclear matrix, nucleo-cytoplasmic interactions.

UNIT-II: Cell membrane and transport mechanism

12 Lectures

Cell membrane organization: cell membrane: origin, structure, composition, models and function. Fluid mosaic model. Lipid Composition, inner and outer leaflets. Structure and functions of membrane proteins: Integral, peripheral and lipid-anchored membrane proteins.

Junctional complexes, membrane receptor modifications: microvilli, desmosomes and plasmodesmata. Receptor mobility and clustering in the lipid bilayer. Cell receptor function - cellular trafficking. Transport across membrane: diffusion and osmosis. Active and passive transport, endocytosis and exocytosis

UNIT-III: Cell cycle, cell signaling and cell culturing

14 Lectures

Cell cycle, cell division- mitosis and meiosis. Cell division check points and their regulation. Role of growth factors. Mutations in the genes that regulate cell cycle and division and their role in causing cancer. Programmed cell death (Apoptosis). Cell regulation and Cell signaling: Signaling molecules and their receptors. Functions of cell surface receptors. Regulation of signaling pathways. Cell culture: Types of cell culture- monolayer and suspension culture. Types of culture media. Sterilization methods for culture wares and culture media. Maintenance of a cell line and storage of cells. Subcellular fractionation by differential centrifugation. Somatic cell hybridization. Basic characteristics of tissue culture media. Tissue culture and engineering.

UNIT-IV: Structural and functional significance of animal tissues

13 Lectures

Introduction to tissues. Epithelial tissue: types, structure and characteristics. surface modifications. Basement membrane: structure and characteristics. Cell junctions. Exocrine and endocrine glands: types and structure. Connective tissue cells. Structure and function of loose, dense and adipose tissue. Cartilage and bone: classification, and fine structure. Blood: plasma, blood cells, lymph- their structural and functional. Bone marrow and haemopoiesis. Structure and function of spleen. Muscular tissue: ultrastructure of smooth, skeletal and cardiac muscles. Muscle-tendon attachment. Structure and classification of neurons. Types of supporting (glial) cells and their function. Myelin sheath and its formation. Types of sensory nerve endings. Degeneration and regeneration of neurons. Membranes of the brain and spinal cord.

Recommended readings

1. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments (6th edition) John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006) Cell and Molecular Biology (8th edition) Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. (5th edition) ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M.; Kleinsmith, L.J.; Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. (7th edition) Pearson Benjamin Cummings Publishing, San Francisco.

Practical

1. Study of prokaryotic and eukaryotic cell types with the help of chart, slide and video.
2. Separation and isolation of cells by sedimentation velocity in unit gravity.
3. Disruption of cells, isolation and identification of subcellular components, isolation of nuclei.
4. Isolation of mitochondria by differential centrifugation and identification of succinic dehydrogenase in the mitochondrial pellet.
5. Chromosome segregation in mitosis and meiosis.
6. Preparation of chromosome squashes from grasshopper/cockroach testes for the observation of stages of meiosis.
7. Study of types of tissue through permanent slides: epithelial, connective, muscular, nervous etc.
8. Study of histology of tissues by preparing permanent stained slides through microtomy.
9. Isolation and estimation of DNA.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core	Course Title	Credit
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	course		
III	CC-5	Comparative Anatomy and Physiology of Chordates	Theory:04 Practical: 02 Total: 06

About the course

The course offers insight into the physiology of chordates while giving an account of their anatomy. This course also explores vertebrate morphology with the aims of understanding major events in the history of vertebrate evolution and integrating the morphology of vertebrates with their ecology, behaviour and physiological adaptation in diverse habitats. Thermal relations encountered in endo- and ectothermic animals will be explained. Selective pressures that shape to different physiological phenotypes will also be addressed in the course.

Learning outcomes

After successfully completing this course, the students will be able to:

- Develop an understanding of the evolution of vertebrates thus integrating structure, function and development.
- Have an overview of the evolutionary concepts including homology and homoplasy, and detailed discussions of major organ systems.
- Understand how cells, tissues, and organisms function at different levels. The course content also provides the basis of understanding their abnormal function in animal and human diseases and new methods for treating those diseases.
- Develop an understanding of the related disciplines, such as cell biology, neurophysiology, pharmacology, biochemistry etc.
- Get a flavor of research besides improving their writing skills and making them well versed with the current trends. It will further enable the students to think and interpret individually due to different aspects chosen.
 - Undertake research in any aspect of animal physiology in future.

Theory

UNIT- I: Structure and function of integument, skeletal and muscular systems

11 Lectures

Structure of integument from fishes to mammals with an account on epidermal and dermal derivatives and their functional significance. Anatomy and physiology of axial and appendicular skeleton. Comparative anatomy of pelvic and pectoral girdles from fishes (cartilaginous and bony) to mammals. Types of muscles, physical properties and ultrastructural organization of skeletal muscle fibres, muscle contraction.

UNIT-II: Structure and function of digestive, circulatory and endocrine systems

13 Lectures

Comparative anatomy of jaw suspension, oral cavity, teeth (dentition mammals). Structure and diversity of alimentary canal and digestive glands in chordates. Biological significance of nutrients- carbohydrates, proteins, fats, vitamins and minerals. Physiology of digestion with special reference to enzymes involved. Evolution of aortic arches and their significance. Visceral arches and their functional significance in vertebrates. Structure and evolution of heart in vertebrates. Functional anatomy of heart, cardiac cycle, cardiac output, Integration of cardiovascular function, electrocardiogram. Composition of blood, blood groups, Mechanism of blood coagulation. Types and functional significance of endocrine glands and hormones.

UNIT-III: Structure and function of respiratory and excretory systems

14 Lectures

Aquatic and terrestrial respiration; transition from water to air breathing. Breathing and gas exchange, gas transport, Hb and O₂ dissociation, BMR. Comparative anatomy and functional significance of lungs in amphibians, reptiles, birds and mammals. Types and development of kidneys and their ducts in anamniotes and amniotes. Nephron- structure, types and their function. Physiology of excretion in vertebrates; urine formation, counter current mechanism, Role of ADH and RAAS in excretion. Mechanisms of osmoregulation in fresh water and marine organisms, stenohalinity and euryhalinity.

UNIT- IV: Structure and function of nervous and reproductive systems

14 Lectures

Introduction to central and peripheral nervous systems. Structural and functional evolution of brain and spinal cord in various classes of chordates. Peripheral nervous system- functional significance of somatic and autonomic nervous systems. Structure and functions of neuron, ionic basis of resting and action potentials, nerve impulse and its transmission, synapse and synaptic transmission, Reflex action. Types of sense organs- vision, hearing, taste, smell and touch in chordates. Mechanism of thermoregulation in homeotherms and poikilotherms. Comparative details of testes and ovaries from fishes to mammals; modes of reproduction; estrous and menstrual cycle, implantation, gestation, parturition, lactation and birth control.

Recommended readings

1. Weichert, C.K. (1970) *Anatomy of Chordates* (4th edition).
2. Jordan, E. L. and Verma, P. S. (2013) *Chordate Zoology* (14th edition).
3. Saxena, R. K. and Saxena, S. (2015) *Comparative Anatomy of Vertebrates* (2nd edition).
4. Vander, A.; Sherman, J. and Luciano, D. (2003) *Human Physiology* (9th edition).
5. Randall, D. *et al.* (2002) *Eckert Animal Physiology* (5th edition) Freeman.
6. Hill, R.W. *et al.* (2008) *Animal Physiology* (3rd edition) Sinaur Associates.
7. Guyton, A.C. *et al.* (2008) *Textbook of Medical Physiology* (12th edition) W.B. Saunders Co.
8. Withers, P.C. *et al.* (1992) *Comparative Animal Physiology* (1st edition) Brooks Cole.

Practical

1. Temporary mount of external scales in fishes (cycloid, placoid, ganoid, ctenoid).
2. Comparative study of brain with the help of models and charts.
3. Comparative study of urinogenital system with the help of models and charts.
4. Comparative study of heart with the help of models and charts.
5. Mount of weberian ossicles of fish.
6. Study of axial and appendicular skeleton of vertebrates.
7. Qualitative analysis of nutrients: Carbohydrate, Proteins, Lipids.
8. Estimation of haemoglobin.
9. Counting of different types of blood cells using haemocytometer.
10. Study of action of salivary amylase.
11. Rate of oxygen uptake in fish.
12. Effect of temperature on opercular movement of fish.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
III	CC-6	Genetics	Theory:04 Practical: 02

			Total: 06
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About the course

The course is designed to revise basic concepts of Genetics and then move on to advanced concepts. Some key aspects include the mechanism of inheritance, gene structure and function, sex chromosomal and autosomal anomalies, aspects of human genetics, etc. will be covered. A strong emphasis will be laid on the modern tools and techniques used in genetics.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand how DNA encodes genetic information and the function of mRNA and tRNA
- Apply the principles of Mendelian inheritance.
- Understand the cause and effect of alterations in chromosome number and structure.
- Relate the conventional and molecular methods for gene manipulation in other biological systems.
- Discuss and analyse the epigenetic modifications and imprinting and its role in diseases.
- Get new avenues of joining research in related areas such as genetic engineering of cells, cloning, genetic disorders, human fertility programme, genotoxicity, etc

Theory

UNIT I: Concept of Genes and Genomics

13 Lectures

Genetics: scope and importance. Elements of heredity and variation: Classical and Modern concept of Gene (Cistron, muton, recon), Alleles etc. Mendel's laws of inheritance, Chromosomal basis of inheritance and its applications. Exceptions to Mendelian Inheritance: Incomplete dominance, Codominance, Multiple allelism, Lethal alleles, Pleiotropy, Epistasis - Recessive, Double recessive and double dominant. Genomic imprinting, Penetrance and expressivity, Phenocopy, Polygenic inheritance. Mendelian traits in man.

UNIT II: The recombination and interaction of Genes

13 Lectures

Linkage and crossing over, cytological basis of crossing over. Organelle inheritance (Mitochondrial) Extra-nuclear inheritance, Maternal Inheritance, Sex Chromosomes and sex-linkage: XX/XO, XX/XY, ZZ/ZW and haploidy/diploidy types, Gene dosage Compensation, Epigenetics. Structural and numerical alterations of chromosomes, meiotic consequences in structural heterozygotes. Autosomal dominant and autosomal recessive, X-linked dominant, and X-linked recessive. Haplodiploidy. Genic balance theory, intersex, gynandromorphs.

Hormonal influence on sex determination-Freemartin and sex reversal. Role of environmental factors- *Bonellia* and Crocodile.

UNIT III: Regulation of Gene expression, regulation and mapping

13 Lectures

Gene Expressions and regulation: One gene-one enzyme hypothesis /one polypeptide hypothesis. Concept of operon of bacteria and bacteriophages. Bacterial transposons. Vertical and horizontal gene transfer. Transformation, transfection and transduction. Genetic complementation. Genetic mapping. Genetic screens as a basis for functional genomics. Deficiencies, EMS & X-ray-based mutagenesis screens. Creating alleles. Enhancer traps, EP-Lines, RNA-inheritance, FLP-FRT & Cre- Lox Systems. Behaviour mutant screens. Utility of the model organisms: *Escherichia coli*, *Arabidopsis thaliana*, *Caenorhabditis elegans*, *Drosophila melanogaster* & *Mus musculus*.

UNIT IV: Human Population Genetics and Genetic Counselling

13 Lectures

Human Genetics: Pedigree analysis; Karyotype, banding and nomenclature of chromosome subdivisions. Genetic disorders: chromosomal aneuploidy (Down, Turner and Klinefelter syndromes), chromosome translocation (Chronic Myeloid Leukemia) and deletion (“cry of cat” syndrome), gene mutation (sickle cell anemia). Genetic counselling, Gene isolation Manipulation and the techniques that revolutionized modern genetics. Transcription of mRNA Translation. Genetic code. Working with nucleic acids and proteins. Polymerase Chain Reaction. DNA Sequencing; Southern, Western & Northern Blots. *In situ* Hybridization, FISH, SNPs, RFLPs, ESTs, STS and Oligonucleotide arrays. Gene Cloning vs Animal Cloning, Nuclear transplantation, stem cells and IPS cells.

Recommended readings

1. Gardner, E.J. *et al.* (2006) Principles of Genetics (John Wiley).
2. Russell, P.J. (2010) Genetics (Benjamin Cummings).
3. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. (VIII edition) Wiley India.
4. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics. (V edition) John Wiley and Sons Inc.
5. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2012). Concepts of Genetics. (X edition) Benjamin Cummings.
6. Carroll S.B.; Doebley J.; Griffiths, A.J.F. and Wessler, S.R. (2018) An Introduction to Genetic Analysis. W. H. Freeman and Co. Ltd.

Practical

1. Application of probability in the law of segregation with coin tossing
2. Frequency of the following genetic traits in human: widow's peak, attached ear lobe, dimple in chin, hypertrichosis, colour blindness, PTC tasting
3. Study of mode of inheritance of the following traits by pedigree charts – attached ear lobe, widow's peak
4. Familiarization with techniques of handling *Drosophila*, identifying males and females; observing wild type and mutant (white eye, wing less) flies, and setting up cultures
5. Demonstration of law of segregation (monohybrid and test cross) sex-linked inheritance in *Drosophila* making a cross between white eye dumpy winged or sepia eyed and wild type flies (criss-cross inheritance)
6. Demonstration of lethal alleles using Curly (Cy) mutant in *Drosophila*
7. Demonstration of multiple allelism by showing mutants of white eye series in *Drosophila*
8. Study of structural chromosome aberrations (dicentric, ring chromosomes and inversions in polytene chromosomes) from prepared slides/photographs
9. Study of human karyotypes and numerical alterations (Down syndrome, Klinefelter syndrome and Turner syndrome)
10. Extraction of Genomic DNA from bacteria.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
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IV	CC-7	Biochemistry	Theory:04 Practical: 02 Total: 06
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About the course

The course provides an introduction to the structure of biomolecules with emphasis on the techniques used for structure determination and analysis. The course covers basic aspects of sample preparation for analysis and aims to enlighten the students how structural information can be utilized for better understanding of biological processes.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand about the importance and scope of biochemistry.
- Understand the structure and biological significance of carbohydrates, amino acids, proteins, lipids and nucleic acids.
- Understand the structure and function of immunoglobulins.
- Understand the concept of enzyme, its mechanism of action and regulation.
- Understand the process of DNA replication, transcription and translation.
- Learn the preparation of models of peptides and nucleotides.
- Learn biochemical tests for amino acids, carbohydrates, proteins and nucleic acids.
- Learn measurement of enzyme activity and its kinetics.

Theory

UNIT I: Introduction to Biochemistry, Carbohydrates

12 Lectures

Introduction, scope and importance of Biochemistry. Principle of bimolecular organization, configuration and conformation. Water as biological solvent. Carbohydrates: Structure and biological importance. Classification - Reducing and non-reducing sugars, monosaccharides, Oligosaccharides (Disaccharides), polysaccharides (peptidoglycans and glycosaminoglycans). Catabolism of carbohydrates and ATP production, Glycolysis, Krebs cycle, Electron transport chain and ATP synthesis Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

UNIT II: Lipids: Structure and Biological significance

13 Lectures

Lipids: Structure and Biological significance. Fatty acids- Types and nomenclature (saturated and unsaturated). Classification- Triglycerides, Phospholipids, Sphingolipids, Cholesterol, β -oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms. Biosynthesis of palmitic acid; Ketogenesis.

UNIT III: Protein structure and metabolism

16 Lectures

Proteins: Composition and Biological significance. Amino acids -Structure, classification and properties, Ionization, titration curve, pK and pI. Physiological importance of essential and non-essential amino acids. Catabolism of amino acids: Transamination, Deamination, Urea cycle. Structural organization, N-terminal analysis: Sanger and Edman's reactions, denaturation and degradation, functions and diversity. Immunoglobulin: Basic structure and classes, functions and antigenic determinants. Enzymes: Nomenclature and classification, general properties, specificity, cofactors, isozymes. Mechanism of enzyme action (ES complex and lowering of activation energy, chemical catalysis). Kinetics (determination of K_m and V_{max} using Michaelis-Menten and Lineweaver-Burk plots). Regulation of enzyme activity, inhibition, allosteric regulation, role of covalent modifications, ribozymes and concept of abzymes.

UNIT IV: Nucleic acids and mechanisms of replication, transcription and translation

11 Lectures

Structure -Bases, nucleosides and nucleotides. DNA structure: Conformation (A, B and Z), DNA double helix (Watson and Crick model). DNA and RNA as genetic material. Organization of nucleosomes and higher order structure. DNA replication: Machinery and Basic mechanism (Prokaryotes). Transcriptional unit and basic mechanism of transcription (Prokaryotes). Genetic code and basic mechanism of translation (Prokaryotes). Introduction to recombinant DNA techniques and their applications. Determination of atomic structure using X-ray crystallography and graphic tools.

Recommended readings

1. Nelson, D.L. & Cox, M.M. (2017) Lehninger Principles of Biochemistry (7th edition) Worth.
2. Berg, J.M.; Tymoczko, J.L. and Stryer, L. (2012) Biochemistry (7th edition) Freeman.
3. Zubay, G. (2017) Biochemistry (4th edition) McGraw-Hill.

4. Conn, E.E.; Stumpf, P.K.; Bruening, G. and Doi, R.H. (2006) Principles of Biochemistry (5th edition) Wiley.

Practical

1. Preparation of models of amino acids and dipeptides.
 2. Ninhydrin test for α -amino acids.
 3. Determination of pK and pI values of glycine.
 4. Benedict's test for reducing sugars.
 5. Iodine test for starch.
 6. Determination of acid value of oil.
 7. Preparation of models of nitrogenous bases, nucleosides and nucleotides.
 8. Qualitative test for DNA & RNA.
 9. Determination of the activity of enzyme (Urease).
 - 9.1. Effect of [S] and determination of K_m and V_{max} .
 - 9.2. Effect of temperature.
 - 9.3. Effect of time.
- Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
IV	CC-8	Behaviour and Chronobiology	Theory:04 Practical: 02 Total: 06

About the course

The course aims to explain the natural behaviour patterns, how the behaviour varies among individuals and species (wild, domestic, and captive), how current and past environments and ecology influence not only behaviour, but also the underlying gene-environment interactions that shape it.

Learning outcomes

After successfully completing this course, the students will be able to:

- Learn a wide range of theoretical and practical techniques used to study animal behaviour.
- Develop skills, concepts and experience to understand all aspects of animal behaviour.
- Objectively understand and evaluate information about animal behaviour and ecology encountered in our daily lives.
- Understand and be able to objectively evaluate the role of behaviour in the protection and conservation of animals in the wild.
- Consider and evaluate behaviour of all animals, including humans, in the complex ecological world, including the urban environment

Theory

UNIT I: Behaviour and the response invoking stimuli

12 Lectures

Animal behaviour. Scope and importance of study. Proximate and ultimate causes of behavior and the evolutionary approach to studying behaviour. Methods and recording of a behavior Types of stimuli invoking response: internal and external cues. Patterns of behaviour: Kinds of behaviour: foraging behaviour, Territorial behaviour. Mate selection and courtship behaviour. Parental care, defensive behaviour. Allelomimetic and maladaptive (abnormal) behaviour. Stereotyped Behaviours (Orientation, Reflexes); Innate/ Instinct behaviour. vs. Learnt Behaviour.

UNIT II: Communication and regulation of behaviour

13 Lectures

Social organization (e.g., Honey bee, Termites etc.). Communication in living in groups. Evolution of sociality, eusocial organisation. Genetic basis of behaviour. Regulation of behaviour: Neural control: kinesis, taxis, simple reflexes. Sensory processing: toad prey capture, sound localization (owls), echolocation (bats). Hormonal control. Biological clocks: Advantages of biological rhythms. Circadian and circannual rhythms. Photoperiodism, tidal, solar and lunar rhythms, entrainments. Biological oscillation: the concept of Average, amplitude, phase and period, Role of melatonin. Applications of Chronobiology. Chronopharmacology, Chronomedicine, Chronotherapy. Migratory behaviour in birds and fishes.

UNIT III: Innate behaviour; Evolution of reproductive behaviour

13 Lectures

Innate behaviour: communication (primates, bees and ants). Decision making. Motor Output: leech swimming/crawling, escape behavior, cricket vocalizations. Sensorimotor integration: electric fish, bird song instinct and motivation. territorial behaviour, schooling behaviour. Displacement activities, Ritualization, Habitat selection, food selection and foraging behaviour in African ungulates. Mimicry and colouration. Evolution of reproductive behavior, mating systems and parental care. Asymmetry in sex, sexual dimorphism.

Unit IV: Learning behaviour; conditioning; socio-biology

14 Lectures

Learning (Learnt behaviour): habituation, imprinting, conditioned reflex, trial and error learning, latent learning, insight learning. Types of learning -Habituation, Imprinting and types of imprinting -filial and sexual, Classical conditioning, Instrumental learning and insight learning. Social behaviour: Social and cultural transmission of Behaviour; aggregation, group selection, kin selection, altruism. Social organization (e.g., Honeybee, Naked Mole Rat and Monkey). Elements of Socio-biology: Selfishness, cooperation, altruism, kinship and inclusive fitness

Recommended readings

1. McFarland, D. (1999) Animal Behaviour (3rd edition) Pitman Publishing Limited, London, UK.
2. Manning, A. and Dawkins, M. S. (2012) An Introduction to Animal Behaviour (6th edition) Cambridge, University Press, UK

3. Alcock, J. (2005) *Animal Behaviour* (8th edition) Sinauer Associate Inc., USA.
4. Sherman, P. W. and Alcock, J. (2013) *Exploring Animal Behaviour* (6th edition) Sinauer Associate Inc., Massachusetts, USA.
5. Dunlap, J. C.; Loros, J.J. and DeCoursey, P. J. (2009) *Chronobiology Biological Timekeeping* (1st edition) Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
6. Kumar, V. (2002). *Biological Rhythms*: Narosa Publishing House, Delhi/ Springer - Verlag, Germany.

Practical

1. Orientation of an animal to light.
 2. Constructing an ethogram.
 3. Chemical communication in ants.
 4. Selective predation of coloured prey items.
 5. Predatory behaviour of a carnivorous animal.
 6. Nests and nesting habits of the birds and social insects
 7. To study the behavioural responses of wood lice to dry and humid conditions.
 8. To study geotaxis behaviour in earthworm.
 9. To study the phototaxis behaviour in insect larvae.
 10. Study of circadian functions in humans (daily eating, sleep and temperature patterns).
 11. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.
- Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
V	CC-9	Ecology	Theory:04 Practical: 02 Total: 06

About the course

This course will take students on a journey through the physical workings of the Earth, the interactions between species and their environments. The course highlights on some of the important aspects *viz.* growth and survival of populations and communities in different habitats, energy flow in the ecosystems, interactions between the communities, exclusion of niches and consequences of changing environment on the biodiversity.

Learning outcomes

After successfully completing this course, the students will be able to:

- Know the evolutionary and functional basis of animal ecology.
- Understand what makes the scientific study of animal ecology a crucial and exciting endeavour.
- Engage in field-based research activities to understand well the theoretical aspects taught besides learning techniques for gathering data in the field.
- Analyse a biological problem, derive testable hypotheses and then design experiments and put the tests into practice.
- Solve the environmental problems involving interaction of humans and natural systems at local or global level.

Theory

UNIT I: An overview of Ecology, Ecosystems and Biomes

13 Lectures

Introduction and scope of Ecology. Multidisciplinary relevance in current perspective. Structure and function of ecosystem; Abiotic factors affecting survival and sustenance of organisms e.g., water, temperature, light, pH and salinity. Role of limiting factors in survival of biotic components. Major ecosystems of the world: Ecological features, limiting factors, zonation and classification of organisms of fresh water and marine ecosystems. Introduction to Biome: Ecological features of Tundra, Desert, Savannah and Tropical Rain forest Biomes. Energy flow in ecosystem, food chain and food web. Productivity. Mineralization and recycling of nutrients: C, N, P & S.

UNIT II: Population ecology; Human population growth

13 Lectures

Ecology of populations: Unitary and Modular populations. Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves. Unique and group attributes of population: mortality, age ratio, sex ratio, dispersal. Factors regulating population dispersal and growth: Exponential and logistic growth. Population regulation: density-dependent and independent factors; r and K strategies. Metapopulations, demes and interdemic extinction. Life history strategies: reproductive effort, offspring size and cost-benefit ratio. Ecological efficiencies. Human population growth: Impacts on environment, carrying capacity, human health and welfare.

UNIT III: Biotic community, characteristics and attributes

13 Lectures

Community characteristics: stratification; Dominance, diversity, species richness, abundance, Evenness, Similarity. Diversity and food-web indices. Ecotone and edge effect; Types of interaction: Positive interactions: commensalism, proto-cooperation, and mutualism. Negative interactions: parasitism and allelopathy; predation and predator-prey dynamics; herbivory. Interspecific competition and coexistence, Inter and intra-specific; abundance. Niche overlap and segregation. Gause's Principle with laboratory and field examples. Ecological succession: Definition, Process, types, theories of succession.

UNIT IV: Environmental degradation; Environmental movement etc. 13 Lectures

Environmental ethics; Pollution: Air, water and noise pollution and their control; Natural resources: Mineral, water and forest, their significance and conservation; Types of biodiversity, Hotspots, benefit and threat of conservation strategies; Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; Biodiversity mapping using GPS, GIS and remote sensing. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value. Application of ecology in management and Conservation programmes. Role of gender and cultures in environmental conservation. Environmental movements: Bishnois. Chipko, Silent valley, Big dam movements. Environmental education and public awareness

Recommended readings

1. Colinvaux, P. A. (1993) Ecology (2nd edition) Wiley, John and Sons, Inc.
2. Krebs, C. J. (2001) Ecology (6th edition) Benjamin Cummings.

3. Odum, E.P., (2008) Fundamentals of Ecology. Indian Edition. Brooks/Cole.
4. Ricklefs, R.E. (2000) Ecology (5th edition) Chiron Press.
5. Southwood, T.R.E. and Henderson, P.A. (2000) Ecological Methods (3rd edition) Blackwell Sci.
6. Kendeigh, F C. (1984) Ecology with Special Reference to Animal and Man. Prentice Hall Inc.
7. Stiling, P. D. (2012) Ecology Companion Site: Global Insights and Investigations. McGraw Hill Education.

Practical

1. To measure microclimatic variables *viz.*, temperature, humidity and light conditions in a microhabitat.
2. Making an ecosystem in a wide-mouthed bottle.
3. Constructing a food web by observing and collecting organisms from a given area.
4. Preparing and clearly present an essay based on the evaluation of 4-7 publications
5. Studying the impact of herbivore on plant species (planted in pots under specific conditions)
6. Constructing distribution map of species of a genus through GPS by estimating the coordinates.
7. Investigation of volatile inhibitory substances produced through decomposition of plant debris and root exudates.
8. Estimation of the ratio of the producers and consumers.
9. Studying insect diversity in a habitat.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
V	CC-10	Molecular Biology	Theory:04 Practical: 02 Total: 06

About the course

The course provides an insight into the life processes at the subcellular and molecular levels. Other important aspects include DNA and molecular genetics including gene cloning, sequencing and gene mapping in addition to the powerful techniques that revolutionized the pharmaceutical, health and agricultural industries.

Learning outcomes

After successfully completing this course, the students will be able to:

- Develop an understanding of concepts, mechanisms and evolutionary significance and relevance of molecular biology in the current scenario.
- Get well versed in recombinant DNA technology which holds application in biomedical & genomic science, agriculture, environment management, etc. Therefore, a fundamental understanding of Molecular Biology will help in career building in all these fields.
- Apply their knowledge in problem solving and future course of their career development in higher education and research.
- Get new avenues of joining research in related areas such as therapeutic strategies or related opportunities in industry.

Theory

Unit -1: Central dogma; detailed information on nucleic acids

13 Lectures

Introduction to Molecular Biology, Central Dogma of Molecular Biology. Origin and evolution of life/ Prokaryotic and Eukaryotic Genes and Genomes, Model Genomes. Structure and Function of DNA, DNA forms: Plasmid DNA, Genomic DNA and Repetitive DNA. Conformation, Structure and Topology of DNA, DNA-modifications, DNA methylation. DNA-Protein interaction, DNA sequencing, DNA polymorphisms. Structure and Function of RNA, Ribosomal RNA (rRNA), Transfer RNA (tRNA), Messenger RNA (mRNA), Noncoding RNA.

Unit –II: Chromosomes; DNA replication, recombination, repair etc. 13 Lectures

Chromosomes, Chromatin, Histones, Histone-modifications. DNA Replication, plasmid DNA replication and genomic DNA replication. DNA polymerases, other regulatory proteins, centromeric and telomeric DNA replication, DNA replication and cell cycle regulation. Mutation, DNA-damaging agents, DNA recombination. DNA repair, mismatch repair, single strand- and double strand DNA repair

Unit –III: RNA transcription, processing, editing, splicing etc. 13 Lectures

Transcription, RNA polymerase I, II, III, transcription factors, chromatin remodeling. Regulation of gene expression in prokaryotes and eukaryotes. RNA processing, splicing of hnRNA into mRNA, 5'-capping and 3'-polyadenylation of mRNA, rRNA and tRNA modifications and processing. RNA editing, alternative splicing, trans-splicing, miRNA, siRNA, piRNA, lncRNA, RNA-protein complex.

Unit –IV: Ribosomes: Role in cell sustenance. 13 Lectures

Ribosomes, Genetic Code, triplet codons, Wobble base, synonymous codons, degeneracy of codons, missense-, nonsense- and frame shift mutations. Translation, protein synthesis in *E. coli* and eukaryotic cells. Aminoacylation of tRNA, initiation, elongation, peptide bond formation, translocation, termination, recycling of ribosome, regulation of protein synthesis and codon bias. Post-translational modifications and processing of proteins, large protein-protein complexes and protein trafficking

Recommended readings

1. Watson, J.D. *et al.* (2013) *Molecular Biology of the Gene* (7th edition) CSHL Press Pearson.
2. Green, M. R and Sambrook, J. (2012) *Molecular Cloning: a Laboratory Protocol* (4th edition) CSHL Press.
3. Walter, P. (2007) *Molecular Biology of the Cell* (5th edition) Garland Science.

Practical

1. Preparation of ball and stick model for B-DNA molecule (A=T and G=C base pairs).
2. Isolation of genomic DNA by ethanol precipitation method.
3. Preparation of LB-agar plates (with and without 100 microgram/ml Ampicillin and 10 microgram/ml Tetracycline), streaking of *E. coli* DH5alpha strain (normal) and

transformed with plasmids [Ampicillin-resistant (pBluescript) and Tetracycline-resistant (pBR322)].

4. Isolation of the plasmid DNA from the *E. coli* culture by alkaline lysis method.
5. Agarose gel electrophoresis of the plasmid DNA and the genomic DNA.
6. Staining of β -galactosidase activity in the DH5alpha cells with pBluescript plasmid by IPTG+X-Gal as an example of induction of gene expression.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
V	CC-11	Biotechniques	Theory:04 Practical: 02 Total: 06

About the course

This is the only laboratory course taught independently of lecture courses. It has full hands on approach to expose the students to modern techniques and methodologies. The diverse techniques from microscopy to spectroscopy, calorimetry, chromatography ELISA, tissue culture to cloning etc. are included to make the student well versed with these protocols and methods.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand the purpose of the technique, its proper use and possible modifications/ improvement.
- Learn the theoretical basis of technique, its principle of working and its correct application.
- Learn the construction repair and adjustment of any equipment required for a technique.
- Learn the accuracy of technique.
- Learn the maintenance laboratory equipments/ tools, safety hazards and precautions.
- Understand the technique of cell and tissue culture. Learn the preparation of solution of given percentage and molarity.
- Understand the process of preparation of buffer. Learn the techniques of separation of amino acids, proteins and nucleic acids.

Theory

UNIT I : Microscopy and Microtomy

13 Lectures

Microscopy: Introduction to Microscopy. Definitions-Resolving Power, Limit of Resolution and Magnification, Numerical Aperture. Types of microscopes. bright field, dark-field, phase contrast. Basic principles of Light, Electron, Fluorescence and Confocal Microscopy. Measurements, Drawings and photomicrography. Microtomy: Tissue preparation, fixation, block preparation, sectioning, staining, dehydration and mounting.

UNIT II : Tools and techniques in Biochemistry and Physiology **13 Lectures**
Biochemistry and Physiology: Physiological Salines, Buffers and the use of pH meter. Extraction of Tissue Glycogen, Proteins, Lipids and Nucleic Acids by Graaf's Method. Subcellular Fractionation by Differential Centrifugation. Basic Principle and Application of Colorimetry and Spectrophotometry, Beer-Lambert's Law. Principle and applications of Electrophoresis: Separation of Biomolecules by Native PAGE, 2D PAGE. Agarose gel electrophoresis. Principle and Applications of Paper chromatography, Thin layer chromatography, Gel-filtration chromatography.

.UNIT III : Tools and Techniques in Endocrinology and immunology **13 Lectures**
Immunology and Endocrinology: Introduction to Antigens, Antibodies, Adjuvants. Raising Polyclonal and Monoclonal Antibodies. Antigen-Antibody Interactions- Immunodiffusion, Ouchterlony's Double Immunodiffusion, Counter-Current, Immunoelectrophoresis, Western Blotting, ELISA, RIA. Principle & Working of ELISA, Reader, Hormones assay methods. Application of Immunological techniques in disease diagnosis. Tracer techniques: Principle and Applications, Unit of radioactivity, half-life and measurement of radioactivity.

UNIT IV: Cell culture, maintenance of Laboratory animals **13 Lectures**
Cell Culture and Laboratory Animals: Cell culture and its basic requirements. Culture media- Nutrient and Non-nutrient, commonly used media for human cell lines. Sterilization of culture wares and Media, laminar flow. Types of animal cell culture, cell viability testing. cryopreservation. Lymphocyte culture. Cell harvesting and Storage Methods. *In Vitro* culture of *Entamoeba histolytica*, *Coenorhabditis elegans*. Maintenance and Handling of laboratory rats and rabbits. Bioethics.

Recommended readings

1. Boyer, R. (2000) Modern Experimental Biochemistry (3rd edition) Benjamin-Cummings.
2. Pearse, A.G.E. (1980-1993) Histochemistry - Theoretical and applied, Volume I-III, Churchill-Livingstones.
3. Plummer, D. (2017) An Introduction to Practical Biochemistry (3rd edition) McGraw Hill.
4. Wilson, K. and Walker, J. (2010) Experimental Biochemistry, Cambridge.

Practical

1. Preparation of buffer and determination of pH.
2. Identification of amino acids in the mixture using paper chromatography.
3. Verification of laws of spectrophotometry.
4. Separation of proteins using SDS-PAGE.
5. Tissue fixation, paraffin block preparation, sectioning.
6. Preparation of permanent slides of microscopic organisms/ small insects.

7. Demonstration of bright field, phase contrast, fluorescence, confocal and electron microscopes.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
VI	CC-12	Microbiology, Parasitology and Immunology	Theory:04 Practical: 02 Total: 06

About the course

This is a composite course with remarkable utility and importance. Microbiology being the study of microorganisms such as viruses, bacteria etc., covers theoretical studies and practical proficiency training which may help in their placement at a clinical microbiological laboratory. Parasitology component takes care of the parasites and parasitism, emphasizing the influence of parasites on the ecology and evolution of free living species, and the role of parasites in global, public, health. Immunology part provides the students with the fundamental knowledge of the immune system and its protective roles against diseases.

Learning outcomes

After successfully completing this course, the students will be able to:

- Carry out common procedures for culturing, purifying and diagnostics of micro-organisms understand the disease-causing potential of bacteria and viruses, and the responses of the immune system.
- Summarise and orally present current microbiological problem areas.
- Describe the mechanisms for transmission, virulence and pathogenicity in pathogenic micro-organisms.
- Diagnose the causative agents, describe pathogenesis and treatment for important diseases like malaria, leishmaniasis, trypanosomiasis, toxoplasmosis, schistosomiasis, cysticercosis, filariasis etc.
- Assess the importance of incidence, prevalence and epidemiology in microbiological diagnostic activities.
- Know how resistance development and resistance transfer occur.
- Identify the major cellular and tissue components which comprise the innate and adaptive immune system.
- Understand how are immune responses by CD4 and CD8 T cells, and B cells, initiated and regulated.
- Understand how does the immune system distinguish self from non-self .
- Gain experience at reading and evaluating the scientific literature in the area.

Theory

UNIT: Microbiology: A brief account of pathogenic bacteria and viruses.

13 Lectures

Brief history of microbiology- germ theory of disease, discovery of penicillin. Diversity of microbes- viruses and bacteria. Host pathogen interaction: invasion, antigenic heterogeneity, toxins and enzymes secretions. Kinetics of bacterial growth and staining techniques. Viral diseases: polio, rabies, hepatitis, influenza, dengue, AIDS, chicken pox, swine flu, chikungunya with emphasis on their causative agents, pathogenesis, diagnosis, prophylaxis and chemotherapy. Bacterial diseases caused by *Bacillus anthracis*, *Streptococcus pyogenes*, *Streptococcus pneumoniae*, *Salmonella typhi*, *Escherichia coli*, *Helicobacter pylori*, *Mycobacterium tuberculosis*, *Vibrio cholerae*. Fungal diseases: Ringworm infection, aspergillosis, candidiasis.

UNIT-II: Parasitology: an overview of common parasitic infections. 13 Lectures

Introduction to parasites and parasitic diseases. Mode of transmission, portal of entry and implications of parasitism. Parasitic adaptations. Concept of zoonotic diseases. Protozoan diseases of medical importance: amoebiasis, giardiasis, malaria, trypanosomiasis, leishmaniasis and toxoplasmosis. Helminthic diseases of medical importance: Schistosomiasis, taeniasis, echinococcosis, ascariasis, enterobiasis, dracunculiasis and filariasis.

UNIT-III: Immunology: Immune mechanism and related pathways. 13 Lectures

Definition and classification. Cells and organs of immune system- primary and secondary lymphoid organs. Innate immunity: First and second lines of defense. Characteristics of antigen- antigenicity and immunogenicity, epitopes, haptens, adjuvant. Factors influencing immunogenicity. Classical and molecular structure of immunoglobulin. Classification, properties and functions of immunoglobulins. Antigenic determinants: isotype, allotype and idiotype. Antigen and antibody interactions, affinity, avidity. Complement system (Classical, alternative and lectin pathways).

UNIT-IV: Acquired immunity, Hypersensitivity and autoimmune disorders

13 Lectures

Acquired immunity: Humoral and cell mediated immune response. Role of B and T cell in immunity. Receptors, activation and differentiation of B and T cells. Cytokines: Properties and function. MHC complex and molecules with classification and function. Graft rejection. Antigen processing and their presentation. Hypersensitivity: Gell and Coomb's classification

with mechanism and examples. Autoimmune disorders. Hybridoma technology, monoclonal antibodies, immunotoxins and their applications.

Recommended readings

1. Jawetz, M. and Adelberg (2015) Medical Microbiology (27th edition)
2. Chatterjee, K.D (2015) Parasitology (13th edition)
3. Goldsby, R.A.; Kindt, T.J. and Kuby, J. (2006) Immunology (6th edition).
4. Roitt, I.; Brostoff, J. and Male, D. (2012) Immunology (8th edition).

Practical

1. Study of permanent slides and specimens of parasitic protozoans and helminthes.
2. Pathological examination of sputum, blood, urine and stool.
3. Blood: Erythrocyte Sedimentation Rate (ESR), Haematocrit.
4. Staining and identification of Gram positive and Gram negative bacteria.
5. Preparation of thin and thick blood films to diagnose *Plasmodium* infections.
6. Preparation of temporary and permanent slides of faecal matter by saline preparation and concentration techniques to identify cysts of parasitic protozoans and helminthes eggs.
7. Demonstration of antigen-antibody interaction in gel.
8. Separation of γ -globulin by salt precipitation.

Group discussion or Seminar presentation on one or two related topics to those provided in the list (page no. 25-28).

Semester	Core course	Course Title	Credit
VI	CC-XIII	Biostatistics and Bioinformatics	Theory:04 Practical: 02 Total: 06

About the course

The course is aimed at introducing the application of bioinformatics and statistics in biology. The course gives an insight into the key concepts and methods used in bioinformatics; and computer storage, retrieval, analysis, visualization and distribution of information data related to biological macromolecules like DNA, RNA and proteins. It provides foundation on statistical methods to enable students to compute and interpret basic statistical parameters. As an interdisciplinary field it integrates biology, computer science, chemistry and statistics together sequence analysis structure analysis and functional analysis of biological data.

Learning outcomes

After successfully completing this course, the students will be able to:

- Know the theory behind fundamental bioinformatics analysis methods.
- Be familiar with widely used bioinformatics databases.
- Know basic concepts of probability and statistics.
- Describe statistical methods and probability distributions relevant for molecular biology data.
- Know the applications and limitations of different bioinformatics and statistical methods.
- Perform and interpret bioinformatics and statistical analyses with real molecular biology data.
- Acquire knowledge of various databases of proteins, nucleic acids. Primary, secondary and composite databases. BLAST, FASTA, DOT PLOT
- Make phylogenetic predictions or prediction of structure of proteins and nucleic acids
- Develop understanding in Primer designing
- Understand data mining tool and its practical application in a case study
- Apply the knowledge in future course of their career development in higher education and research.

Theory

UNIT I: Data collection, distribution, presentation, authentication and analysis

13 Lectures

Collection and classification of data. Graphical representation of data: Pie chart, Bar diagram, Histogram, Frequency polygon. Cumulative frequency curve (Ogive), Box plot. Probability theory: Binomial distribution, Poisson distributions. Measures of

central tendency: Arithmetic Mean, Median, Mode; Measures of dispersion: Variance, Standard deviation and Standard error, Concept of Coefficient of variation.

UNIT II: Correlation, regression, analysis of variance etc. 12 Lectures

Correlation: Types of correlation, Calculation of correlation in continuous data and ordinal data. Regression: Linear regression, regression coefficient. Analysis of variance (ANOVA): One way, post-hoc tests. Hypothesis testing: Parametric tests (Paired and unpaired t-test, z-test, F-test) & Non Parametric tests (Chi-square test, Mann-Whitney U-test)

UNIT III: Basics of IT; Data archiving systems etc. 12 Lectures

Introduction and scope of bioinformatics: concept of digital laboratory. Basics of information technology, computer, operating systems, network. Concept of internet protocol (TCP/IP), hypertext, home-page, web-page and uniform resource locators (URL). Introduction to data archiving systems (FASTA format, Accession, and GI-Number)

UNIT IV: Data base management: software, packages and tools 15 Lectures

Basic features and management systems of following: Nucleic acid sequences databases, Genome databases, Protein sequence, structures and interacting proteins databases, Literature databases, Biodiversity and ecosystem based databases. Introduction to data retrieval systems, Search engines, Entrez, sequence retrieval system (SRS) and protein identification resource (PIR). Introduction to molecular sequence analysis software packages and tools, Prediction of motifs, folds and domains, Sequence alignments (BLAST and Clustal W) and phylogenetic trees (PHYLIP). Applications of bioinformatics: Clinical informatics, Cheminformatic resources and pharmacoinformatics

Recommended readings

1. Daniel, W.W. (2012) Biostatistics: A Foundation for Analysis in Health Sciences (10th edition) John Wiley.
2. Milton, J.S. & Tsokos, J.O. (1992) Statistical Methods in the Biological and Health Sciences (2nd edition) McGraw Hill.
3. Zar, J.H. (2013) Biostatistical Analysis (5th edition) Pearson.
4. Barnes, M.R. and Gray, I.C. (2003) Bioinformatics for geneticists, Wiley.
5. Mount, D.W. (2006) Bioinformatics (2nd edition) CBS.

Practical

1. Calculation of mean, standard deviation and standard error.
2. Calculation of correlation coefficient values and finding out the probability
3. Calculation of 'F' value and finding out the probability value for the F value.
4. Student's t-test: Independent and dependent. Hand calculation and calculation using MS Excel.
5. ANOVA and Tukey's HSD: Hand calculation and calculation using MS Excel.
6. Handling and interpretation of Nucleic acid and protein databases.
7. Sequence retrieval from databases.
8. Pair-wise alignment of sequences (BLAST) and interpretation of the output
9. Sequence homology and Gene annotation. Translation of a nucleotide sequence and selection of the correct reading frame of the polypeptide from the output sequences
10. Construction of phylogenetic tree.
11. Comparative analysis of different databases in metabolomics.
Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Core course	Course Title	Credit
VI	CC-XIV	Applied Zoology	Theory:04 Practical: 02 Total: 06

About the course

The course is unique in highlighting the commercial and industrial significance/value of animals. It discusses the techniques/ methods of rearing of animals for commercial usage and the prerequisites for their successful maintenance and sustenance.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand the culture techniques of prawn, pearl and fish.
- Understand silkworms rearing and their products.
- Understand the Bee keeping equipments and apiary management.
- Understand dairy animals management, the breeds and diseases of goats and learn the testing of egg and milk quality.
- Learn various concepts of lac cultivation.
- Be aware of a broad array of career options and activities in human medicine, biomedical research and allied health professions.

Theory

UNIT I: Aquaculture

13 Lectures

Aquaculture: Prawn culture: Culture of fresh water prawn; culture of marine prawn; preparation of farm. preservation and processing of prawn. Export of prawn. Pearl Culture, protocol followed; Fish Culture, Breeding Pond, Fish Seed, Hatching pond. Transport of fish fry to rearing ponds. Harvesting, preservation of fish. Composite fish farming. By products of fishing industry and common fish diseases.

UNIT II: Apiculture, Lac culture and Sericulture

13 Lectures

Apiculture: Species of honey bees in India. Life history of *Apis*. Methods of Bee keeping. Bee products and their uses. Natural enemies and their control. Morphology and Biology of honey bees; social behavior of honey bees. Bee keeping and ancillary industries. Newton's Bee hive Extraction of honey. Medicinal value of honey; bee products. Importance of bee colonies in crop pollination. Lac culture: Lac insect and its life cycle.

Cultivation of lac insect, host plants, processing and uses of lac. Sericulture: Types of silk; Silkworms and their host plants; Mulberry silkworm culture; Life history of silkworm; Natural enemies and their control

UNIT III: Dairy management and poultry farming

13 Lectures

Dairy: Introduction to common dairy animals. Techniques of dairy management. Milk and milk products. Cattle Diseases. Poultry: Types of breeds. Rearing method. Diseases and control measures. Breeds of fowl, Housing and Equipment, Deep litter System, Laying cages, Methods of brooding and Rearing, Debeaking. Management of growers, Layers, Broilers; Feed formulations for chicks, Diseases of fowl. Nutritive value of egg and meat. Incubation and hatching of eggs.

UNIT IV: Vermiculture; Maintenance of reared animals

13 Lectures

Vermiculture: Biology of *Eisenia foetida*. Rearing of earthworms, Equipments, devices used in vermiculture, Vermicompost Technology. Methods and products, Vermiwash Collection, Composition and use. Introduction and importance. Health care and maintenance of reared animals. Methods for analysis of blood. Methods for analysis of urine. Infectious diseases. Non-infectious diseases

Recommended readings

1. Shukla, G.S. and Upadhyaya, V.B. (1999-2000). Economic Zoology (Rastogi Publishers).
2. Mani, M.S. (2006). Insects, NBT, India.
3. Jabde, P.V. (2005) Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac culture.

Practical

1. Morphological characterization of common fish species.
2. Identification of two major carps – *Labeo rohita* and *Catla catla* and their life cycles.
3. Mounting of the sting apparatus.
4. Castes (through charts/specimens) study of bees
5. Worker honey bee with emphasis on leg modifications (through specimens/charts) and whole mount preparation of the 3 pairs of legs.
6. Life cycle of mulberry silkworm, *Bombyx mori* (model/chart/specimens) and life cycle of tasar silkworm, *Antheraea mylitta*.
7. External morphology and nomenclature of dairy animals. Determination of the specific gravity of milk by using a mercury lactometer.

8. Test for good quality eggs (Floating test, cracking test) and for fertilized and unfertilized eggs (Light test, Cracking test).
9. External morphology of poultry birds (model).
10. Project report on visit to dairy farm and visit to Poultry farm (Poultry management and Poultry breeds).

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Discipline Specific Elective Courses (DSE)

Semester	Course	Course Title	Credit
V/ VI	DSE-1	Neuroscience	Theory:04 Practical: 02 Total: 06

About the course

This course will start from the basics of the nervous system of invertebrates and will gradually move towards a more complex vertebrate nervous system. The students will also be taught about the types of synapse, neurotransmitters and their receptors besides other related aspects.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand the structure of brain and improved methods to study it.
- Develop treatments for neurodegenerative diseases (such as Alzheimer's and Parkinson's diseases) and mental illnesses.
- Understand the structure of different lobes of the brain and their corresponding functions.
- Understand intricacies of nerve impulse conduction.

Theory

Unit-I: Brain and spinal cord: Diversity in animals

12 Lectures

General organization of nervous system: Invertebrate Nervous system: Organization of neurons in brain and ganglia of invertebrates nerve net, nerve plexus and ganglionated nervous system (hydra, starfish and earthworm); Functional organization of the human central nervous system, subdivisions of the CNS – spinal cord, medulla, pons, cerebellum, midbrain, diencephalon and cerebral hemispheres; Various lobes of the brain- fore brain, mid brain and hind brain and their functional familiarization; Limbic System and its related functions.

Unit-II: Nerve cells and action potential

12 Lectures

Types of cells: neuronal, glial, ependymal and Schwann cells; Chemical basis of neural transmission- ionic basis of resting membrane potential: Donnan's equilibrium experiments, Nernst's potential, Goldman's equation, sodium-potassium pump; Action Potential &

propagation- Hodgkin and Huxley's model, voltage clamp experiment and the derivation and propagation of action potential.

Unit-III: Synaptic potential, neurotransmission etc.

14 Lectures

Neuromuscular junctions, synapse and synaptic transmission. Synaptic potential and synaptic integration [Electrical and Chemical Synaptic Potential], Excitatory Post Synaptic Potential (EPSP), Inhibitory Post Synaptic Potential (IPSP). Neurotransmitters–Different types– catecholamines, amino acidergic and peptidergic neurotransmitters and their biosynthesis. Physiological role and pharmacological significance of neurotransmitters. Agonist and antagonist for neurotransmitters: Acetylcholine, Dopamine, GABA and Glutamate, Neuropeptide (Endorphin and Enkephalin). Neurotransmitter receptors: (a) Ionotropic receptors (nicotinic receptors of acetylcholine) (b) Metabotropic receptors like G-protein coupled receptors (D1 and D2 of dopamine and muscarinic receptors of acetylcholine).

Unit-IV: Neuropharmacology and molecular pathogenesis

14 Lectures

Relationship of functional properties of neural systems with perception and behaviour; sensory systems, molecular basis of behaviour including learning and memory. Neuropharmacology: Introduction and its branches. Behavioural neuropharmacology: Effects of drug dependence and addiction. Molecular neuropharmacology: Neurons and neurochemical interactions for developing drugs having beneficial effects on neurological functions. Roles of neurotransmitters, neuropeptides, neurohormones and neuromodulators in neuropharmacology. Molecular pathogenesis of pain and neurodegenerative diseases such as Parkinson's, Alzheimer's, psychological disorders, addiction, etc.

Recommended readings

1. Baer, M.F. and Connors B.W. (2015) Neuroscience: Exploring the brain.
2. Byrne, J.H.; Heidelberg, R. and Waxham, M.N. (2014) From Molecules to Networks: An Introduction to Cellular and Molecular Neuroscience.
3. Kandel, E.R.; Schwartz, J.H. and Jessell, T.M. (2000) Principles of Neural Science (4th edition) McGraw Hill Companies
4. Simmons, J. and Young, D. (2003) Nerve Cells and Animal Behaviour (2nd edition) Peter. CUP.

5. Stahl, S.M. (2000) Essential Psychopharmacology- Neuroscientific Basis and Practical Applications (2nd edition) CUP
6. Vilayanur, S.R. and Blakeslee S. (1998) Phantoms in the Brain. Probing the Mysteries of the Human Mind.

Practical

1. Dissection and study of *Drosophila* nervous system using GFP reporter.
2. Observation and counting of *Drosophila* photoreceptor neurons in healthy and diseased condition.
3. Nerve Cell preparation from the spinal cord.
4. Study of neurons and/ or myelin by Nissl, Giemsa or Luxol Fast Blue staining.
5. Study of olfaction in *Drosophila*.
6. Study of novelty, anxiety and spatial learning in mice.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
V/ VI	DSE-2	Endocrinology	Theory:04 Practical: 02 Total: 06

About the course

The course envisages information on endocrine system with emphasis on the structure of hypothalamus and anterior pituitary. The associated hormones and the related disorders will be explained.

Learning outcomes

- Understand neurohormones and neurosecretions.
- Learn about hypothalamo and hypophysial axis.
- Understand about different endocrine glands and their disorders.
- Understand the mechanism of hormone action.

Theory

Unit-I: The chemical messengers

8 Lectures

Definition and classification of hormones. Endocrine, paracrine and autocrine modes of hormone delivery, Feedback mechanism.

Unit II: Hypothalamo-hypophysial Axis

20 Lectures

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, Its hormones and their functions; Hypothalamo-hypophysial portal system; Disorders of pituitary gland.

Unit-III: Peripheral Endocrine Glands

20 Lectures

Structure, Hormones, Functions and Regulation of Thyroid gland; Parathyroid & Adrenal glands; Pancreas; Ovary and Testis; Hormones in homeostasis; Disorders of endocrine glands.

Unit-IV: Regulation of Hormone Action

12 Lectures

Hormone action at Cellular level: Hormone receptors; Transduction and regulation of
Hormone action at Molecular level; Molecular mediators; Genetic control of hormone action.

Recommended readings

1. Turner, C. D. (1971) General Endocrinology, Pub- Saunders Toppan.
2. Nussey, S.S.; and Whitehead, S.A. (2001) Endocrinology: An Integrated Approach, Oxford: BIOS Scientific Publishers.
3. Hadley, M.E. and Levine J.E. (2007) Endocrinology (6th edition) Pearson Prentice-Hall, New Jersey.
4. David, O.N. (2013) Vertebrate Endocrinology.

Practical

1. Dissection and demonstration of Endocrine glands in laboratory bred rat*.
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. Designing of primers of any hormone.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
V/ VI	DSE-3	Nanobiology	Theory:04 Practical: 02 Total: 06

About the course

This course is foundation for students who are interested in molecular materials, nanomaterials, biology-chemistry interface and self-assembly in chemical and biological systems.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand examples of Nano-science and Nano-biology in real life situations.
- Apply their knowledge in their career development in higher education, research and development.

Theory

Unit-I: Nanomaterials, scale scope and future

13 Lectures

Introduction to Nanoscience, History of nanotechnology, and nanoscience in Nature; Molecular based study of condensed matter; low dimensional materials; Properties of nanomaterials: size, surface charge, conductivity, optical properties and biocompatibility.

Unit-II: Synthesis and characterization of nanomaterials, nanoparticles

13 Lectures

Synthesis and characterization of nanomaterials, Fabrication of nanostructures, Top-down and bottom-up approaches and their biological relevance; Metallic nanoparticles, semiconductor, biopolymeric nano-structures and magnetic nanoparticles; Synthesis and characterization of nanoparticles. Magnetic nanoparticles.

Unit-III: Composition and functional properties of nanostructures

13 Lectures

Protein and peptide-based nanostructures, carbohydrate and nucleic acid based nanomaterials; Surface functionalization of gold, silver and other metallic nanoparticles and their applications; Biological application of Nanotechnology, Strategies to design biologically active nanostructure-based biomaterials. Interaction of nanoparticles with biomolecules; Determination of binding constants, effect on conformational and functional properties of biomolecules.

Unit-IV: Design and application of nanomaterials

13 Lectures

Nanoparticle-based designing of potential therapeutics; Applications of rationally engineered proteins or peptides in the making of tissue scaffolds, biomaterials, Application of nanostructures in 3D-cell culture; Immobilized enzymes, drug delivery systems, targeted drug delivery systems; Nanomaterials as Biosensors, Cellular imaging tools and diagnostic applications.

Recommended readings

1. Pradeep, T. (2017) The Essentials: Understanding Nanoscience and Nanotechnology: McGraw-Hill Education.
2. Phoenix, D.A. and Ahmad, W (2014) Nanobiotechnology. One Central Press Ltd.

Practical

1. Synthesis of silver nanoparticles by chemical method.
2. Synthesis of silver nanoparticle using microorganisms.
3. Synthesis of silver nanoparticles using plant extract
4. Synthesis of ZnO by hydrothermal method.
5. Synthesis of Polyaniline nanofibers by CBD method.
6. Synthesis of Fe₂O₃ by Sol-gel method.
7. Preparation of CdS by chemical bath deposition.
8. Electrodeposition of Cobalt thin films.
9. Preparation of CdSe by Successive Ionic Layer, Adsorption and Reaction (SILAR) method .
10. Cytotoxicity testing of nanoparticles.(antimicrobial Germination)

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
V/ VI	DSE-4	Evolutionary Biology	Theory:04 Practical: 02 Total: 06

About the course

The present course gives insight into the origin of life and the related evolutionary processes. The evolutionary theories and the process of species formation will be elaborated in view of the natural selection process.

Learning outcomes

After successfully completing this course, the students will be able to:

- Acquire an in-depth knowledge on the diversity and relationships in animal world.
- Develop a holistic appreciation on the phylogeny and adaptations in animals.
- Enable the students to understand the evolution of universe and life.
- Understanding on the process and theories in evolutionary biology.
- Develop an interest in the debates and discussion taking place in the field of evolutionary biology.

Theory

Unit-I: Origin of life and evidences of evolution

16 Lectures

Evolution, science, and anti-science: the present threat to rationality. Life's Beginnings: Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes; Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse, Molecular (universality of genetic code and protein synthesising machinery, three domains of life, neutral theory of molecular evolution, molecular clock ,example of globin gene family, rRNA/cyt c; Sources of variations: Heritable variations and their role in evolution

Unit-II: How do evolutionary forces operate?

16 Lectures

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

Unit-III: Products of evolution: speciation mechanisms

8 Lectures

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches; Extinctions, Back ground and mass extinctions (causes and effects), detailed example of K-T extinction

Unit-IV: Origin and evolution of man and the interpretation method

12 Lectures

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; Phylogenetic trees, Multiple sequence alignment, construction of phylogenetic trees, interpretation of trees.

Recommended readings

1. Ridley, M (2004) Evolution (3rd edition) Blackwell publishing
2. Hall, B.K. and Hallgrimson, B (2008) Evolution (4th edition) Jones and Barlett Publishers
3. Campbell, N.A. and Reece J.B (2011) Biology (9th edition) Pearson, Benjamin, Cummings
4. Douglas, J.F. (1997) Evolutionary Biology. Sinauer Associates.
5. Pevsner, J. (2009) Bioinformatics and Functional Genomics (2nd edition) Wiley-Blackwell.

Practical

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.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
V/ VI	DSE-5	Mammalian Physiology	Theory:04 Practical: 02 Total: 06

About the course

The course deals with various physiological functions in mammals. It also gives an account of the metabolic/ biochemical pathways and the probable impact of environment on them.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand the physiology at cellular and system levels.
- Understand the mechanism and regulation of breathing, oxygen consumption and determination of respiratory quotient.
- Understand how mammalian body gets nutrition from different biomolecules.
- Understand the process of digestion and excretion.
- Understand the organization of nervous system and process of nerve conduction.
- Understand the process of vision and hearing.
- Understand the process of muscle contraction.
- Learn the determination of hemoglobin content, blood groups and blood pressure.

Theory

Unit-I: An overview of respiration and circulation in mammals

12 Lectures

Respiration: Mechanism and regulation of breathing; Transport of oxygen and carbon dioxide; Respiratory quotient. Circulation: Blood buffers, blood groups, blood cells, cardiac cycle, Haemopoiesis, homeostasis.

Unit-II: An overview of digestion and excretion in mammals

10 Lectures

Nutrition and Digestion: Balanced diet; Digestion and absorption of carbohydrates, proteins and fats; Gastrointestinal hormones: role in digestion. Excretion: Nephron; urine formation; Regulation of urine formation: role of renin, ADH, aldosterone.

Unit-III: An overview of nervous system and coordination in mammals

16 Lectures

Nervous System: Organization, neuron and glial cells- types and structure; Synapses – types and transmission, resting membrane potential: genesis; Action potential: initiation and

conduction. Vision: Structure of eye, retinal components, and photoreceptors: ionic basis of potential generation. Hearing: Structure of ear, mechanoreceptor: ionic basis of potential generation.

Unit-IV: An overview of Muscular system and muscle contraction in mammals

11 Lectures

Muscles: Types, Ultra structure of skeletal, smooth and cardiac muscles, muscle proteins; Neuromuscular junction; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch, tetanus and fatigue, isotonic and isometric contractions.

Recommended readings

1. Barret, K.; Brooks, H.; Boitano, S. and Barman, S. (2010) Ganong's Review of Medical Physiology (23rd edition) Lange Medical.
2. Guyton, A.C. and Hall, J.E. (2006) A text book of Medical Physiology (11th edition) Saunders.
3. Keele, C.A. & Neil, E. (1989) Samson Wright's Applied Physiology (13th edition) Oxford.

Practical

1. Preparation of temporary mounts: Blood film, Squamous epithelium, Striated muscle fibres and nerve cells.
2. Counting of white blood corpuscles and red blood corpuscles
3. Preparation of haemin crystals.
4. Estimation of haemoglobin content
5. Determination of blood groups
6. Measurement of blood pressure using sphygmomanometer
7. Determination of oxygen consumption (cockroach)
8. Preparation of casein from milk
9. Recording of simple muscle twitch with electrical stimulation (or Virtual)
10. Demonstration of reflex action
11. Study of permanent histological sections of mammalian oesophagus, stomach, duodenum, rectum, lung, kidney and brain cells

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
V/ VI	DSE-6	Human Reproductive Biology	Theory:04 Practical: 02 Total: 06

About the course

The major objective of this course is to provide students with a sound coverage of human reproductive biology within the framework of Human Biology. It also envisages the detailed structure and function of the male and female reproductive tracts, gametogenesis, fertilization, early embryogenesis, foetal development and preparation for birth, and maternal adaptations to pregnancy.

Learning outcomes

Upon successful completion of this course, students should be able to:

- Explain and contrast the processes of spermatogenesis, oogenesis.
- Demonstrate an understanding of the hormonal control of reproduction in males and how this is regulated;
- Distinguish between the main stages of embryonic, foetal and neonatal development and causes of foetal disorders.
- Understand the origin and characteristics of common congenital malformations;
- Know how sexually transmitted diseases may contribute to altered neonatal or reproductive function.
- Critically assess relevant scientific literature in Human Reproductive Biology and present their argument in oral and written work.

Theory

Unit-I: Human Reproductive system

14 Lectures

Structure and function of male reproduction; Formation of sperm and fertility of individual; Steroids in sports, exogenous and endogenous. Structure and function of female reproduction; Sexual differentiation, Puberty; Formation of the gametes; Formation of ova. Physiology of ovulation, menstrual cycle; Nutrition and stress influences on the ovulatory cycle.

Unit-II: Fertilization, foetal development and senescence**12 Lectures**

Process of fertilization; Implantation and formation of the foetus and placenta; Pregnancy, foetal development; Labour and birth, lactation and neonatal life; Reproductive Ageing; Menopause.

Unit-III: Evolution of reproductive mechanism and regulation**12 Lectures**

Evolution of human reproductive strategy; Evolutionary impact on behaviour; Sexuality hormonal effects on maternal-infant bonding; Parturition; Society's effects on reproduction; Stress, anorexia, steroids in the environment; Endocrine disrupting chemicals.

Unit-IV: Reproductive Health**14 Lectures**

Sexual dysfunctions, sexually transmitted diseases; Cancers of the reproductive system; Adenomyosis: gland-like growth into myometrium; Birth Control; Assisted Reproduction Technologies; Intrauterine devices (IUD), endometriosis, fibroids, Endometritis: chronic infection of uterus, congenital uterine anomalies; Ovarian cysts, pelvic varicosities.

Recommended readings

1. Thomas W.S. (2014) Langman's Medical Embryology (13th edition) Lippincott, Williams & Wilkins, Baltimore.
2. Gary C.S.; Steven B.B.; Philip R.B. and Philippa H.F. (2014) Larsen's Human Embryology (5th edition) Elsevier.
3. Gilbert, S.F. (2016) Developmental Biology (11th edition) Sinauer.

Practical

1. Examination of histological sections from photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems;
2. Sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.
3. Sperm count and sperm motility in rat
4. Study of modern contraceptive devices

Group discussion or Seminar presentation on one or two related topics from the list (page no.25-28).

Semester	Course	Course Title	Credit
V/ VI	DSE-7	Genetic Engineering and Biotechnology	Theory:04 Practical: 02 Total: 06

About the course

This course gives an insight into the direct manipulation of DNA to alter the characteristics of an organism in a particular way. It envisages concepts, mechanisms, biological designs, functions and evolutionary significance of genetic modification or manipulation in special organisms and also discusses the recent advance in recombinant DNA technology.

Learning outcomes

After successfully completing this course, the students will be able to:

- Develop an understanding of the fundamental molecular tools and their applications of DNA modification and cloning.
- Appreciate shifting their orientation of learning from a descriptive explanation of biology to a unique style of learning through graphic designs and quantitative parameters to realize how such research and innovations have made science interdisciplinary and applied.
- Develop future course of their career development in higher education and research with a sound base.
- Apply their knowledge with problem solving approach to recommend strategies of genetic engineering for possible applications in Biotechnology and allied industry.

Theory

UNIT I: Scope of genetic engineering

13 Lectures

Introduction to Genetic Engineering and Biotechnology. Enzymes as Tools for Genetic Engineering: Restriction Enzymes, Restriction-Modification System, DNA-modifying enzymes, T4 and *E. coli* DNA Polymerase (Klenow), DNA-methylase, Polynucleotide Kinase, DNA-ligase, Taq DNA polymerase, Reverse Transcriptase, T7 and T3 RNA polymerases. Vehicles for DNA cloning: Plasmid DNA vectors, bacteriophage lambda-derived vectors.

UNIT II: Recombination and cloning

13 Lectures

DNA (Gene) cloning, recombinant DNA, cDNA library, genomic library. Isolation of gene from gene library. Screening and identification of recombinant DNA clone from gene library. Expression of recombinant protein from a DNA clone in bacteria and purification of the protein. Some examples of the useful recombinant proteins: Insulin, Streptokinase, enzymes, antibodies, vaccines.

UNIT III: Recent advances in gene technology

13 Lectures

Polymerase Chain Reaction (PCR) and Site-directed, Restriction enzyme digestion. Transgenic animals, Ligation, Cloning, Transformation, Calculation of transformation efficiency. Mutagenesis. Recent trends in Gene technology. Gene Targeting: Knock-ins and Knock-outs. Targeted Genome Editing: ZFNs, TALENs, CRISPRs etc.

UNIT IV: Genomic studies; ethical issues in genetic engineering **13 Lectures**

DNA Sequencing and Genome Analysis, Model Genomes. Human Genome Project and Human Genome Sequences. Applications of Genetic Engineering and Biotechnology in agriculture, medicine and its economic and social implications, Ethical precautions.

Recommended readings

1. Primrose, S.B. and Twyman, R. (2006) Principles of Gene manipulation and Genomics (7th edition) Blackwell Publishing.
2. Nicholl, D.S.T. (2008) An introduction to Genetic Engineering (3rd edition) Cambridge University Press.
3. Watson, J.D. (2006) Recombinant DNA (3rd edition) Cold Spring Harbor Laboratory Press.
4. Brown, T.A. (2001) Gene Cloning and DNA Analysis: An Introduction.
5. A PBS Documentary entitled, "Playing God" [History of Genetic Engineering]

Practical

1. Video-graphic demonstrations on the above mentioned topics.
2. Models and Presentations by students on the topics: Microbial degradation of waste materials, Antibiotics from microorganisms, Transgenic Tomato and Rice,

Recombinant Interferon, Growth Hormone, Insulin, Colony Stimulating Factor, Streptokinase, Industrial Enzymes.

3. Restriction enzyme digestion.
4. Separation of molecules using electrophoresis, Cloning.
5. Transformation, Calculation of transformation efficiency.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
V/ VI	DSE-8	Agrochemicals and Pest Management	Theory:04 Practical: 02 Total: 06

About the course

The course gives insight into the various types of biological pesticides used to control pest and also about their selective mode of action. It also gives an account of eco-friendly biological pesticides.

Learning outcomes

After successfully completing this course, the students will be able to:

- Gain knowledge and expertise on the agrochemicals and their modes of action and their fates in the agro-ecosystem.
- Have the knowledge of pesticide families and be able to differentiate among families based on their specific modes of activity.
- Aware of the laws and regulations governing the proper use of pesticides.
- Develop appropriate pesticide management strategies by evaluating specific pest type.
- Understand the factors involved in calibrating equipment for pesticide applications.
- Estimate the potential hazards to humans, wildlife, and the environment.

Theory

Unit-I: Concept of pest

13 Lectures

Definition, classification, morphology and internal systems; Plant pests –weeds, bacteria, fungi, Viruses, nematodes, molluscs, Arthropods, birds, mammals etc.; Causes of outbreak of pest, growth and development; Classification based on nature of damage: Public health pests, Agricultural pests, Domestic pests, Animal husbandry pests, Structural pests

Unit-II: Agrochemicals/ nutrients for increasing the health of plants

13 Lectures

Manures: types, composition and value, sources of manures, Compost- Different composting technologies-Mechanical compost plants-Vermicomposting-Green manures-Oil cakes, Sewage sludge-Biogas plant slurry. Chemical fertilizers: Classification and value. N-fertilizers: Manufacturing of Ammonium Sulphate, Ammonium Chloride, Ammonium

Nitrate and urea; P- fertilizers: sources, processing rock phosphate, bones for bone meal preparation; K- fertilizers: sources, Potassium Chloride, Potassium Sulphate and Potassium Nitrate; Biofertilizers: Classification and value; viz., *Rhizobium*, *Azotobactor*, *Azolla*, Blue Green Algae, VAM.

Unit-III: Agrochemicals for pest management

13 Lectures

Conventional chemicals/ pesticides based on target species: Acaricides, Fungicides, Rodenticides, Nematicides, Molluscicides, Fumigants and Repellents; Based on chemical nature: Organophosphates; Organochlorines, Carbamates etc.; Structure, chemical name, physical and chemical properties; Degradation metabolism, Mode of action, uses, toxicity; Application of Pesticides, devices used; dose estimation for field application.

Unit-IV: Botanicals and other biopesticides

13 Lectures

Potential pesticidal plants; Plant extracts and Bio-organisms: Azadirachtin and its role in pest control; Other biopesticides: Pyrethrins, Pyrethroids, Rotenone, Nicotine and Nicotinoids. Growth inhibitors or physiological antagonists, chemo-sterilants; pheromones and attractants; Insect growth regulators, juvenile hormones, moulting hormones; Chitin synthesis inhibitors. Moulting Inhibitors. BT methodology, genetically modified and transgenic plants.

Recommended readings

1. Hill, D.S. (1983) Agricultural insect pests of the tropics and their control- Cambridge Univ. Press.
2. Atwal, A. S. (1979) Agricultural pests of India and south East Asia.
3. Dent, D. (2000) Insect pest management (2nd edition) CAB International.
4. Roberts, D.A. (1978) Fundamentals of Plant Pest Control.
5. De Bach, P. (1964) Biological Control of Insect Pests and Weeds, Chapman & Hall, New York.
6. Koul, O. and Dhaliwal, G.S. (2003) Phytochemical Biopesticides, Harwood Academic Publishers, Amsterdam.
7. Pedigo, L.P. (1996) Entomology and pest management, Prentice Hall, N. Delhi.

Practical

1. Identification of common natural enemies of crop pests (parasitoids, predators, microbes).
2. Study the damage caused by the commonly occurring insect pests – Infected plant/plant parts.
3. Preparation of Neem and *Lantana Camara* based botanical pesticides.
4. Field trips to bio-control laboratories – IARI, CWC, FCI.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
V/ VI	DSE-9	Wildlife Conservation and Management	Theory:04 Practical: 02 Total: 06

About the course

The course is an introduction to wildlife management and gives an account of the tools used by wildlife managers. Topics covered are to equip students with adequate knowledge of various biodiversity monitoring methodologies, conservation and management issues of vertebrate pests, wildlife conflict and over abundant species, wildlife health and diseases.

Learning outcomes

After successfully completing this course, the students will be able to:

- Develop an understanding of how animals interact with each other and their natural environment
- Develop the ability to use the fundamental principles of wildlife ecology to solve local, regional and national conservation and management issues
- Develop the ability to work collaboratively on team-based projects
- Demonstrate proficiency in the writing, speaking, and critical thinking skills needed to become a wildlife technician
- Gain an appreciation for the modern scope of scientific inquiry in the field of wildlife conservation management
- Develop an ability to analyze, present and interpret wildlife conservation management information.

Theory

Unit-I: Value of wildlife and need for its conservation

13 Lectures

Definition, value and importance of wildlife; Types of ecosystems. Causes of depletion of wildlife; Inventory and classification of wetland and animal inhabitants; Population vulnerability analysis and its components; Factors responsible for the extinction of animals; Types of protected areas and the concept of zoning within the protected areas; Wildlife Sanctuaries and National Parks in India: general strategies and issues; Theories of population dispersal; Animal movement, concept of home range and territory; Tracking movement by remote sensing and GIS.

Unit-II: Population and prey-predator dynamics

13 Lectures

Wildlife conservation, ethics and importance of conservation; Impact of topography, geology, soil and water on wildlife; Impact of habitat destruction and fragmentation on wildlife; Biological parameters such as food, cover, forage and their impact on wild life; Population attributes; concepts of exponential and logistic growth rates of wildlife; Density dependent and independent population regulation; Impact of introduced species on preexisting flora and fauna of wildlife; Identification and estimation of wild animals by fecal sample analysis, hair identification, pug marks and census methods. Predator-prey models and impact of predation.

Unit-III: Wildlife Conservation

13 Lectures

Wildlife conservation objectives- strategies and issues; Captive breeding techniques and translocation and reintroduction; Inviolate area and critical habitats and their impact on wildlife; Different terrestrial habitats of wildlife in India; Restoration of degraded habitat; Damage caused by wildlife in India and its mitigation; Sick animal refuges in protected areas.

Unit-IV: Rehabilitation and management

13 Lectures

Type of wildlife management-manipulative, custodial; Management of over abundant wild animal populations causing damages to nearby inhabitants and their crops and animals; Tools and techniques to control the menace of wild animals; man wildlife conflict resolution and mitigation; Management of exotic and invasive wetland species in India. Habitat manipulation– control and regulation of grazing. Weed eradication; Major diseases of domestic and wild animals and their control and impact of wild life tourism.

Recommended readings

1. Caughley, G., and Sinclair, A.R.E. (1994) Wildlife Ecology and Management. Blackwell Science.
2. Woodroffe, R., Thirgood, S. and Rabinowitz, A. (2005) People and Wildlife, Conflict or Co-existence? Cambridge University.
3. Bookhout, T.A. (1996) Research and Management Techniques for Wildlife and Habitats (5th edition) The Wildlife Society, Allen Press.
4. Sutherland, W.J. (2000) The Conservation Handbook: Research, Management and Policy. Blackwell Sciences

5. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008) Problem solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

Practical

1. Identification of flora, mammalian fauna, avian fauna, herpeto-fauna.
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, pellet groups, nest, antlers etc.
4. Demonstration of different field techniques for flora and fauna.
5. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
V/ VI	DSE-10	Aquatic Biology	Theory:04 Practical: 02 Total: 06

About the course

The program of study aims to provide students with a broad-based foundation in science together with extensive subject knowledge in the discipline of aquatic biology. It also aims to develop a range of transferable research, analytical and communication skills.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand and apply relevant scientific principles in the area of aquatic biology
- Employ scientific methodologies such as experimentation and data analysis in the area of aquatic biology
- Critically analyse, interpret and evaluate information relevant to aquatic biology
- Appreciate the multidisciplinary nature of the study of aquatic biology and engage positively with people and ideas beyond their own discipline.
- Explore some of the unique environmental problems dealing with aquatic environments.
- Develop *employable skills* in freshwater biological water quality analysis.

UNIT – I Abiotic conditions of Freshwater ecosystems

14 Lectures

Physical Properties of Water; chemical properties of water; Brief introduction of the aquatic ecosystems. Freshwater ecosystems (lakes, wetlands, streams and rivers). Physico-chemical Characteristics of fresh water bodies: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity: dissolved gases (Oxygen, Carbon dioxide). Origin and classification of lakes; Streams: Different stages of stream development.

UNIT II Aquatic organisms

10 Lectures

Feeding in aquatic organisms; respiration in aquatic organisms; osmoregulation in freshwater and marine organisms; sensory world of aquatic organisms; Locomotion in water. Adaptation of hill-stream fishes. Adaptation of deep sea organisms.

UNIT – II Abiotic conditions of marine ecosystems

14 Lectures

Classification of marine ecosystem: Estuaries, intertidal zones, Oceanic pelagic zone, marine benthic zone. Coral reefs. Physico-chemical environment, Salinity and density of sea water and Continental shelf; other factors *viz.*, Light, Temperature, Thermal stratification, Dissolved Solids, Turbidity: dissolved gases (Oxygen, Carbon dioxide).

UNIT – III Management of Aquatic Resources

14 Lectures

Aquatic pollution - Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation. Water pollution acts of India. Sewage treatment and water quality assessment - BOD and COD.

Recommended readings

1. Goldman, C. (1994) Limnology (2nd edition).
2. Ananthkrishnan, T.N. (1989) Bioresources Ecology (3rd edition).
3. Odum, E.P. and Barrett, G.W. (2004) Fundamentals of Ecology (5th edition).
4. Pawlowski, L. (1980) Physicochemical Methods for water and Wastewater Treatment.
5. Wetzel, R. (2001) Limnology (3rd edition) Elsevier.
6. Trivedy, R.K. and Goyal, P.K. (1986) Chemical and biological methods for water pollution studies.
7. Welch, P.S. (2014) Limnology Vol. I-II.

Practical

1. Study of the topography of a lake.
2. Physico-Chemical and biological analysis of a lake.
3. Physico-Chemical analysis of water - O₂, CO₂, BOD, COD.
Biological– Zooplanktons – Identification and population density of Zooplanktons of a lake.
3. Determination 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) and their significance.

5. Identification of Zooplankton- Copepods, Hydromedusae, Pteropods, Chaetognatha etc.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28)

Semester	Course	Course Title	Credit
V/ VI	DSE-11	Live stock management and Animal Husbandry	Theory:04 Practical: 02 Total: 06

About the course

The course provides intensive study in livestock production, management, marketing, nutrition, breeding, production records, selection, animal health, waste management, and conservation practices.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand skills and requirements necessary to find and maintain a job.
- Select and develop a breeding system for a livestock enterprise.
- Understand the importance of genetic improvement in animal production.
- Formulate feed rations for different classes of livestock.
- Identify common problems associated with livestock and horse herd health and solutions.
- Identify current and future issues relating to animal husbandry.
- Understand different marketing opportunities available for livestock production.

Unit I: Animal products and breeding systems

13 Lectures

Scope of Livestock Industry; Livestock Enterprises; Issues in Animal Agriculture. Animal Products: Importance of Animal Products; Beef; Pork; Lamb; Poultry Products. Advanced Reproduction and Breeding: Reproductive Systems, Common Breeding Systems including cattle Breeding, Swine, Sheep and Goat Breeding, Hormones and Cycles and effect of environment. Reproductive Technologies.

Unit II: Animal products and breeding systems

13 Lectures

Nutritional requirements: Energy requirements for maintenance, growth, milk, egg, wool, and meat production. Carbohydrates & Fats, Protein, Minerals & Vitamins, Water etc. Common Feedstuffs Systems for expressing energy value of foods in ruminants, pigs and poultry. Direct and indirect calorimetry. Advanced Ration Formulations .

Unit III: Maintenance of breeds

13 Lectures

Common Breeds of Livestock: Breeds of Cattle, swine, sheep, goat and poultry: Selecting live stocks; Facilities and Equipment; Housing, Maintenance and health care; Management of breeding stocks and products. Vaccination programmes and Deworming programmes.

Unit IV: Marketing and related issues

13 Lectures

Planning and Marketing; Culling, Forward Contracting, Backgrounding. Quality control; Future prospects. Basic principles of Genetics and tools for genetic improvement. Current issues affecting the livestock industry.

Recommended readings

1. Taylor, R.E and Field, T.G. (2004).Scientific Farm Animal Production: An Induction to Animal Science. Prentice-Hall
2. Acker, D. and Cunningham, M. (1998). Animal Science & Industry. Prentice-Hall.
3. Blakely, J. and Bade, D. (1985). The Science of Animal Husbandry. Prentice-Hall.
4. Cambell, J. and Lasley, J. (1975).The Science of Animals that Serve Mankind. McGraw-Hill.
5. Cooper, E. L. (1990). Agriscience: Fundamentals & Applications Delmer: Albany.
6. American Youth Horse Council (1999) Handbook: A Guide to Equine Care and Management.
7. Morrison, F. (1949). Feeds and Feeding (8th edition) Morrison: Ithaca.

Practical

1. Estimation of amino acids, proteins and fatty acids in feed.
2. Virtual demonstration of endocrine glands and their influence on growth of live stock.
3. Estimation of albumen and yolk quantity in eggs.
4. Estimation of calcium in egg shell.
5. Estimation of cholesterol and peroxides in meat.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

General Elective Courses

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-1	Exploring the Brain: Structure and Function	Theory:04 Practical: 02 Total: 06

About the course

The course provides an insight into the structure of brain, its associated functions, its gradual evolution with increased cranial capacity, mechanism of neurotransmission and the associated neurodegenerative disorders.

Learning outcomes

After successfully completing this course, the students will be able to understand:

- The early and current status of neuroscience.
- The structure of brain cells and their circuit.
- Evolution and adaptation of brain.
- Brain development, aging and imaging.
- Neurotransmitters and their action.
- The process of learning and memory.
- Different type of brain disorders.

Theory

UNIT I: Scope of Neuroscience. Brain structure

11 Lectures

Introduction to Neuroscience and its scope. Early and 19th century views of the Brain. Latest advances in Neuroscience today. Brain cells, types: Neurons – types and structure; Glia- types and structure; Neuronal circuit.

UNIT II: Evolution and development of brain

12 Lectures

Evolution and Adaptation of Brain: Theories of brain evolution. Evolution of brain in vertebrates and associated behavioral adaptation. Organization and development of brain

in human. Divisions of the brain. Structure-function relationship. Neuroimaging- CT and MRI.

UNIT III: Neurotransmitters and mechanism of neurotransmission 13 Lectures

Neurotransmitters and neurotransmission: Noradrenergic, serotonergic, dopaminergic and cholinergic system. Mechanism of neurotransmission and drug action. Learning and memory. Types, mechanism, disorders.

UNIT IV: Managing brain health 16 Lectures

Brain aging: Structural and chemical changes. Functional changes. Maintenance of healthy brain. Brain disorders: Neurodegenerative diseases- Epilepsy, Stroke, Alzheimer's, Parkinsons. Neuropsychiatric disorders- Anxiety, Depression, Mood disorders, Schizophrenia.

Recommended readings

1. Squire, L. *et al.* (2003) Fundamental Neuroscience, Academic Press.
2. Kandel, E. (2000) Principles of Neural Science, McGraw Hill

Practical

1. Dissection and study of *Drosophila* nervous system using GFP reporter.
2. Observation and quantization of *Drosophila* photoreceptor neurons in healthy and diseased conditions.
3. Experiments based on the course contents.
4. Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-2	Human Physiology	Theory:04 Practical: 02 Total: 06

About the course

The course provides an insight into the structure and function of organ systems in humans and their involvement in body metabolism towards maintenance of homeostasis.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand the process of digestion and its control
- Develop understanding in muscle structure and contraction mechanism
- Learn the process of respiration and transport of gases
- Understand kidney structure and regulation of urine formation
- Understand heart structure and functioning
- Understand function of endocrine glands and formation of gametes.

Theory

UNIT I: How are processes of digestion and excretion accomplished in man ?

13 Lectures

Digestive glands: Structure and function. Digestion and absorption of nutrients: carbohydrates, fats and proteins. Neural and hormonal control of digestion. Excretory system: Functional anatomy of kidney. Mechanism of excretion and regulation of urine formation.

UNIT II: An overview of muscular function and respiration in man **13 Lectures**

Structure of smooth, skeletal and cardiac muscles. Neuromuscular junction. Mechanism of muscle contraction. Respiration: Ventilation, External and internal respiration. Transport of carbon dioxide and oxygen in blood and tissues. Factors affecting gaseous transport.

UNIT III: Cardiovascular functions in man

10 Lectures

Structure of heart. Coordination of heartbeat; control of heart beat (neural and hormonal)
Blood cells and blood vessels. Cardiac cycle. ECG. Lymph and lymph vessels.

UNIT IV: Endocrine and reproductive physiology

16 Lectures

Structure and function of endocrine glands *viz.*, pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries and testes. Processes of spermatogenesis and oogenesis. Fertilization and implantation. Menstrual cycle. Pregnancy and Parturition.

Recommended readings

1. Tortora, G.J. and Derrickson, B.H. (2009) Principles of Anatomy and Physiology (12th edition) John Wiley and Sons, Inc.
2. Widmaier, E.P., Raff, H. and Strang, K.T. (2008) Vander's Human Physiology (9th edition) McGraw Hill.
3. Guyton, A.C. and Hall, J.E. (2011) Textbook of Medical Physiology (12th edition) Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
4. Marieb, E. (1998) Human Anatomy and Physiology (4th edition) Addison-Wesley.
5. Kesar, S. and Vashisht, N. (2007) Experimental Physiology, Heritage Publishers.

Practical

1. Temporary mount preparation of Neurons and Blood film.
2. Preparation of haemin and haemochromogen crystals.
3. Haemoglobin estimation using Sahli's haemoglobinometer.
4. Study of permanent histological sections of mammalian oesophagus, stomach, duodenum, rectum, lung, adrenal, kidney, thyroid, pancreas, testis, ovary.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-3	Vectors, Diseases and Management	Theory:04 Practical: 02 Total: 06

About the course

The course provides an insight into the common vector-borne diseases, their etiology, role of vectors in their spread, host- parasite relationship and finally the strategies to manage these vectors.

Learning outcomes

After successfully completing this course, the students will be able to:

- Develop awareness about the causative agents and control measures of many commonly occurring diseases.
- Develop understanding about the favourable breeding conditions for the vectors.
- Devise strategies to manage the vectors population below threshold levels, public health importance.
- Undertake measures or start awareness programmes for maintenance of hygienic conditions, avoidance of contact from vector, destruction of breeding spots in the vicinity of houses and cattle shed by public health education campaign.

Theory

Unit I: Vector and vector bionomics

13 Lectures

Brief introduction, types and morphological peculiarities of vectors such as mosquitoes, flies, fleas, lice, bugs, ticks and mites. Host-vector relationship. Primary and secondary vector concept. Vectorial capacity. Vector bionomics-larval habitats and host biting preferences, human and animal biting indices. Evolution of vector bionomics and its effect on disease transmission. Vector incrimination. Human practices and the occurrence of pests

Unit II: Disease vectors and the causes of disease outbreaks

13 Lectures

Salient features of the vectors belonging to Diptera, Siphonaptera, Siphunculata, Hemiptera, Arachnida, Blattaria, Acarina (families Ixodidae and Argasidae) etc. Role of non-blood sucking flies in myiasis; of blood sucking flies in transmission of plague and typhus; of lice (body, head, pubic) in transmission of typhus, relapsing and trench fevers, Vagabond's disease and Phthiriasis; of bugs in transmission of Chaga's disease of. Brief account of mites and the associated diseases. Population biology, Factors affecting abundance, Density dependence and independence, How do people cause outbreak?

Unit III: Vector management strategies

13 Lectures

Control of vector flies by screening, fly traps, electrocution, poison baits and outdoor residual sprays; biological control by natural parasites and predators. Chemical control. Efficacy of synthetic pyrethroids, residual spray of insecticides, treated bed nets/curtains and fumigations. Biological control of mosquitoes by the use of viruses, bacteria, fungi, parasites, nematodes and larvivorous fishes. Sterile insect technique, Eradication, Other genetic approaches, Pheromones/allelochemicals, Attract-and -kill, Mating disruptors, alarm pheromones and oviposition disruptors

Unit IV: Emerging concepts and approaches to vector management

13 Lectures

Legislation and regulation, Methods of sampling and monitoring, sampling plan, Allocation of sampling units. Exclusion and routes of entry. Controlled atmosphere, Risk assessment, The integrated control/ IPM approach, Damage thresholds estimation, Forecasting, Increasing agroecosystem resistance, Pesticide selection, Eradication versus control, Up to what limits IPM should be adopted. Decision support

Recommended readings

1. Imms, A.D. (1977). A General Text Book of Entomology. Chapman & Hall, UK.
2. Chapman, R.F. (1998). The Insects: Structure and Function.IV Edition, Cambridge University Press, UK.
3. Mathews, G. (2011). Integrated Vector Management: Controlling Vectors of Malaria and other Insect Vector borne Disease.Wiley-Blackwell.

4. Belding, D.L. (1942). Textbook of Clinical Parasitology. Appleton-Century Co., Inc., New York.
5. Roy, D.N. and Brown, A.W.A. (2004). Entomology. Biotech Books, Delhi

Practical

1. Study of mouth parts of different insects.
 2. Study of permanent slides of the following insect vectors: *Aedes*, *Culex*, *Anopheles*, *Pediculus humanus corporis*, *Pediculus humanus capitis*, *Phthirus pubis*, *Xenopsylla cheopis*, , *Musca domestica*, *Cimex lectularius*, *Phlebotomus argentipes* through permanent slides/ videos.
 3. State the diseases transmitted by above insect vectors.
 4. Project report submission on any one of the insect vectors and the disease transmitted.
- Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28)

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-4	Food, Nutrition and Health	Theory:04 Practical: 02 Total: 06

About the course

The course covers the basic concepts of balanced diet for people of different ages besides focusing on the consequences of malnutrition and the deficiency diseases and the diseases caused due to poor hygiene.

Learning outcomes

After successfully completing this course, the students will be able to:

- Understand the role of food and nutrients in health and disease.
- Provide culturally competent nutrition services for diverse individuals.
- Implement strategies for food access, procurement, preparation, and safety that are relevant for the culture, age, literacy level, and socio-economic status of clients and groups.
- Perform food system management and leadership functions that consider sustainability in business, healthcare, community, and institutional arenas.

Theory

Unit 1: Nutrition and dietary nutrients

12 Lectures

Basic concept of Food: Components and nutrients. Concept of balanced diet, nutrient requirements and dietary pattern for different groups viz., adults, pregnant and nursing mothers, infants, school children, adolescents and elderly people.

Unit II: Macro nutrients and micronutrients

12 Lectures

Nutritional Biochemistry: Macronutrients. Carbohydrates, Lipids, Proteins- Definition, Classification, their dietary source and role. Micronutrients. Vitamins- Water-soluble and Fat-soluble vitamins- their sources and importance. Important minerals viz., Iron, Calcium, Phosphorus, Iodine, Selenium and Zinc: their biological functions.

Unit III: Malnutrition and nutrient deficiency diseases

15 Lectures

Definition and concept of health: Common nutritional deficiency diseases- Protein Malnutrition (e.g., Kwashiorkor and Marasmus), Vitamin A deficiency, Iron deficiency and Iodine deficiency disorders- their symptoms, treatment, prevention and government initiatives, if any. Life style dependent diseases- hypertension, diabetes mellitus, and obesity- their causes and prevention. Social health problems- smoking, alcoholism, narcotics.

Acquired Immuno Deficiency Syndrome (AIDS): causes, treatment and prevention. Other ailments viz., cold, cough, and fever, their causes and treatment.

Unit IV: Diseases caused by microorganisms

13 Lectures

Food hygiene: Potable water- sources and methods of purification at domestic level. Food and Water-borne infections: Bacterial diseases: cholera, dysentery; typhoid fever, viral diseases: Hepatitis, Poliomyelitis etc., Protozoan diseases: amoebiasis, giardiasis; Parasitic diseases: taeniasis and ascariasis their transmission, causative agent, sources of infection, symptoms and prevention. Causes of food spoilage and its prevention.

Recommended reading

1. Mudambi, S.R. and Rajagopal, M.V. (2007). Fundamentals of Foods, Nutrition and Diet Therapy; Fifth Ed; New Age International Publishers
2. Srilakshmi, B. (2002). Nutrition Science; New Age International (P) Ltd.
3. Srilakshmi, B. (2007). Food Science; Fourth Ed; New Age International (P) Ltd.
4. Swaminathan, M. (1986). Handbook of Foods and Nutrition; Fifth Ed; BAPPCO.
5. Bamji, M.S.; Rao, N.P. and Reddy, V. (2009). Text Book of Human Nutrition; Oxford & IBH Publishing Co. Pvt Ltd.
6. Wardlaw, G.M. and Hampl, J.S. (2007). Perspectives in Nutrition; Seventh Ed; McGraw Hill.
7. Lakra, P. and Singh M.D. (2008). Textbook of Nutrition and Health; First Ed; Academic Excellence.
8. Manay, M.S. and Shadaksharaswamy, M. (1998). Food-Facts and Principles; New AgeInternational (P) Ltd.
9. Gibney, M.J. et al. (2004). Public Health Nutrition; Blackwell Publishing.

Practical

1. Detecting adulteration in a) Ghee b) Sugars c) Tea leaves and d) Turmeric.
3. Estimation of Lactose in milk.
4. Titrimetric method for Ascorbic acid estimation .
5. Estimation of Calcium in foods by titrimetry.
6. Study of the stored grain pests from slides/ photograph(*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.

7. Project- Computer aided diet analysis and nutrition counselling for different age groups.
8. Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-5	Global Climate change	Theory:04 Practical: 02 Total: 06

About the course

This course provides an overview of the Earth's climate system, the various forcing and feedbacks controlling the Earth's climate variability in short and long timescale. It will give a brief introduction to the atmosphere and ocean circulation.

Learning outcomes

After completing this course, the student will be able to:

- Develop understanding on the concept and issues of global environmental change.
- Analyse the causes and effects of depletion of stratospheric ozone layer.
- Examine the climate change and its effect on living beings.
- Understand the physical basis of natural green gashouse effect on man and materials.
- Evaluate human influenced driver of our climate system and its applications.

Theory

Unit I: An overview of earth system

13 lectures

Global Environmental change issues. Paleoclimate – what can we learn from the past? Concept of earth system, climate forcing, responses, feedback loops, equilibrium states, Daisy world model, Solar Flux at Earth's Orbit, Stratospheric ozone layer: Evolution of ozone layer; Planetary Energy balance, seasonal variability. Radiative transfer, an improved estimate of climate sensitivity.

Unit II: Causes and consequences of Ozone layer depletion

12 lectures

Greenhouse gases and their sources; Greenhouse effects; Causes of depletion of ozone layer and consequences; Climate change: Effects of enhanced UV-B on plants, microbes, animals, human health and materials; global energy infrastructure and GHG emissions.

Unit III: Other adverse impacts on climate

14 lectures

Atmospheric deposition: Past and present scenario; Causes and consequences of excessive atmospheric deposition of nutrients and trace elements; Acid rain and its effects on plants, animals, microbes and ecosystems. Eutrophication, Consequences on climate, oceans, agriculture, natural vegetation and humans; Clouds, Storms and Climate -Cloud Formation and Climate, El Niño and the Southern Oscillation -El Niño and its Effects.

Unit IV: International summits and agreements

13 lectures

International efforts on climate change issues. Global efforts for mitigating ozone layer depletion. Climate modeling and climate change feedbacks. International Agreements: the United Nations Framework Convention on Climate Change, Kyoto Protocol, Paris Agreement. Integrated Assessment, Decisions under uncertainty: Abate now, or delay? Emissions budgets.

Recommended readings

1. Adger, N.; Brown, K. and Conway, D. (2012). Global Environmental Change: Understanding the Human Dimensions. The National Academic Press.
2. Turekian, K.K. (1996). Global Environmental Change-Past, Present, and Future. Prentice-Hall.
3. Matthew, R.A.; Barnett, J. and McDonald, B. (2009). Global Environmental Change and Human Security. MIT Press., USA.
4. Hester, R.E. and Harrison, R.M. (2002). Global Environmental Change. Royal Society of Chemistry.

Practical

There are no structured class lab experiments involved. However, the students are expected to visit various sites on the web, make teams for group-discussion indulge in debates, collect justifiable information from various sources, make historical report on the science, impact, future and politics behind climate change.

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28)

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-6	Environmental Microbiology	Theory:04 Practical: 02 Total: 06

About the course

The course provides an insight into the immense importance of the microbes around us. Their uses and benefits outweigh their harmful aspects. It focuses on the role of microbes in waste management and environmental restoration.

Learning outcomes

After successfully completing this course, the students will be able to:

- Develop understanding on the microbiology diversity, processes and applications in the environment.
- Analyze the contribution of microbiology area of science in water treatment, solid waste management, bioremediation and phytoremediation.
- Evaluate the implications of mass cultivation, inoculums preparation, quality control, and vermicomposting
- Apply the skills for environmental protection

Theory

Unit I: Microbiology and the microbes

12 Lectures

Introduction to environmental microbiology; History and scope, cultivation of microbial communities, importance and significance of community culture. Methods for detection of community cultures, culturable microorganisms, phylogenetic and molecular profiling of microbes in the environment

Unit II: Bioremediation of waste water

13 Lectures

Water microbiology: waste water treatment, method, aerobic and anaerobic processes, solid waste management, landfills, containment types, composting and applications; Bioremediation, bio-filters, microbial polymers, microbial plastics, Bioaccumulation, Biomagnification, marine pollution, concepts and remediation strategies.

Unit III: Microbes in air and water

15 Lectures

Aeromicrobiology: Intramural and extramural aero-microbiology, Aerosols and Bioaerosols: Sources and launching, Diversity and Survival of microbes in air, control, Aeroallergens, Pollen allergy, Hypersensitivity, effect of climate change on pollen and spore discharge. aquatic

microbiology: aquatic environment; fresh, brackish and marine waters and their microbiology, hydrothermal vents, hot spring, Arctic and Antarctic environment. Soil Microbiology: Soil formation, sampling of soil and deep subsurface soil, rhizospheric and agricultural soil; microbes of surface and subsurface soil. Environmentally stressed soil.

Unit IV: Nutrient recycling and manuring

12 Lectures

Biogeochemical cycling: Carbon, Nitrogen, Phosphorus and Sulphur; Importance. Biofertilizers: Definition, types, mass cultivation, inoculums preparation, quality control, significance and applications. Vermicomposting.

Recommended readings

1. Sharma, P. D. (2005). Environmental Microbiology. Alpha Science International Ltd. ISBN. 1842652761
2. Bertrand, J. C., Caumetter, P., Laboron, R., Matheron, R., Normand, P., SIme-Nganda. (2015). Environmental Microbiology: Fundamental and Applications of Microbial Ecology. Editor: Springer
3. Pepper, I.; Gerba, C. and Gentry, T. (2014). Environmental Microbiology Academic Press.
4. Pradipta, K. and Mohapatra, I. K. (2008). Text book of Environmental Microbiology.

Practical

The goal of the practical is to get acquainted with the microbiological laboratory techniques of environmental analysis.

1. Monitoring of pollution indicating microbe communities in case of hydrocarbon-polluted soil/groundwater systems.
2. Application of respirometric methods to assess the speed of degradation processes.
3. Assembly of a composting model system, analysis of basic thermal etc. properties.
4. Visit at a composting plant and remediation site.
5. Visit to some nearby forests to collect soil and isolate a variety of microbes.
6. Process of cleaning and disinfecting of the glassware/ plasticware.
7. Preparation of vermicompost.
8. Preparation of culture media for studying bacterial growth.
9. Preparation of Biofertilizer.
10. Measurement of Microbial growth - cell number, cell mass and cell constituent.
11. Study impact of environmental conditions on microbial growth.

Group discussion or Seminar presentation on one or two related topics from the list
(page no. 25-28)

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-7	Environmental Biotechnology	Theory:04 Practical: 02 Total: 06

About the course

This course will provide details about the environmental problems, interaction of microbes with animals, microbial diseases, xenobiotic compounds, and role of enzymes in degradation of toxic compounds.

Learning outcomes:

On the completion of the course, the students shall be able to

- Understand different causes of environmental pollution and their remedies
- Analyze microbiology of waste water and its implications
- Examine the role of immobilized cells/enzymes in treatment of toxic compounds
- Reflect upon various sustainable environmental protection strategies
- Evaluate the implications of international legislations, policies for environmental protection

Theory

Unit-I: Environmental Problems

13 Lectures

Basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities and their impacts. Environmental pollution: types and sources of pollution, levels of pollutants, fate of pollutants in the environment, Bioconcentration, bio/geomagnification.

Unit-II: Types of interaction with microbes

13 Lectures

Types of interaction between animals and microbes, Microbes and public health: Brief account of microbial diseases in humans (water and air borne disease). Microbiology of water: Aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process - anaerobic digestion, anaerobic filters. Treatment schemes for waste-waters of dairy, distillery, tannery, sugar and antibiotic industries.

Unit-III: Xenobiotic compounds and microbial remediation

13 Lectures

Xenobiotic compounds: Organic compounds (Chlorinated hydrocarbons, Polyaromatic hydrocarbons, Pesticides, Surfactants etc.) and inorganic compounds (metals, radionuclides, phosphates, nitrates etc.). Xenobiotic bioremediation: decay behaviour and degradative plasmids, molecular techniques used in bioremediation.

Unit-IV: Environmental Awareness and Management

13 Lectures

Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. Economic growth, Gross National Productivity and the quality of life. Tragedy of Commons, Pollution control Economics, Cost-benefit and cost effectiveness analysis, WTO and Environment, Environmental Education and awareness programmes; Environmental Ethics. Regulation of the safety of biotechnology procedure and products: Deliberate release and fate of genetically modified microorganisms.

Recommended readings

1. Metcalf and Eddy Inc. (1978) Waste engineering - treatment, disposal and reuse (2nd edition) Tata McGraw Hill, New Delhi.
2. Baaker, K.H. and Herson, D.S. (1994) Bioremediation, Mc.GrawHill Inc, New York.
3. Ahmed, N.; Qureshi, F.M. and Khan, O.Y. (2006). Industrial and Environmental Biotechnology - Horizon Press.
4. Rochelle, P.A. (2001). Environmental Molecular Biology, Horizon Press.
5. Pepper I.; Gerba, C.; Gentry, T. and Maier, R. (2008) Environmental Microbiology. Academic Press.

Practical

1. Soil/ Water analysis - pH, DO, salinity, chloride, hardness, alkalinity, acidity, dissolved substances viz., nitrate, calcium, magnesium and phosphorus.
2. Gravimetric estimation-Total solid, dissolved solid, suspended solid in an effluent
3. Microbial study of air (open plate and air sample) and water
4. Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-8	Biodiversity Conservation and Sustainable Development	Theory:04 Practical: 02 Total: 06

About the course

The course provides information regarding the status of environment, the depletion of its resources, the loss of biodiversity and the remedial efforts undertaken by various agencies. The course is also focused to creating environmental awareness among learners.

Learning outcomes

After successfully completing this course, the students will be able to:

- Develop understanding for the environment which is largely degraded in the current scenario.
- Understand the importance of bio diversity and the consequences of bio diversity loss
- Learn about the judicious utilisation of natural resources
- Follow the concept of green technology and the eco-friendly practises and other prospects of environment protection
- understand and practice appropriate legal/regulatory and ethical issues in the context of the work environment.
- design research projects to collect information to assess the effectiveness of current practices, and interpret the results of a statistical analysis of data, and use this to make informed decisions.

Theory

Unit I: Anthropogenic impact on environment

13 Lectures

Man as an animal species in the ecosystem. Population explosion. carrying capacity, exploitation of resources due to urbanization, industrialization and agricultural practises. Generation of agricultural, municipal, industrial waste; Pollution of air, water, soil and noise; radioactive pollution. Eutrophication. Deforestation; Threats to biodiversity, Extinction of species.

Unit II: Depletion and contamination of resources

10 Lectures

Natural resources: Land resources. Air and water resources. Bioresources. Conventional Fuel, wood, fossil fuels. Non-conventional or alternate sources of energy: sun, wind, bio-

energy, geothermal, ocean, nuclear etc. Green house effect and global warming; climate change; Shrinking of glaciers. Threats to sustainable development.

Unit III: Biodiversity and resource conservation programmes **14 Lectures**

Management of wastes and disposal. Concepts of three Rs: reduce, reuse and recycle. Methods of prevention and control of Eutrophication. Bioremediation. Biodiversity conservation– In-situ e.g., Sanctuaries, National Parks, Biosphere Reserves, World Heritage Sites; Ex-situ e.g., botanical gardens, gene banks, cryopreservation etc. Contour farming, reforestation; Rainwater harvesting, groundwater water recharge. Green technologies, Eco-cities, Social and Joint forestry.

Unit IV: Sustainable development and green technology **15 Lectures**

Sustainable Development; Brundlandt Report. Biosafety of GMOs and LMOs. Environmental movements. Public awareness of Environment problems. Role of Government, NGO's, Ecological footprint, International treaties and conventions. organizations, International efforts (Vienna Convention, Montreal Protocol, UNFCCC, Kyoto Protocol, Copenhagen Summit, etc.; IPCC; Environmental laws and acts. National Environmental Policy. NBPGR, BSI, ZSI, WWF, IUCN, Convention on Biological diversity; Ramsar Convention, other conservation efforts.

Recommended readings

1. Joseph, B. (2008) Environmental studies, Tata McGraw Hill.
2. Miller, G.T. (2002). Sustaining the earth, an integrated approach. (5th edition) Books/Cole, Thompson Learning, Inc.
3. Chapman, J.L. and Reiss, M.J. (1999). Ecology: Principles and applications (2nd edition) Cambridge University Press.
4. Ghosh, S.K. and Singh, R. (2003). Social forestry and Forest Management. Global Vision Pub.
5. Wilson, E.O. (1986) Biodiversity, Academic press Washington
6. Wagher, R.H. (1974) Environment and Man. (Second Edition), Norton, New York.

Practical

1. Visit to an area to document environmental assets including natural resources/flora/fauna, etc.
2. Identification and study of common insects, fish, birds, mammals of a particular area.
3. To determine the physical conditions of water: Depth, Viscosity, Density, Buoyancy.
4. To determine the chemical conditions of water: pH, dissolved oxygen and carbon-dioxide, hardness etc.
5. To determine Cl, SO₄, NO₃ in soil and water samples from different locations.
6. To study acidity and alkalinity of sample water by methyl orange and phenolphthalein
7. Visit to a local polluted site (Urban/Rural/Industrial/Agricultural).

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-9	Bioeconomics	Theory:04 Practical: 02 Total: 06

About the course

This course focuses on the biodiversity assessment or assessment of ecosystem components for their sustenance over a long period of time. The consequences of globalization and shrinking boundaries of planet prompt for economic eco-solutions.

Learning outcomes

On the completion of the course, the students shall be able to

- Understand different concepts related to ecological economics
- Analyze multi-disciplinary approaches related to ecological, economic and social dimensions for sustainable development
- Evaluate the economic explanations and solutions for environmental problems
- Reflect upon the implications of increasing globalization for sustainable ecosystems

Theory

Unit I: Multidisciplinary approaches for sustainable development **12 Lectures**

Multi-disciplinary approaches related to ecological, economic and social dimensions for sustainable development. Economics versus ecology, economic growth versus sustainable development; Carrying capacity; sustainable or renewable resources, 2nd law of thermodynamics, environmental perspective of entropy; its application.

Unit II: Natural resources, ecosystem services **16 Lectures**

Ecosystem Services. Categories of ecosystem services, Biodiversity and its importance, ecosystem resilience, effects of biodiversity on ecosystem services, biophysical and human factors affecting the delivery of ecosystem services, monitoring of ecosystem services. Millennium Ecosystem Assessment; planetary boundaries in relation to economic growth and sustainable development; Sustainability indicators; Eco-labelling;

Unit III: Efficient and equitable allocation of resources **11 Lectures**

Economic value of the world's ecosystems and services, Economic explanations to and solutions for environmental problems, Environmental economic valuation methods. standard market prices, benefit-cost ratio, net present value, present value ratio, value ecosystem services that are not traded in the market place. Efficient and equitable allocation of resources.

Unit IV: Ecosystem health management

13 Lectures

Spatial scale – Sustainability and the green footprint, measuring ecosystem health, implications of increasing globalization for sustainability. Temporal scale: Equity and discounting the future, opportunity cost, Resource use incentives and property rights, Private, common, and public property rights and limitations, defensible rights to resources.

Recommended readings

1. Mayumi, K., Martinez, J. (2012). The Origins of Ecological Economics: The Bioeconomics of Georgescu-Roegen .Routledge; 1 edition.
2. Vandenbergh, J.C.V.M., Hoekstra, J., Imeson, R., Nunes, P.A.L.D. (2010). Bioeconomic Modelling and Valuation of Exploited Marine Ecosystems. Springer; Softcover reprint of hardcover 1st ed. 2006 edition.
3. Heun, M.K., Dale, M.C. and Haney, B.R. (2016) Beyond GDP: National Accounting in the Age of Resource Depletion.Springer; Softcover reprint of the original 1st ed. 2015 edition.
4. Wagner, J. E. (2011) Forestry Economics. Routledge Press
5. Daly, H. and Farley, J. (2011). Ecological Economics: Principles and Applications (2nd Ed). Island Press, Washington D.C.
6. William, J. G. (2005). Investing in Nature: Case studies of land conservation in collaboration with business. Island Press, Washington, D.C.
7. Daily, G. C. and Ellison, K. (2002). The New Economy of Nature: The quest to make conservation profitable.
8. Assessment, M.E. (2005). Ecosystems and Human Well-being: Synthesis and Biodiversity Synthesis. Washington, DC: WRI

Practical

1. Visit any nature-park / agricultural field / forest/ Garden and count the living organisms
2. Identify the Natural resources – water, fresh air, soil, plants/trees, animals and measure them
3. Attempt to find its costs in terms of use in the ecosystem
4. Try to evaluate the impact of each service rendered by each resource independently and in combination
5. Try to evaluate the contingent value of the scenic beauty by travel cost method
6. Evaluate the potential of manure production value of the plants and animals there.
7. Learn the statistical tools for analysis and interpretation of the data.
8. Methods of measurement of wood volume of standing trees and logs, wood density, specific gravity, yield, and non woody products.
9. Protection of woody and non woody plants from fire and pathogens.
10. Statistical analysis of the data
11. Evaluation of Biomass
12. Evaluation of floor bioproducts- oil, fodder, fruits, manure.
13. Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28).

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-10	Systematics and Evolutionary biology	Theory:04 Practical: 02 Total: 06

About the course

The course provides information about the patterns and processes of evolution above the species level. Besides elaborating the process of speciation, it also categorically differentiates between the three methods of phylogenetic analysis *viz.*, evolutionary systematics, phonetics and cladistics.

Learning outcomes

At the end of the course the students will be able to

- Understand the historical development of systematics from 18th century to the present.
- Understand the complexities of character coding.
- Understand the similarities and differences of different types of data.
- Understand the uses and limitations of phylogenetic trees.
- Appreciate the complexities and difficulties of various species concepts.
- Gain a basic grasp on the rules and philosophy of nomenclature.
- Know about the steps required to do systematic.
-

Theory

Unit I: Biodiversity, systematic and biological classification

14 Lectures

Biodiversity and human welfare, mega diversity regions and biodiversity hot spots with special reference to India. The science of biodiversity inventory. Systematics and taxonomy. Levels of taxonomy: alpha, beta and gamma taxonomy. Micro and macro taxonomy. Scope and application of taxonomy. Systematics. Relevance of Systematics in Biology and Biological Classification. Phenetic and Cladistics concepts. Analyses through dendrogram and cladogram.

Unit II: Species concept and barcoding

12 Lectures

Biological Species concept, Subspecies, Monotypic and Polytypic species, Sibling species. Reproductive and geographical isolation and their role in speciation process (pre mating and post mating). Speciation modes–Sympatric, Allopatric and Parapatric. Type concept –name bearing types (primary and secondary) and their applications. DNA bar coding for identification of species.

Unit III: Natural selection, genetic drift etc.

12 Lectures

History of Origin of life through molecules. Natural selection: Concept of selection: stabilizing, directional and disruptive changes, Hardy-Weinberg equilibrium; estimating allele and genotype frequency, frequency changes in mutation and migration. Genetic drift, founder effect and population bottleneck.

Unit IV: Species distribution and adaptive radiations

14 Lectures

Bathymetric and discontinuous distribution. Barriers and dispersals -types and their impact on animal distribution. Zoogeographical realms –names and distribution of animal according to Wallace scheme, Avian and Mammalian faunal distribution in different realms. Some distinct events in evolution: Adaptive radiations with special reference to Darwin's finches. Origin of birds. Evolution in horse. Xeric (camel and lizard); Arboreal (sloth bear) adaptation.

Recommended readings

1. Futuyama, D. J. (1986). Evolution, Systematics and Animal Behaviour. Evolutionary Biology. Sinauer Associates Inc.
2. Strickberger, M. W. (2007). Evolution. CBS Pub.
3. Colbert, E. H.; Morales, M. & Minkoff, E. I. (2001). Evolution of the Vertebrates, Science.
4. Moody, P. A. (2002). Introduction to Evolution, Kalyani Pub.
5. Dobzhansky, T.; Ayala, F. J.; Stebbins G. L. and Valentine, J. W. (1979). Evolution, Surjeet Pub.
6. Mayr, E. & Ashlock, P. D. (1991) Principles of Systematic Zoology (2nd edition) McGraw Hill Int.
7. Simpson, G. G. (1962) Principles of Animal Taxonomy, Oxford IBH.
8. Darlington, P. J. (1966) Zoogeography (4th edition) John Wiley.

Practical

1. Compilation of a data matrix using characters, character states and construction of classifications which reflect the "relationships" among the taxa
2. The data matrix to be used to construct a key to identification of the taxa.
3. Phylogeny Inference Package (PHYLIP): Programs for distance and character-state data; making consensus trees; DNA sequence programs; and maximum likelihood.
4. Selection of five species (preferably invertebrates, insects) belonging to a clade. A project work on their identification, illustration and assessment of their relationship by constructing a cladogram using characters and character states.

5. Comparison of two species of birds belonging to same species but different subspecies (Intraspecific difference).

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28)

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-11	Global Environmental Issues	Theory:04 Practical: 02 Total: 06

About the course

This course focuses on the diversity of living forms particularly animals with a detailed inference on the loss of species due to various reasons and the need of their conservation.

Learning outcomes

At the end of the course the students will be able to:

- Understand the fundamental issues of environment.
- Analyze different sources of environmental problems and methods of measurement of pollution.
- Examine economic growth and quality of life.
- Examine the microbiology of waste water treatment and its various schemes.
-

Theory

Unit I: Environment and Environmental Problems

13 Lectures

Basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, Fisheries depletion, Eutrophication, their impact and biotechnological approaches for management.

Unit II: Environmental Pollution

11 Lectures

Environmental pollution - types of pollution, Air, water and land pollution. sources of pollution, measurement of pollution, fate of pollutants in the environment, Ocean acidification, Bioconcentration, bio/geomagnification.

Unit III: Environmental Economics

12 Lectures

Environmental Economics : Basic concept; methods of evaluation; Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit ratio and cost effectiveness analysis.

Unit IV: Use of Microbes in Waste Water Treatment

15 Lectures

Aerobic decomposition process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic decomposition process - anaerobic filters, up- flow anaerobic sludge blanket reactors. Treatment schemes for sewage from dairy, distillery, tannery, sugar and pharma industries.

Recommended readings

1. Frances, H. (2012). Global Environmental Issues (2nd edition) Willey-Blackwell
2. Mahesh, R. (2007) Environmental Issues in India: A Reader. Pearson-Longman.

Practical

There are no structured class lab experiments involved. However the students are expected to visit various sites on the web, make teams for group-discussion indulge in debates, collect justifiable information from various sources, make historical report on the following major global environmental issues :

1. Atmosphere Management: Pollution, global warming/climate change, Stratospheric ozone depletion its impact and possible solutions
2. Fresh water Management: Pollution, reasons, severity of problem, impact for the present and the future, its impact and possible solutions
3. Marine Ecosystem: Pollution of marine ecosystem, its impact and possible solutions
4. Soil degradation and Desertification
5. Solid Waste Management
6. Human health and Toxicology

Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28)

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-12	Environmental Monitoring and Management	Theory:04 Practical: 02 Total: 06

About the course

This course focuses on the diversity of living forms particularly animals with a detailed inference on the loss of species due to various reasons and the need of their conservation.

Learning outcomes:

On the completion of the course the students shall be able to

- Understand the fundamental concepts of environmental monitoring and management
- Analyze the different methods of air, water, and soil quality monitoring process
- Examine different environmental management systems and trade related intellectual properties (TRIPs), intellectual property rights (IPRs).
- Evaluate the status of environmental education and public awareness along with their implications

Unit I: Concept note on environment

13 Lectures

Concept and Approaches for environment, environmental science, global concerns about environment, Environmental Protection and sustainability: principles of sustainability, structure of natural systems, causes of land degradation and environmental pollution, population growth and environment Monitoring, Legal and institutional status of environment.

Unit II: Air Quality, Water Quality and Solid Quality Monitoring

11 Lectures

Ambient and indoor air quality monitoring; Methods of collection and analyses of gaseous and particulate pollutants, air pollution standards. Monitoring of agricultural systems and aquatic habitats: understanding the degradation processes, steps of environment monitoring: indices and indicators

Unit III: Biomonitoring, Instrumentation

12 Lectures

Passive and active biomonitoring, bioindication, bioindicator parameters; zonation study. Principles of chromatography, spectrophotometry, electro-analytical and radio-analytical techniques.

Unit IV: Environmental Management System and Ethics

16 Lectures

Environmental management system (EMS): ISO-14000; Environmental audit; Environmental clearance for establishing industries; Environmental Impact Assessment (EIA); EIA

guidelines, Environmental taxes International trade and environment; Trade Related Intellectual Properties (TRIPs), Intellectual Property Rights (IPRs). Environmental education, public awareness, peoples participation in resource conservation and environmental protection.

Recommended readings

1. Sawyer, C. N.; McCarty, P. L. and Parkin, G. F. (2002). Chemistry for Environmental Engineering and Science. John Henry Press.
2. Rump, H. H. (2000). Laboratory Manual for the Examination of Water, Waste water and soil. Wiley-VCH.
3. Sapru, R. K. (1987). Environmental Management in India (Vol. I & II). Ashish Publishing House.
4. Bryan, F.J. Manly. (2009). Statistics for Environmental Science and Management. CRC Press.
5. Naik, S.C. and Tiwari, T.N. (2006). Society and Environment. Oxford & IBH Publishers.
6. Santra, S.C. (2011). Environmental Science. New Central Book Agency.

Practical

1. Monitoring of dust load at different sites.
 2. Rapid soil test for pH, alkalinity, nitrate, oxidizing potential.
 3. Rapid water quality test for temperature, pH, nitrate.
 4. Identification of water bloom forming micro-organisms.
 5. Visit to sophisticated environmental analysis lab.
 6. Field work for resource conservation and environmental protection.
 7. Project Report on a visit to a Sewage treatment plant / Marine bio-reserve/Fisheries Institutes.
- Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28)

Semester	Course	Course Title	Credit
I/ II/ III/ IV	GEC-13	Basics of Systematics and Classification	Theory:04 Practical: 02 Total: 06

About the course

. The course will provides a comprehensive survey of the theory and methodology of systematics as they are applied today to all groups of organisms. The course is directed at those students interested in studies of evolutionary biology, biodiversity, conservation biology, and/or systematics.

Learning outcomes

At the end of the course the students will be able to;

- Comprehend the basic concepts of animal taxonomy and zoological nomenclature
- Evaluate the significance of museum specimens
- Analyze the implications of biometrics, numerical taxonomy and cladistics.
- Understand the historical development of systematic biology from the 18th century to the present.
- Gain a basic grasp on the rules and philosophy of nomenclature.
- Question what you know, and need to know, to do systematic.
- Develop the capacity to critically evaluate the primary literature.
-

Theory

Unit I: Introduction to systematic and classification

13 Lectures

Kinds and diversity of living forms. Biogeographical zones; Endemism. Importance of collections/ museum specimens of the world and India; Documentation of biodiversity. Systematics and taxonomy. Importance and basis of classification. Heirarchy of classification and classification systems. Types of classification-artificial, natural and phylogenetic.

Unit II: Taxonomic treatment and phylogenetics

14 Lectures

Systematic data: kinds of data. Taxonomic treatment of allopatric variation, homology; Reproductive isolating mechanisms; Hybridization and introgression; Polyploidy; Modes of speciation. Principles and criteria of taxonomic treatment: Taxonomic evidence: Characters and character states. Taxonomic characters; OTUs, character weighting, cluster analysis; Phenetics, Evolutionary taxonomy, Cladistics. Constructing trees/ dendrograms: Phenogram, phylogram and cladogram and turning them into classifications.

Unit III: Molecular phylogenetics

12 Lectures

Molecular phylogenetics: Gene structure, mutation and rates and patterns of nucleotide substitutions. Mitochondrial genome. Molecular "clock" hypothesis. Phylogeny estimation methods: Distance data, Maximum-parsimony, Maximum-likelihood etc. Cladogram reliabilities, Molecular characterization versus morphological characterization: Conflict or compromise?

Unit IV: International code of Nomenclature

13 Lectures

Identification, Description, Naming of taxa. Keys: indented and racketed keys. Principles and rules of International Code of Nomenclature (ICN), binominal system, type material, author citation, criteria for publication, types of names, principle of priority and its limitations. curation of taxonomic collections. Taxonomic revision. Taxonomic literature. The relevance of systematics in conservation programmes.

Recommended readings

1. Mayr, E. and Ashlock, P.D. (1991). Principles of Systematic Zoology. (2nd edition) New York: McGraw Hill, Inc.
2. Quicke, D. L. J. (1993). Principles and Techniques of Contemporary Taxonomy. New York: Chapman and Hall

Practical

1. General discussion, distinguishing characters and classification of selected animals.
2. Preparation of identification keys for select specimens of non chordate (e.g., insects) and chordates (e.g., birds)
3. Generation of a character-state matrix by selecting and scoring diagnostic taxonomic characters.
4. Interactive software for exploring phylogeny and analyzing character state to construct dendrogram.
5. Distance-based methods of phylogenetic reconstruction using manual and computer methods.
6. Molecular data analysis by aligning sequences and constructing trees using PAUP
Group discussion or Seminar presentation on one or two related topics from the list (page no. 25-28)

Ability Enhancement Courses

Semester	Course	Course Title	Credit
I/ II	AEC-1	Science Communication and Popularization	Theory:04

About the course

The course highlights the importance of science communication and popularization and its role in human development.

Learning outcomes:

After the completion of this course, the learner will be able to:

- Utilize visual media science communication for creating scripts and documentaries.
- Identify the need and role of science communication in human development.
- Contribute in science popularization through internet communication and public Sensitization.

Unit-I: Print Science Communication

16 Lectures

Value of Science Journalism: Science's potential for breaking news. Role of science and technology in human development. Framing policies at national and international levels. Writing and communicating popular articles effectively, case studies of celebrated works of science communicators including Cosmos by Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and Matt Riddley, importance for communication through regional languages.

Unit-II: Visual Media Science Communication

13 Lectures

Science outreach through visual media: Creating science documentaries, creating the outline and expanding, scripts, citing authentic sources, case study: Famous documentaries of Carl Sagan, David Attenborough and Prof. Yashpal. Cultural Studies of Science and Technology- technoscientific culture- Science Fiction Studies-cinema and science-Science in Indian popular culture.

Unit-III: Internet Science Communication

10 Lectures

Science popularization through internet: Social media, Websites, Blogs, You tube, Podcast etc. sensitization on important issues like climate change, deforestation, biodiversity loss, important of science etc.

Unit-IV: Science Outreach Talks and Public Sensitization

13 Lectures

Tactics for providing a charismatic and effective public talk, use of metaphors, speaking in context, Museum displays and public exhibitions Science outreach for biodiversity conservation sensitization of public. Science communication during disasters- Public Engagement with Science and Technology, public sphere-multiple publics-the deliberative turn

Recommended readings

1. Selected works of Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and Matt Riddley.
2. Gigante, E. Marie (2018). *Introducing Science Through Images: Cases of Visual Popularization (Studies in Rhetoric/Communication)*, University of South Carolina Press.

Semester	Course	Course Title	Credit
I/ II	AEC-2	Good Laboratory Practices	Theory:04

About the course

This course was designed to improve knowledge and understanding of the requirements of good laboratory practices which encompasses facility and equipment requirements, documentation requirements, roles and responsibilities and outsourcing services.

Learning outcomes

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

- Apply practical skills in science courses with the understanding of general laboratory practices
- Use various micro techniques used in Zoology
- Apply various techniques to study animal tissues
- Explore various research issues and their solutions

Unit-I: General Laboratory Practices

14 Lectures

Understanding the details on the label of reagent bottles. Preparation of solutions. Molarity and normality of common acids and bases. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common corrosive and toxic chemicals and safety measures in their handling. Maintenance of equipments.

Unit-II: Tissue Micro-Techniques

12 Lectures

Weighing and staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluoro-chromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed tissues.

Unit-III: Methods to Study Tissue Structure

14 Lectures

Whole mounts, squash preparations, clearing, maceration and sectioning; Tissue preparation: living *vs* fixed, physical *vs* chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series; Paraffin; Preparation of thin and ultrathin sections.

Unit-IV: Overview of Biological Problems

12 Lectures

History; Key relevant problems associated in Zoology research areas, their solution and basic understanding of animal models. Identifying sources of hazards e.g., poisonous chemicals, Broken glass, Explosion, Fire. Safety/First aid measures: Fume hoods, eye fountain, emergency shower, fire extinguisher, eye protection gear, Sample collection, recording of data. Analytical quality control

Recommended readings

1. Seiler, J.P. (2005). Good Laboratory Practices: the why and how. Springer-Verlag Berlin and Heidelberg GmbH & Co. K; (2nd edition).
2. Garner, W.Y., Barge, M.S. and Ussary, P.J. (1992). Good Laboratory Practice Standards: Application for field and Laboratory studies. Wiley VCH.

Semester	Course	Course Title	Credit
I/ II	AEC-3	Basic Mathematics for Zoologists	Theory:04

About the course

The course offers the zoology student an opportunity to learn basic mathematical principles for their effective use in solving biological problems and in data interpretation.

Learning outcomes

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

- Understand the different Graphs and Functions of Basic Mathematics
- Recognize simple functions of basic Mathematics.
- Evaluate slope of curves and derivatives of different functions
- Apply various types of Differentiation and Integration in biology
- Comprehend the interrelationships among different components of Algebra

Unit I: Applications of mathematics in Biology

13 Lectures

Mathematics as a language, Need of learning mathematics, Applications of mathematics in Biology. Graphs and functions: Linear function, Quadratic function, Exponential function, Periodic functions, Combination of simple functions, Examples from Biology, Logarithmic function, Slope of curves, Idea of derivatives.

Unit II: Integration and its application in biology

13 Lectures

Calculus: Differentiation and its applications to biology, Integration and its applications to biology. Indefinite integrals, integration of simple functions, Integral as “anti-derivative” Definite integrals, Integral as area under a curve, Integration by parts, Finding derivative and integral given a set of data points.

Unit III: Algebra and its applications

13 Lectures

Algebra: Basics of algebra, Linear algebra, Eigenvalues, Differential equations, Simple differential equations, First order differential equations, Examples: Polymerizing and depolymerizing filaments, Partial differential equations, Vector algebra.

Unit IV: Fourier series, plotting functions

13 Lectures

Fourier Series: Introduction to Fourier series, Fourier coefficients, Calculation of Fourier series for simple functions, Sum of periodic functions. Plotting functions using computer, gnuplot demonstration, numerical calculations, Interpolation

Recommended readings

1. NPTEL Course on Biomathematics accessible at <https://nptel.ac.in/syllabus/102101003/>
2. Cann, J.A. (2002). Maths from Scratch for Biologists. Wiley
3. D'Arcy Wentworth Thompson (1992). On Growth and Form: The Complete Revised Edition, Dover Books on Biology.
4. Ahmad, V.U., and Basha, A. (2010). Spectroscopic Data of Steroid Glycosides: Volume 1. Springer; Softcover reprint of hardcover 1st ed. 2007 edition.
5. Aitken, M.; Broadhursts, B. and Haldky, S. (2009). Mathematics for Biological Scientists, Garland Science.
6. Batschelet, E. (2003). Introduction to Mathematics for Life Scientists (3rd edition) Springer Verlag
7. Murray, J.D. (1989). Mathematical Biology, Springer.
8. Sneyd, J. and Keener, J. (2000). Mathematical Physiology, Springer.
9. Fall, C.P. *et al.* (2002) Computational Cell Biology, Springer.

Semester	Course	Course Title	Credit
I/ II	AEC-4	Research Methodology	Theory:04

About the course

The aim of the course is to familiarize students with basics of research and the research process; provide an introduction to research methods and report writing; give insight into various kinds research design and sampling.

Learning outcomes

At the end of the course the students will be able to,

- Understand the concept of research and different types of research in the context of biology
- Have basic awareness of data analysis-and hypothesis testing procedures
- Develop laboratory experiment related skills.
- Have basic knowledge on qualitative research techniques
- Develop competence on data collection and process of scientific documentation
- Analyze the ethical aspects of research
- Evaluate the different methods of scientific writing and reporting

Unit-I: Basic Concepts of Research

16 Lectures

Research-definition and types of research (Descriptive *vs* analytical; applied *vs* fundamental; quantitative *vs* qualitative; conceptual *vs* empirical). Research methods *vs* methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

Unit-II: Data Collection and Documentation of Observations

12 Lectures

Maintaining laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Unit-III: Overview of Biological Problems

12 Lectures

History; Key biology research areas, Model organisms in biology (A brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network.

Unit-IV: Ethics and Art of Scientific Writing

12 Lectures

Authors, acknowledgements, reproducibility, plagiarism, Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Power-point presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

Recommended readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Ruzin, S. E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

Semester	Course	Course Title	Credit
I/ II	AEC-5	History of Indian Science	Theory:04

About the course

The course provides an insight into the status of science in ancient India, its gradual development, innovations and the pioneers in the field of science, reputed research institutions in India and cutting edge research in science.

Learning outcomes

On completion of this course, the students will be able to

- Develop understanding of various branches of science during different eras
- Analyze the role played by different Indian organizations in science
- Appraise the contribution of different Indian Scientists.

Unit-I: Science in Ancient and Medieval India

14 Lectures

History of development in astronomy, mathematics, engineering and medicine subjects in Ancient India, Use of copper, bronze and iron in Ancient India, The geography in literature of Ancient India. Influence of the Islamic world and Europe on developments in the fields of mathematics, chemistry, astronomy and medicine, innovations in the field of agriculture-new crop introduced new techniques of irrigation.

Unit-II: Indian Science in before and after Independence

12 Lectures

Introduction of different surveyors, zoologists and doctors as early scientist in Colonial India, Indian perception and adoption for new scientific knowledge in Modern India, Establishment of premier research organizations like CSIR, DRDO and ICAR and ICMR, IIT's, Establishment of Atomic Energy Commission, Launching of the space satellites, ISRO's accomplishments. Zoological survey of India.

Unit-III: Prominent Indian scientists

14 Lectures

Eminent scholars in mathematics and astronomy: Baudhayana, Aryabhata, Brahmgupta, Bhaskaracharya, Varahamihira, and Nagarjuna, Medical science of Ancient India (Ayurveda and Yoga): Susruta, Charak. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha, Vikram Sarabhai etc.

Unit-IV: Prominent research in Animal Sciences in Republic of India

12 Lectures

History of animal tissue culture with context to India; green, white and pink revolutions in India: causes, details, and outcomes. The pioneers associated with. First gene cloning, First genome sequencing from India. Premier Research institutes and current eminent scientists in India, GM organisms.

Recommended readings

1. Kuppuram, G. (1990) History of Science and Technology in India, South Asia Books.
2. Handa, O.C. (2014) Reflections on the history of Indian Science and Technology, Pentagon Press.
3. Basu, A. (2006) Chemical Science in Colonial India: The Science in Social History, K.P. Bagchi & Co.
4. Habib, I. (2016) A people's history of India 20: Technology in Medieval India, 5th Edition, Tulika Books.
5. Rahman, A. *et al* (1982) Science and Technology in Medieval India – A Bibliography of Source Materials in Sanskrit, Arabic and Persian, New Delhi: Indian National Science Academy.
6. Subbarayappa, B.V. & Sarma, K.V. (1985), Indian Astronomy -- A Source Book, Bombay.
7. Srinivasan, S., Ranganathan, S. (2013) Minerals and Metals heritage of India, National Institute of Advanced Studies.
8. Srinivasiengar, C.N. (1967) The History of Ancient Indian Mathematics, World Press Private Ltd. Calcutta.
9. Bhardwaj, H.C. (2000) Metallurgy in Indian Archaeology. Tara Book Agency

Semester	Course	Course Title	Credit
I/ II	AEC-6	Personality Development	Theory:04

About the course

The course includes diverse aspects of personality development including the principles and methods to achieve success by enhancing psychological skills and time management abilities. The course also deals with ways of human resource improvement by enhancing creativity and thinking skills.

Learning outcomes

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

- Develop understanding of the concepts and principles of basic psychological skills
- Apply techniques and methods to enhance productivity and time management
- Develop critical thinking and managerial skills
- Organize human resources with improved leadership qualities

Unit-I: Basic Psychology Skills

13 Lectures

Mental Heuristics and Priming, Cialdini's six psychological principles, Self Awareness and Self Development: Self appraisal, thoughtful and responsible approach, value and belief system, perception and attitude. Charisma and charisma enhancements, facing interviews.

Unit-II: Productivity and Time Management

13 Lectures

Eisenhower Matrix, Pomodoro Technique, Dealing with Procrastination, Journaling methods, Checklists, to-do lists and scheduling the events. Swot analysis. Identifying one's strength and failures. Knowing

Unit-III: Dealing Negativity

13 Lectures

Work-life balance, stress management, coping with failures and depression. Interpersonal skills and communication skills, learning about commitment and how to move things forward, making key decisions

Unit-IV: Critical Thinking and Human resources

13 Lectures

Logical fallacies, Cognitive biases, Mental Models, Critical Thinking. Evaluation and improvement; Leadership qualities. Leading by example, effective feedback, ethical reasoning.

Recommended readings

1. Bast, F. (2016) Crux of time management for students. Available at: <https://www.ias.ac.in/article/fulltext/reso/021/01/0071-0088>
2. Cialdini, R.B. (2001) Influence: The Psychology of Persuasion, Revised Edition. Harper Collius.
3. Green, C.J. (2015) Leadership and soft skills for students: Empowered to succeed in High School, College and beyond. Dog Ear Publishing.
4. Velayudhan, A. and Amudhadevi, N. V. (2012) Personality Development for College Students. LAP Lambert Academic Publishing.

Semester	Course	Course Title	Credit
I/ II	AEC-7	Human Health and Sex Education	Theory:04

About the course

The course is designed to address problems associated with health and sex thereby, promoting fitness and well being.

Learning outcomes

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

- understand the importance of good health.
- observe clean sexual habits thereby warding off sexually transmitted diseases.

Unit I: Health: Physical and spiritual

14 Lectures

Health as a state of wellbeing, health awareness, Physical health, immunization and vaccination, healthy food, balanced diet, food supplements, proper sleep, exercise and keeping away from stress, pathogens and pollution. Reproductive health, adolescence, senescence. Prevention from mental illness and disabilities, alcoholism, tobacco addiction, de-addiction, lifestyle diseases. Community health centres, role of health centres. Spiritual health, yoga and meditation.

Unit II: Human reproductive and developmental cycle

14 Lectures

Human reproductive system: structural details of male reproductive system, semen, hormonal control. Female reproductive system- structure of ovary, accessory structures, puberty, reproductive cycles and hormonal control, menstrual cycle, gestation period, hysterectomy, menopause. Events of human reproduction: Gametogenesis- spermatogenesis and oogenesis, ovulation, fertilization, embryonic development, parturition.

Unit III: Infertility and assisted reproductive techniques

12 Lectures

Human intervention in reproduction: Contraception and birth control-barrier method, hormonal methods, natural methods, sterilization, termination of pregnancy. Infertility-male and female infertility, causes and treatment for infertility. Advanced Reproductive Technologies- IVF, GIFT, ZIFT, Donor Insemination (DI). Sperm transfer techniques. Surrogacy.

Unit IV: Sex education and prevention from Sexually transmitted diseases 12 Lectures

Sexually transmitted diseases: Syphilis, genital warts, chlamydia, chancroid, trichomoniasis, gonorrhoea, genital herpes, AIDS, Sex education: Adolescent sexual activity, teenage pregnancy, sexual harassment, sexual awareness and policies (legal aspects), lesbian and gay sex, bisexual, transgender youth, adolescent stress management

Recommended readings

1. Kothari P. (1994) Common sexual problems and solutions by, UBS Publishers and Distributors Ltd.

2. Hadley, Mac. E.. (2004) Endocrinology. (5th edition) Pearson Education, Singapore.
3. Taylor, D.J., Green, N.P.O., Stout G. W. (2005) Biological Science. (Editor R. Soper) 3rd Edition, Cambridge University Press.
4. The Complete Manual of Fitness and Well-being. The Reader's Digest Association, Inc. Pleasantville, New York / Montreal.
5. Guyton, A.C. and Hall, J.E..Textbook of Medical Physiology.

Semester	Course	Course Title	Credit
I/ II	AEC-8	Human Nutrition	Theory:04

About the course

The course deals with the importance of nutrition in maintaining health; the essential nutrients, balanced diet, the calories associated with different food items and the factors affecting the fitness in humans, food sanitation and hygiene.

Learning outcomes

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

- Know about essential nutrients and required macro and micro nutrients
- Cultivate proper feeding habits.
- Learn the proper and scientific value of different food items.
- Know caloric value of the food items

Unit I: Carbohydrate and protein as important food sources

13 Lectures

Introduction and scope. Carbohydrates, Proteins and Lipids – Carbohydrates: Functions, classification, food sources, storage in body, biomedical importance. Brief outline of metabolism : glycogenesis & glycogenolysis (in brief), glycolysis, citric acid cycle. Clinical significance. Proteins - Functions, classification, food sources, composition, essential & non-essential amino acids, protein deficiency. biomedical importance. Metabolism: Transformation, Decarboxylation, Ammonia formation & transport, Urea cycle. Clinical significance.

Unit II: Fat as a source of energy

13 Lectures

Fats & oils: Function of fats, classification, food sources, composition, saturated and unsaturated fatty acids, biomedical importance, essential fatty acids. Brief out line of metabolism: Beta oxidation of fatty acids, Ketosis, Cholesterol. Clinical significance. Vitamins and minerals - sources and functions, deficiency status. Minerals - macro & micronutrients; functions, sources. Bioavailability and deficiency of Calcium, Iron, Iodine, Sodium & Potassium. Water: importance as a nutrient, function, sources, requirement, water balance & effect of deficiency.

Unit III: Nutritional requirements and calories of a balanced diet

12 Lectures

Basal metabolic rate, energy requirements of man, women, infants and children. Nutritional value of foods- cereals, fruits, milk, egg, meat, fish. Balanced diet, Nutrition requirements as per physiological stages of pregnancy, food selection, complication of pregnancy. Nutrition requirements during lactation and during infant growth and development, breast feeding, infant formula, introduction of supplementary diet.

Unit IV: Malnutrition and health requirements

14 Lectures

Nutritional requirement and growth in preschool children growth, Nutritional requirement of school children., importance of snacks, school lunch. Nutritional needs and feeding pattern during adolescence and adulthood. Geriatric nutrition: Factors affecting food intake and nutrition related problems. Foods of nutritional value, Balanced diet, Malnutrition, Use of

food in body. Role of fibres in human nutrition; Effect of cooking and heat processing on the nutritive value of foods; Processed supplementary foods; Food sanitation in hygiene.

Recommended readings

- Gopalan, C., Ramasastri, B.S. & Balasubramanian, S.C. (1971). Nutritive value of Indian foods. National Institute of Nutrition, Hyderabad.
- Gopalan, D. & Vijayaraghavan, K. (1971). Nutrition atlas of India, ICMR, New Delhi.
- Ghosh, S. (1981). The feeding care of infants and young children, UNICEF, New Delhi.
- Mudambi, S.R. (1995). Fundamentals of food and nutrition. New age international, New Delhi.
- Swaminathan, M. (1989). Handbook of food and nutrition. Bappco, Bangalore.
- Swaminathan, M. (1974). Essentials of food and nutrition. Vol I & II, Ganesh and Co. Madras.

Semester	Course	Course Title	Credit
I/ II	AEC-9	Intellectual Property Rights	Theory:04

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About the course

The present course gives a detailed account of intellectual property right (IPR), its genesis and scope, the steps involved in submitting and publication of patent; trademark and copyright rules.

Learning outcomes

On completion of this course, the students will be able to:

- Understand the concept of IPR
- Differentiate between various agreements of IPR
- Compare between copyrights, patents and Geographical Indicators
- Examine various legal issues related to IPR
- Relate to various cyber issues concerning IPR

Unit-I: Introduction to Intellectual Property Right (IPR) 12 Lectures

Copyright Act and IPR and its importance. IPR in India and other countries of the world: Genesis and scope. IPR and WTO (TRIPS, WIPO). Objectives, Rights, Patent treaty, 1970 and its amendments.

Unit II: Patents, Copyrights and Trademarks 13 Lectures

Protocol of obtaining patents, Industrial Application - Non - Patentable Subject Matter - Registration Procedure, Rights and Duties of Patentee, Licence; Infringement of patents, Patent office. Copyrights: type of work protected under copyright laws, Rights, Transfer of Copyright, Infringement and penalties. Trademarks: Objectives, Rights of holder, Assignment, Infringement, Remedies and Penalties.

Unit-III: Protection of Traditional Knowledge, Industrial Designs 14 Lectures

Concept of Traditional Knowledge, Holders, Traditional knowledge on the International Arena, at WTO, at National level, International enforcement of intellectual property rights. Bioprospecting and Bio-piracy, Commercial piracy,

Transnational lawsuits. Germplasm protection in India. National gene bank, Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit-IV: Other examples of IPR and ethical issues

13 Lectures

Biotechnological Inventions: Objective, Applications, Concept of Novelty, Concept Originality or creativity requirements. Patenting with microorganisms. Ethical issues in Patenting Biotechnological inventions. Computer Software and Intellectual Property, Database and Data Protection, Protection of Semiconductor chips etc.

Recommended readings

1. Gopalakrishnan, N.S. and Agitha, T.G. (2009) Principles of Intellectual Property right. Eastern Book Company, Lucknow.
2. David Kitchin, Q.C.; Llewelyn, D.; Mellor, J.; Meade, R.; Moody-Stuart, T.; Keeling, D. and Jacob, R. (2005) Kerly's Law of Trade Marks and Trade Names (14th Edition) Thomson, Sweet & Maxwell.
3. Narayanan, P. (2010) Law of Copyright and Industrial Designs; Eastern law House, Delhi.
4. Parulekar, A. and D' Souza, S. (2006) Indian Patents Law – Legal & Business Implications; Macmillan India Ltd.
5. Wadehra, B. L. (2000) Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India.

Skill Enhancement Courses

Semester	Course	Course Title	Credit
III/ IV	SEC-1	Reproductive Technologies	Theory:04

About the course

The course is designed for the students to make them aware of the induced release of gametes, multiple ovulation, superovulation, *in vitro* oocyte maturation and cryopreservation of gametes and embryos. It will also explain the causes of infertility and the techniques for intrafallopian and intrauterine transfer and *in vitro* fertilization.

Learning outcomes

At the end of the course the students will be able to

- identify structures and function of reproductive anatomy in the male and female
- identify hormones, their production site, physiology impacts and how to manipulate specific hormones to control reproduction either positively or negatively.
- summarize critical components of reproductive technologies involved in breeding, semen collection, gamete biology and embryonic development.
- communicate via oral, written, podcast, and website modalities.
- recognize how differences based on cultural and ethnicity impact individuals.

Unit-I: Assisted reproductive technologies

15 Lectures

Scope of reproductive technologies; Induced release of gametes and its significance; Biochemistry of semen composition and formation; Assessment of sperm functions; Role of assisted reproductive technologies in infertile human and animals; Constraints in assisted reproductive technologies; Culture techniques for farm animals' embryos.

Unit-II : Ovulation and implantation

11 Lectures

Fertilization and implantation. Infertility in male and female individuals: causes, diagnosis and management; Multiple ovulation, superovulation; In vitro oocyte maturation; Cryopreservation of gametes and embryos.

Unit-III : Intrafallopian transfer

11 Lectures

Intracytoplasmic sperm injection; In vitro fertilization of gametes; Intrafallopian transfer (GIFT) of gamete; Intrafallopian transfer (ZIFT) of zygote; Intrauterine transfer (IUT) of embryo; Transgenic animals and their uses.

Unit-IV. Contraceptive technologies

15 Lectures

Introduction to contraceptive technologies; Immunocontraception. Antibody mediated infertility; Surgical methods; Oral contraceptives; Injectables; Implants; Intrauterine uterine device (IUD); Physical and chemical barrier methods; Demographic terminology used in family planning.

Recommended readings

1. Jones, R. E. and Lopez, K. H. (2013) Human Reproductive Biology (3rd edition)

Semester	Course	Course Title	Credit
III/ IV	SEC-2	Public Health and Hygiene	Theory:04

About the course

The course designed for public health and hygiene at graduation level will give understanding for health hygiene, dietary issues, diseases related to malnutrition, communicable and non-communicable diseases.

Learning outcomes

After successfully completing the course, the students will be able to

- Identify current national and global public health problems.
- Aware about the issues of food safety, water safety, vaccination, exercise and obesity, exposure to toxins.
- frame a public health plan during any epidemic or spread of infectious disease etc.
- Analyze case studies of infant mortality and obesity.
- Assess the health inequalities with regard to gender, race, ethnicity, income etc.

Students may make an oral presentation and compare the health care system of India with a country having advanced one.

Unit-I: Maintenance of personal hygiene

13 Lectures

Introduction to public health and hygiene- determinants and factors. Pollution and health hazards; water and air borne diseases. Radiation hazards: Mobile Cell tower and electronic gadgets (recommended levels, effects and precaution). Role of health education in environment improvement and prevention of diseases. Personal hygiene, oral hygiene and sex hygiene.

Unit-II: Nutrient deficiency diseases

13 Lectures

Classification of food into micro and macro nutrients. Balanced diet, dietary plan for an infant, normal adult, pregnant woman and old person. Importance of dietary fibres. Significance of breast feeding. Malnutrition anomalies – Anaemia (Iron and B12 deficiency), Kwashiorkar, Marasmus, Rickets, Goiter (cause, symptoms, precaution and cure). Substitution of diet with required nutrients to prevent malnutrition disorders.

Unit-III: Communicable and contagious diseases

13 Lectures

Infectious agents responsible for diseases in humans. Communicable viral diseases- measles, chicken pox, poliomyelitis, swine flu, dengue, chickungunya, rabies, leprosy and hepatitis. Communicable bacterial diseases- tuberculosis, typhoid, cholera, tetanus, plague, whooping cough, diphtheria, leprosy. sexually transmitted diseases- AIDS, syphilis and gonorrhoea. Health education and preventive measures for communicable diseases.

Unit-IV: Non-communicable diseases and cure

13 Lectures

Non-communicable diseases such as hypertension, stroke, coronary heart disease, myocardial infarction. Osteoporosis, osteoarthritis and rheumatoid arthritis-cause, symptom, precautions. Diabetes- types and their effect on human health. Gastrointestinal disorders- acidity, peptic ulcer, constipation, piles (cause, symptoms, precaution and remedy) etc. Obesity (Definition and consequences). Mental illness (depression and anxiety). Oral and lung cancer and their preventive measures.

Recommended readings

1. Mary Jane Schneider (2011) Introduction to Public Health.
2. Muthu, V.K. (2014) A Short Book of Public Health.
3. Detels, R. (2017) Oxford Textbook of Public Health (6th edition).
4. Gibney, M.J. (2013) Public Health Nutrition.
5. Wong, K.V. (2017) Nutrition, Health and Disease.

Semester	Course	Course Title	Credit
III/ IV	SEC-3	Dairy Production and Technology	Theory:04

About the course

The course is designed to give an account of different breeds of dairy cattle, their characteristics and performance, the factors affecting their health and the technologies that help artificial insemination and genomic testing.

Learning outcomes

After successfully completing the course, the students will be able to

- learn about protein metabolism and nutritional recommendations for various stages of the lactating mother and diet preparation techniques.
- acquire the skills to manage a dairy farm or to start one with adequate inputs.

Unit-I: Planning and maintaining desired cattle breeds

15 Lectures

History and future of Dairy Industry, Major dairy markets of the world, Distribution map of dairy farming areas/ major milk producing regions in India. Dairy Products and their nutritive value. Milk, cheese, yoghurt, gluten etc; Dairy farm planning Management. Challenges in setting up a dairy farm. Environment and facilities: Expertise, Animals Dairy herd health and production; Managing Dairy Cattle. Breed selection: Breeds of cattle and buffalo, Native cow varieties, Indian exotic breeds their popularity and performance; Forage Production and Pasture Management. Nutritional requirements, Sources of feed: Temperate and tropical grasses. Feed composition– nutrients for milk production, Water Energy, Protein, Fibre, Energy and digestibility, Vitamins.

Unit-II: Housing and maternity management

13 Lectures

Housing of Dairy Cattle. Dairy and shed design. Cooling strategies, Cow comfort Management; Cleaning Management. Animal signs Management. Dairy herd Management and growth; Cow health and reproductive performance. Breeding Dairy Cattle. Artificial insemination and conception; Maternity management, The Lactation Cycle. Calf

management, Calf diseases; Common management procedures. Vaccination, dehorning, weaning etc.

Unit-III: Milk products management

11 Lectures

Milk products: Cheese, yogurt, gluten etc. Milking Management. Gathering cow for milking; Milking machines for smallholders; cleaning and sanitizing dairy equipment; Milking procedure. Dry cow therapy; Milk filtration Management. Milking Hygiene; Post-harvest milk quality.

Unit-IV: Business prospects, Biosecurity

13 Lectures

Dairy business profit strategies. Common disorders in Dairy Cattle; Managing Dairy Facilities for sick and lame cows. Mastitis, metabolic disorders, hypermagnesemia, ketosis and fatty liver, Ruminant acidosis, metritis; Hoof management. Manure handling. Cow Longevity; Dairy buffalo Production Management, Biosecurity; Farm level economics affecting productivity and profitability.

Recommended readings

1. Klaus, A. J. (2015) Dairy Farming: The Beautiful Way
2. Leitch, A. (2018) The Dairy Farm: Dairy Cattle Methods, and Dairy Farm Management

Semester	Course	Course Title	Credit
III/ IV	SEC-4	Computer Applications	Theory:04

About the course

The course is designed to give an insight into the basic computer applications besides giving an idea about the internet resources, multimedia, citations and bibliography management and important software.

Learning outcomes

After the completion of this course the learner will be able to:

- Apply the basic operations of spreadsheet applications
- Recognize advanced resources for accessing scholarly literature from internet
- Utilize bibliography management software while typing and downloading citations
- Operate various software resources with advanced functions and its open office substitutes.

Unit-I: About PC, operating system and software

14 Lectures

Introduction to PC and Window operating system, application software (Windows, MS word). Introduction of spreadsheet (MS Excel): application, formula and functions; performing basic statistics using spreadsheet applications; creating basic graphs using spreadsheet applications, logical (Boolean) operators. MS Power point application and functions, Microphotography and scale calibration and digital image processing.

Unit-II: Computer Networking

11 Lectures

Introduction to computer network, data communication, components of data communication, data transmission mode, data communication measurement, LAN, MAN, WAN, wireless LAN, internet, intranet, extranet; www, telnet, ftp, e-mail, social networks, search engines.

Unit-III: Internet Resources and Multimedia

14

Lectures

The Internet and Multimedia: Internet History. Multimedia on the Web. Designing for the World Wide Web: Developing for the Web, Text and pictures for the web page. Video Conferencing, e-Commerce, m-Commerce, VOIP, blogs.

Unit-IV: Bibliography management

13 Lectures

Advanced Google search operators. Introduction to Google Scholar and accessing scholarly literature from Internet. Introducing a bibliography management software (for e.g. Endnote), Styles and Templates, making bibliography style as per journal format; Citing while typing in the office application.

Recommended readings

1. User manual and online user manual of respective softwares for the most updated content
2. Published books are not recommended as versions keep on updating very frequently; therefore, it is not easy to follow.

Semester	Course	Course Title	Credit
III/ IV	SEC-5	Biofertilizers	Theory:04

About the course

The course will provide information on useful microbes such as Cyanobacteria, Mycorrhiza and their role in manufacture of biofertilizers. Use of microbes in production of bioinsecticides and the methods of Organic farming, Recycling, Vermicomposting etc. will also be discussed.

Learning outcomes:

On the completion of this course, the students will be able to;

- Develop their understanding on the concept of bio-fertilizer
- Identify the different forms of biofertilizers and their uses
- Compare between the Green manuring and organic fertilizers
- Develop the integrated management for better crop production by using both nitrogenous and phosphate bio fertilizers and vesicular arbuscular mycorrhizal (VAM).
- Interpret and explain the components, patterns, and processes of bacteria for growth in crop production

Unit I: Microbes as fertilizers

15 Lectures

General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, inoculum production and field application, legume/pulses plants. carrier based inoculants, Actinorrhizal symbiosis. *Azospirillum*: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. *Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication.

Unit II: Blue green algae, Phosphate solubilising microbes

12 Lectures

Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation. Phosphate solubilizing microbes - Isolation, characterization, mass inoculum production, field application.

Unit III: Mycorrhizal effect on plant growth

12 Lectures

General account of Mycorrhizae; Types of mycorrhizae: ectomycorrhizae and endomycorrhizae; Types of associations, occurrence and distribution, Nutrition, growth and yield – colonization of vesicular-arbuscular mycorrhiza (VAM)– isolation and inoculums; production of VAM and its influence on growth and yield of crop plants.

Unit IV: Microbial use in bioinsecticides and biocompost

13 Lectures

Microbes used as bioinsecticides and their merits over synthetic pesticides, *Bacillus thuringiensis*, production and Field application. Viruses – cultivation and field applications. Organic farming – Green manuring and organic fertilizers, Recycling of bio-degradable wastes: municipal, agricultural and Industrial wastes. Methods of making biocompost; Procedure of vermicomposting and field application.

Recommended readings

1. Dubey, R.C. (2005). A Text book of Biotechnology S.Chand & Co, New Delhi.
2. John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
3. Kumaresan, V.(2005). Biotechnology, Saras Publications, New Delhi.
4. NIIR Board. (2012). The complete Technology Book on Biofertilizer and organic farming. 2nd Edition. NIIR Project Consultancy Services.
5. Sathe, T.V. (2004) Vermiculture and Organic Farming. Daya publishers.
6. Subba Rao, N.S. (2017). Biofertilizers in Agriculture and Forestry. Fourth Edition. Medtech.
7. Vayas, S.C.; Vayas, S. and Modi, H.A. (1998). Bio-fertilizers and organic Farming Akta Prakashan, Nadiad

Semester	Course	Course Title	Credit
III/ IV	SEC-6	Environmental impact analysis	Theory:04

About the course

The course provides information on Environmental Impact Assessments (EIA) that helps in the anticipation and minimization of development's negative effects. This course enlightens about effective monitoring and controlling the trans-boundary pollution.

Learning outcomes

After completing this course the learner will be able to;

- Have critical understanding of environmental impact
- Learn important steps of EIA process
- Interpret the environmental appraisal and procedures in India.

Unit I: Origin and Development

13 Lectures

Purpose and aim, core values and principles, History of EIA development, Environmental Management Plan, Environmental Impact Statement, Scope of EIA in planning a Project and its implementation.

Unit II: EIA Process

16 Lectures

Assessment process of Environmental Impact: Screening, Scoping, Baseline data, Impact Identification, Prediction, Evaluation and Mitigation, Appendices and Forms of Application, Techniques of Assessment-Cost-benefit Analysis, Matrices, Checklist, Overlays, EIA Document.

Unit III: Main participants in EIA Process

11 Lectures

Roles of Project proponents and environmental consultants, Roles of the State Pollution Control Boards (PCBs) /Pollution Control Committee (PCCs), Impact Assessment Act (IAA). Public participation.

Unit IV: Environmental Appraisal and Procedures in India and EIA

12 Lectures

Environmental Audit of different environmental resources, Risk Analysis, Strategic environmental assessment, ecological impact assessment: legislation. Impact on Environmental component: air, noise, water, land, biological, social and environmental factors.

Recommended readings

1. Kulkarni V and Ramachandra TV, (2006). Environmental Management, Capital Pub. Co. New Delhi.
2. Petts, J. (2005) Handbook of Environmental Impact Assessment- Volume 1 and 2. Blackwell Publishers, UK.
3. Glasson, J. Therivel, R. and Chadwick, (2006) A. Introduction to Environmental Impact Assessment. Routledge, London.
4. Canter, W. L. (1995) Environmental Impact Assessment, McGraw-Hill Science/ Engineering/ Math, New York;
5. Morris, P. and Therivel, R. (1995) Methods of Environmental Impact Assessment, UCL Press, London;
6. Petts, J. (1999) (ed) Handbook of Environmental Impact Assessment, volume 1 and 2, Blackwell Science, Oxford;
7. Therivel, R. and Partidario, M.R. (1996) (eds) The Practice of Strategic Environmental Assessment, Earthscan, London;
8. Vanclay, F. and Bronstein, D.A. (1995) (eds) Environmental and Social Impact Assessment, Wiley & Sons, Chichester.

Semester	Course	Course Title	Credit
III/ IV	SEC-7	Insect Pest, Vector Biology and Management	Theory:04

About the course

The course provides an insight into the types of insect pests and vectors and the factors driving their spread. It also enlightens about the methods used to bring down their population below the threshold for a better management.

Learning outcomes

After completing this course the students will be able to

- Identify the types of insect pests particularly the most common one.
- Know the methods of sampling of the pests.
- Understand the mode of action of nematicides and the consequences of their use.
- Understand the effective way of insect pest management strategy.

UNIT I : Background to Insect Pests and Vectors **13 Lectures**

Insect pests and vectors of plant and animal diseases. Pest status: (major, minor, occasional, migrant). Human practices and pest occurrence. Disease outbreaks. Population dynamics of pest. Density dependent and independent factors affecting pest and vector population. Allocation of sampling units. Sampling and monitoring methods of arthropod pests.

UNIT II: Approaches to Insect Pest and Vector Management **13 Lectures**

Insecticides. Types of insecticides, Formulation; Toxicity and safety. Application of insecticides: Droplet size; Application equipment Problems associated with using insecticides. Environmental and cultural control (Irrigation, Fertilizer, Sanitation. Alternate hosts, Multiple and intercropping, Separation in time and space, Crop geometry). Host resistance: Basis for resistance, mechanisms of resistance.

UNIT III: Approaches to Insect Pest and Vector Management **14 Lectures**

Biocontrol agents: Predators, Parasitoids, Parasites. Pathogens: fungi, viruses, bacteria, microsporidia, nematodes, arthropods. Transmission of pathogens. Area-wise management. Techniques of biocontrol: constraints and reasons for failure of biocontrol. Use of pheromones/ allelochemicals in pest management; Mating disruption/confusion, Alarm pheromones and oviposition deterrents; repellents. Exclusion and barriers, Traps. Physical disturbance. Use of Larvivorous Fish and plants in vector control.

UNIT IV: Legislation and other alternatives **12 Lectures**

Exclusion and routes of entry. Risk assessment; Damage thresholds Forecasting; Increasing agroecosystem resistance Legislation for Pesticide use; Effects of regulation; Genetically modified organisms. New concepts and practices. Integrated vector management.

The integrated control/ IPM; Constraints towards IPM adoption. Eradication versus management concept.

Recommended readings

1. Van Emden, H.F. and M.W. Service. (2004) Pest and Vector Control. Cambridge University Press.
2. Cameron, M. & Lorenz, L. (2013) Biological and Environmental Control of Disease Vectors. CABI, UK
3. Chaterjee, K.D. (1981) Parasitology : Protozoology and Helminthology : Introduction to Clinical Medicine.(12th .Edition) Chaterjee Medical Publishers
4. Mullen, G. and Durden L. (2009). Medical and veterinary entomology, Academic press, London.
5. Kochchar, S.K. (2009). A Text Book of Parasitology. Wisdom Press

Semester	Course	Course Title	Credit
III/ IV	SEC-8	Preventive medicine	Theory:04

About the course

The course focuses on types of disease and injury prevention and control. The course also gives an account of the health and disease surveillance, health interventions, and implementation of disease prevention strategies.

Learning outcomes

After completing this course the learners will be able to

- Develop and implement public health interventions
- Engage with health systems and public health initiatives.
- Increase their skills, attitudes and knowledge towards causes of diseases
- Apply knowledge of the principles of disease, injury prevention and control
- Prepare expert educational outreach lectures and presentations
- Increase their skills towards knowledge of community health improvement

Unit-I: Human health and its determinants

13 Lectures

Definition of health; concepts of health – Biomedical, ecological, psychological and holistic. Dimensions of health – physical, mental, social, spiritual, emotional and vocational. Determinants of health – biological, behavioural, environmental, socio-economic and health services.

Unit-II: Man and Medicine: Towards Health for all

11 Lectures

History of scientific medicine. Concept of well being – Standard of living, level of living and quality of life..Theory of diseases. Communicable and non communicable diseases. Epidemiology, Etiology, Pathogenesis, Disease control/elimination/eradication. Role of Genetics in Health and Disease, Levels of Prevention. Types of Epidemiology. Uses of Epidemiology

Unit-III: Concept of Health and Diseases

14 Lectures

Prevention and Control of Communicable Diseases, like Malaria, Cholera, Tuberculosis, Leprosy, Diarrhoea, ARI, Poliomyelitis, Viral Hepatitis, Measles, Dengue, Rabies, AIDS, etc. Non communicable diseases, like coronary heart disease, hypertension, diabetes mellitus, cancers, etc. Occupational disorders like, pneumo-coniosis, hearing loss, accidents, dermatosis, etc.

Unit-IV: Health promotion and awareness programmes

14 Lectures

Modes of Interventions: health promotion, specific protection Ecology of health and right to health, early diagnosis and treatment, disability limitations and rehabilitations. Health programmes in India – NVBDCP, NLEP, NTP, National AIDS control programme, Immunization programme; other awareness programmes.

Reference

- 1.Park, K. (2017) Park's Textbook of Preventive and Social Medicine.
- 2.Mahajan, K. (2013) Principles of Preventive and Social Medicine.
- 3.Holland, W.W., Detels, R. & Knox, G. (2002) Oxford text book of Public Health (4th edition).

Semester	Course	Course Title	Credit
III/ IV	SEC-9	Ornamental Freshwater fish production	Theory:04

About the course

To make the students aware of the vast potentials involved in ornamental fish farming and trading besides making them learn the diseases in fishes and other constraints in their culturing.

Learning outcomes

After completing this course the learners will be able to

- To learn the scientific method of setting an aquarium
- To learn the culture breeding and marketing techniques of common indigenous ornamental fishes

Unit I: Designing and preparation of aquaria with all accessories 13 Lectures

Importance and history of aquarium fish keeping. Design and construction of aquaria: aquarium fabrication- shape, size, volume, type of glass tank, cutting of glass, preparation of glass tank, strengthening and supporting of tank, fitting of tanks into room settings; aquarium floor setting – type and size of pebbles, gravels, granites used for bed setting and its advantages. Filters- biological, chemical and mechanical. Aquarium accessories like aerators, decorative, lighting, heating and feeding trays. Water quality management in aquarium systems – sources of water, containers, storage, temperature, pH, dissolved carbon dioxide, ammonia, hardness, turbidity and ozone in aquarium. Aquarium plants: Uses of aquarium plants, different varieties of plants like submerged plants (tubers, rooted plants, cutting plants) and emerged plants.

Unit II: Common fresh water ornamental fishes. 13 Lectures

Fresh water ornamental fishes : Common ornamental fishes- indigenous and exotic species; Identification and biology of the common ornamental fishes. *Cyprinus carpio* (koi carp), *Molliensia sphenops* (black molly lyre tail), *Poecilia reticulata* (guppy), *Poecilia latipinna*, *Xiphophorous helleri* (red sword tail) *Xiphophorous maculates* (red platy) *Pterophyllum scalare altum* (angel fish) *Carassius auratus* (red oranda) *Betta splendens* (Siamese fighting fish) *Trichogaster leeri* (pearl gourami). Live bearers and egg layers. Sexual dimorphism in ornamental fishes.

Unit III: Important indigenous ornamental fishes. 13 Lectures

Indigenous ornamental fishes - Common indigenous ornamental fishes. Identification and biology of the common ornamental fishes. Cyprinids :*Puntius denisonii* (red line torpedo fish),*Puntius fasciatus* (melan barb), *Puntius filamentosus* (Indian tiger barb), *Puntius curmuca* (red tailed silver shark), *Danio malabaricus* (Malabar danio); Loaches: *Nemacheilus triangularis* (Zodiac loach), *Lepidocephalus thermalis* (Malabar loach); Cichlids: *Etoplus maculatus* (yellow and orange chromides), *E . suratensis* (pearl spot), Anabantids: *Anabas testudineus* (climbing perch) and Catfishes : *Horabagrus brachysoma* (Yellowish catfish), *H . nigricollaris* (White collared imperial catfish).

Unit IV: Management of the brood stock

13 Lectures

Breeding and rearing of common ornamental fishes. Conditions for breeding- pH, temperature and sex ratio. Brood stock management- selection of brooders, maintenance and management of brood stocks. Selective breeding and hybridization techniques. Induced breeding. Colour enhancement techniques. Food and feeding - live feed and formulated feed. Preparation and culture of live feed (Artemia, Infusoria, Spirulina). Control of algal growth, snails and other predators. Common disease of ornamental aquarium fishes - their causative agents - virus, bacteria, fungi, protozoa and nematode; symptoms, treatment and prophylactic measures.

Recommended readings

1. Axelrod, H.R. (1967). Breeding aquarium fishes, T F H Publications.
2. Mills, D. (1981). Aquarium Fishes, Arco publishing.
3. Mills, D. and Vevers, G. (1982). The Practical encyclopedia of fresh water ,Tropical Aquarium fishes, Salamander Books limited, London.
4. Gahlawat, S.K., *et.al.* (2007). Manual of experimental Ichthyology, Daya publishing House, Delhi.
5. Brunner, G. (1973). Aquarium plants, T F H Publications, Inc. Ltd., Hongkong.
6. Hansen, J. (1979). Making your own aquarium, Bell and Hyman Ltd., London.
7. Lovell, T. (1998). Nutrition and feeding of fish second Ed. Kluwer Academic publishers.
8. Talwar, P.K., and Jhingran, A.G. (1991). Inland fishes Oxford and IBH Publishing Co. PVT LTD,New Delhi.

Semester	Course	Course Title	Credit
III/ IV	SEC-10	Aquaculture	Theory:04

About the course

This course will give the students an understanding of the principles of aquaculture, including production systems, water quality, nutrition, spawning, larval culture and culture methodologies with special reference to fish, and prawn. The course will include an opportunity to conduct hands-on activities related to culture and husbandry of animals

Learning outcomes

After completing this course the learners will be able to

- understand the aquaculture systems
- Understand conditioning factors and how they can be manipulated
- Describe water depuration mechanisms
- Understand the environmental impacts of aquaculture

Unit I : Freshwater aquaculture systems

13 Lectures

Aquaculture concept, Culture systems: Freshwater prawn culture, fish culture in paddy fields, Brackish water culture, Mariculture: Oyster culture, Crab culture, Lobster culture, mussel culture, culture of Eels, Culture of aquatic weeds. Composite fish culture: Definition and various patterns. Mixed fish farming in India. Techniques of composite culture. Culture of buffalo fish ..Culture of Catfishes. Culture of miscellaneous fishes. Cray fish culture.

Unit II: Preparation and management of fish culture ponds

13 Lectures

Nursery ponds. Predatory and Weed fishes and their control. Fish toxicants. Fertilization. Aquatic insects and their control. Fish food organisms and their production. Supplementary feeding. Transport of fish seed and Brood fish. Causes of mortality in transport. Methods for packaging and transport. Open systems. Closed systems. Use of chemicals in live fish transport. Anesthetic drugs. Antiseptics and Antibiotics.

Unit III: Fish pathology

13 Lectures

Parasitic infections. Fungus infections. Protozoan diseases.suryodata; Worm diseases. Non parasitic diseases. Rearing ponds, Stocking ponds. Fish breeding: Natural and artificial. Harvesting: Fishing techniques, preservation & processing of fish. Fresh water prawn culture. Introduction. Breeding characteristics. Juvenile prawn migration. Seasonal & regional distribution of seeds. Identification of juveniles. Controlled breeding. Culture: Ponds, Monoculture. Mixed culture.

Unit IV: Technologies in Fisheries development

13 Lectures

Role of hard water in culture of *Macrobrachium* species. Fertilization & feeds. Pearl culture: Introduction, Pearl producing mollusks, pearl formation, collection of oysters, Rearing of oysters, insertion of nucleus, harvesting of pearls, composition & quality of pearl. Recirculation technology, Geographic Information System (GIS) technology, passive Acoustics in fisheries, Use of Information Communication Technology (ICT) in fishes: production aspects, marketing aspects.

Recommended readings

1. Jingran, V. G. (1983) Fish and fisheries of India , Hindustan pub. corp. New Delhi.
2. Hute, M. and Kahn, H. (2000) Textbook of fish culture, Blackwell Scientific Publication, Australia.
3. Srinivasulu, M., Reddy, K.R.S., Rao, S. (1999) Text book of Aquaculture, Discovery Publishing House New Delhi.
4. Yawn Mehta, Fisheries & Aquaculture Biotechnology (2011) Campus Books International, Prahalad street, Ansari Road, Durga Ganj, New Delhi.

Semester	Course		Credit
III/ IV	SEC-11	Toxicology	Theory:04

About the course

This course is focused on theoretical and applied knowledge on the effects of chemical substances on human health. The students will also get introduced to the toxicological analysis and the signs and symptoms of important toxic syndromes. The students will also study the basic toxicokinetic principles and metabolic systems to elucidate mechanisms of toxicity induced by xenobiotic compounds.

Learning outcomes

After completing this course the students will be able to

- learn basic principles of signaling pathways and mechanisms of cell death
- understand gene-environment interactions
- examine the application how xenobiotics disrupt normal cellular processes of genomics, proteomics, and metabolomics data
- understand mechanisms of systemic and organ toxicity induced by xenobiotics; and 5) learn how to analyze and interpret complex data sets in toxicological research and deliver a scientific presentation.
- use clinical and laboratory findings in the treatment of acute toxic exposures

Unit I: Basic Concept of Toxicology

12 Lectures

Introduction of toxicology, history of toxicology, definition of toxicology, definition of poison, definition of toxicity and classification of toxicants. Mode of action of toxic agents.

Unit II: Xenobiotics

14 Lectures

Introduction, Important of xenobiotics concerned to Human health, absorption of xenobiotics, distribution of xenobiotics, accumulation of xenobiotics, elimination, biotransformation and excretion. Adverse effects of xenobiotics through Biological Magnification and Biotransformation, mechanism of Xenobiotic Translocation, Membrane permeability and mechanism of chemical transfer,

Unit III: Pesticides and Heavy Metal Toxicity

14 Lectures

Pesticides and their toxicological effects. Classification of Pesticides, Insecticides, Mode of action of Insecticide. Heavy Metal Toxicity: Introduction, dispersion, general principal of metal toxicity, sources, toxic metals and their toxicity. Arsenic, Alumunium, Cadmium (Itai-Itai disaster), Chromium Lead, Mercury, Manganese, Zinc and Nickel.

Unit IV: Evaluation of toxicity.

12 Lectures

Acute subAcute and chronic assays LD₅₀, LC₅₀, NOEL. Maintenance and general handling of animals for toxicological laboratory. Ecotoxicology, clinical toxicology, occupational and nanotoxicology.

Recommended readings

1. Williams, P.L.; James, R. C. Roberts, S.M. (2003) Principles of Toxicology: Environmental and Industrial Applications, John Wiley & Sons, Inc.
2. Klaassen, C. (2007) Casarett and Doull's Toxicology The basic science of poisons – McGraw-Hill.
3. Duffs, J. and Worth, H. (2006) Fundamental Toxicology, RSC Publishing.

Semester	Course	Course Title	Credit
III/ IV	SEC-12	Beekeeping	Theory:04

About the course

This course tells the students what tools and equipment will be needed, the main activities in the beekeepers year, the laws and by laws governing keeping bees; discover the principles of sustainable beekeeping and how these principles can guide your beekeeping into an enduring practice.

Learning outcomes

Upon successful completion of this course, the student should be able to:

- Explain what are the prerequisite to get started in beekeeping
- Describe the laws around beekeeping in Vancouver
- Discuss the responsibilities of urban beekeepers
- Identify where to purchase equipment and demonstrate how to assemble it
- Name and identify major parts of the honeybee such as the stinger or mandibular parts
- Describe bee biology and anatomy from the perspective of managing bees
- Describe the importance of wax and identify what to look for in comb during hive inspections

Unit I: Introduction to Apiculture

12 Lectures

History of Bees and Beekeeping, Systematics, Bee species, Bee morphology, Colony organization, Polymorphism, Caste system, Division of labour, Bee flora, Foraging and Honey flow periods.

Unit II: Bee keeping as an occupation

13 Lectures

Extent of Beekeeping in Maharashtra and India, Limitations on the development of beekeeping, Advantages of extensive Beekeeping. Beekeeping equipments: Bee box and tools and initiation into keeping a colony, the future of beekeeping.

Unit III: The first step in beekeeping

14 Lectures

Purchase of a colony, the Apiary site, how to manage a colony, the manipulation of a colony. Bee products: Honey, Bees wax, Pollens, Royal Jelly, Propolis and Bee venom. taking care of bee diseases and enemies. Establishment of a colony. Bee flora and planned pollination services.

Unit IV: Beekeeping techniques and Apiary management

13 Lectures

Routine management, Seasonal management, Migratory beekeeping, Harvesting and marketing of bee products. Important Institutions pertinent to Apiculture: National Bee Board, Bee research and Training Institute, Apiaries. Economics and extension of Bee keeping.

Recommended readings

1. Abrol , D. P. (1997) Bees and Beekeeping. Kalyani Publisher, New Delhi.

2. Abrol, D. P. (2010) A Comprehensive guide to Bees and Beekeeping. Scientific Publisher, New Delhi.
3. Withhead, S. B. (2010) Honey bees and their management Axis books Publisher, Jodhpur.
4. Nagaraja, N. and Rajagopal , D. (2013) Honey bees: Diseases, Parasites, Pests, Predator and their management. M.J.P Publisher, Chennai.
5. Dharamsing and Singh, D. P. A Handbook of Beekeeping, Agrobios India (Publisher), Jodhpur.

Semester	Course	Course Title	Credit
III/ IV	SEC-13	Sericulture	Theory:04

About the course

The course gives insight into the principles of sustainable sericulture and how these principles can guide your silkworm rearing into an enduring practice. The students will know about the laws and by laws governing keeping silkworm.

Learning outcomes

Upon successful completion of this course, the student should be able to:

- Generation of skilled man power in the field of sericulture,
- To impart training in extension management and transfer of technology,
- To impart training in Post Cocoon Technology, and
- To provide field exposure

Unit I: Silkworm distribution and races

12 Lectures

The silkworms. Its morphological characteristics. Distribution and types of races. Exotic and indigenous races of silkworm. World silk production World map and silk road, spread of Sericulture to Europe, South Korea, Japan, India and other countries. Sericultural practices in tropical and temperate climate.

Unit II: Biology of silkworm

13 Lectures

Mulberry and non-mulberry Sericulture. Biology of silkworm. Selection of mulberry variety and establishment of mulberry garden, Rearing house and rearing appliances. Silkworm rearing technology: Early age and Late age rearing Selection of silkworm races/breeds for rearing. Incubation- definition, requirement of environmental conditions, incubation devices; identification of stages of development; black boxing and its importance.

Unit III: Diseases of silk worm and prevention and control

14 Lectures

Diseases of silkworm. Disinfectants: Formalin, bleaching powder RKO. Types of mountages, Spinning, harvesting and storage of cocoons. Introduction; classification of silkworm diseases. Protozoan disease: symptomatology due to *Nosema bombycis* infection, source, mode of infection and transmission, cross infectivity, prevention and control. Bacterial, Viral, Fungal diseases: causative agents, symptoms, transmission prevention and control.

Unit IV: Prospects of Sericulture in India

13 Lectures

Sericulture Types- natural and synthetic fibres- types of silk produced in India; Importance of mulberry silk. Silk industry in different states, employment, potential in mulberry and non-mulberry sericulture. Employment generation in sericulture: Role of women in sericulture.

Sericultural practices in rain-fed and irrigated conditions; traditional and non-traditional areas. Sericulture organization in India; role of state departments of Sericulture, Central Silk Board, Universities and NGOs in Sericulture development

Recommended readings

1. Manual on sericulture (1976). Rome : Food and Agriculture Organization of the United Nations, Agricultural Services Division.
2. Ullal, S.R. and . Narasimhanna, M.N. (1987) Handbook of Practical Sericulture: CSB, Bangalore
3. Silkworm Rearing and Disease of Silkworm (1956) Ptd. By Director of Ptg., Stn. & Pub. Govt. Press, Bangalore
4. Jolly, M. S. (1986) Appropriate Sericultural Techniques; Ed., Director, CSR & TI, Mysore.
5. Handbook of Silkworm Rearing: Agriculture and Technical Manual-1 (1972) Fuzi Pub. Co. Ltd., Tokyo, Japan.
6. Narasimhanna, M. N. (1988) Manual of Silkworm Egg Production;, CSB, Bangalore.
7. Sengupta, K. (1989) A Guide for Bivoltine Sericulture. CSR & TI, Mysore.

Semester	Course	Course Title	Credit
III/ IV	SEC-14	Ecotourism	Theory:04

About the course

This course is designed to provide students with an understanding of the management and planning of ecotourism opportunities. The course will give students to the concept of ecotourism and its economic, cultural and environmental impacts at different scales. Students will learn the methods through which ecotourism can be marketed and managed, together with its potential adverse impacts.

Learning outcomes

Upon successful completion of this course, the student should be able to:

- identify and manage for ecological impacts to soil, water, vegetation, and wildlife resulting from recreation and tourism development;
- understand ecological impacts and ecotourism management approaches in a variety of ecosystems under diverse landowners;
- ability to analyze the environmental and social consequences of ecotourism management strategies and decisions;
- understand management tools to reduce visitor related impacts that occur in ecotourism areas (impacts of outdoor recreation include impacts to soil, vegetation, water, wildlife, air, soundscape, night sky, historical/cultural resources, visitor experiences, and facilities/services).

Unit I: Baseline information about Ecotourism

13 Lectures

History of ecotourism and its definitions. Types of Tourism: Extreme tourism Mass tourism. Why is mass tourism NOT eco-friendly? Evolution and characteristics of ecotourism, relevance of responsible tourism. World Ecotourism Summit- policies and formulations How an ecotourism development can benefit future generations. Ecotourism as a tool of capacity building and conservation.

Unit II: Ecotourism as an industry

13 Lectures

Ecotourism as a growth sector within the tourism industry. Tourist resorts. Environmental, socio-cultural and economic impacts of ecotourism. Viewpoints on tourism industry and major constituents, Tourism organizations – international, national, state level and private sector, Importance of tourism statistics. Tourism industry in India, Ecotourism in Kerala-possibilities and problems.

Unit III: Management functions and practices in tourism

12 Lectures

Tourism policies and planning, Involvement of local bodies and officials in tourism, Coordination between tourists and hosts, Tourism products and operation, Tourist sites and attractions. Managing personnel in tourism, Managerial practices in tourism, Tourism services and management, Seasonality and destination in tourism, Preparation of maps and charts.

Unit IV: Marketing ecotourism

13 Lectures

Tourism marketing- definition, concepts and features Advertising and publicity in tourism Role of media in tourism, Tourism writing. Communication skills and tourism Ecotourism and competing resource users. International and domestic tourism markets, Marketing research and analysis, Tourism forecasting and use of technology in tourism marketing, Airlines, Travel Agency, hotel accommodation, tour packages marketing etc.

Recommended readings

1. Mowforth, M., & Munt, I. (2009). Tourism and sustainability (3rd Edition). London, UK: Routledge.
2. Newsome, D., Moore, S.A., & Dowling, R.K (2002). Natural area tourism. Bristol, UK: Channel View. (Publications.
3. Weaver, D. (2008). Ecotourism (2nd Edition). Hoboken, NJ: JS Wiley. Staff : Dr Julian Clifton

9. Teaching-Learning Process (may be expanded keeping in view needs and outcomes of the subject)

As programme of study in Zoology is designed to encourage the acquisition of disciplinary/subject knowledge, understanding and skills and academic and professional skills required for Zoology-based professions and jobs, learning experiences should be designed and implemented to foster active/participative learning. Development of practical skills will constitute an important aspect of the teaching-learning process. A variety of approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching and learning, practicum and project-based learning, field-based learning, substantial laboratory-based practical component and experiments, open-ended project work, games, technology-enabled learning, internship in industry and research establishments etc. will need to be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

The syllabus aims to provide this knowledge, capitalising upon the research activity and teaching expertise of the academic staff. The syllabus is also designed to develop the “analytical techniques and problem-solving skills” relevant to graduate-level employment. Students are encouraged to see themselves as producers of knowledge and collaborators in their learning experience. Lectures introduce key topics in the subject area and guide students ‘independent study. Practical will allow students to develop laboratory skills and skills in

fieldwork, surveying, data handling and processing, as well as to encounter at first hand the principles introduced in the lectures. Students will also develop their own interests through self-guided research skills, as library based study and background research and project work. Seminars and small group tutorials will be used to facilitate class discussion. There have to be site visits and lectures by external specialists to provide opportunities to meet animal scientists employed in graduate roles and their employers. There will be an emphasis on the practical application of principles and the development of graduate skills will be included in subject specific units.

A teacher offer ways for the learners to take an active role, for at least a portion of the course, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate strategies and evaluating the outcomes both internal and external. A teacher has not only to instruct but also to inspire the students; he or she has to influence the life and character of his or her students, and equip them with ideas and values which will enable them to enter the national stream as worthy citizens. Teachers are supposed to do all these during the years as the students are under their contact and influence in the College. Learning technology is the broad range of communication, information and related technologies that can be used to support learning, teaching, and assessment. Blended Learning is learning that is facilitated by the effective combination of different modes of delivery, models of teaching and styles of learning and applying them in an interactively meaningful learning environment. E-Learning is the use of technology to enable people to learn anytime and anywhere. E-Learning can include training, the delivery of just-in-time information and guidance from experts. Video lectures recorded in segments, case studies, reading material, homework, and quizzes are designed in advance and made available for online streaming or download. Students are expected to watch the videos, read the assigned material, and do homework before attending class, online or face-to-face, for discussions with the instructor or a teaching assistant. Technology-enabled instructor engagement and robust learning cohorts give students the experience of learning with peers and from a teacher rather than in isolation from a book or content management system. Importantly, these new technologies allow class enrolment to scale effectively from tens or hundreds of students to thousands of students per class. Scalable online courses can be designed to fit the operational and economic needs of most degree or certificate granting enterprises to:

- Enforce and control registration and course credit, prerequisites and advisor approval.
- Secure tuition payments either before course start or before certification.
- Engage local instructors and/or teaching assistants in the delivery of the course even if the professor's home institution is remote.

Following Active Learning Methodologies may need to implement: –

- Learning by Doing
- Concept Maps
- Brainstorming
- In class surprise quizzes and discussion –
- Combine lectures with videos and discussions –
- Process Oriented Guided Inquiry Learning (POGIL) – Flipped Classroom

Using quality scalable online courses taught by other faculty is probably even more important to the long run economic health of most institutions, though this requires a substantial change in culture. Computer supported collaborative learning (CSCL) is a pedagogical approach wherein learning takes place via social interaction using a computer or through the Internet. This kind of learning is characterized by the sharing and construction of knowledge among participants using technology as their primary means of communication or as a common resource.

10. Assessment Methods (may be expanded keeping in view the needs and outcomes of the subject)

The assessment of students' achievement in zoology will be aligned with the course/programme learning outcomes and the academic and professional skills that the programme is designed to develop. A variety of assessment methods that are appropriate within the disciplinary area of zoology will be used. The assessment strategy adopted within the BSc (Hons) Zoology aims to test subject knowledge, independent thought and skills acquisition and to provide information about candidates that will be useful to employers. Learning outcomes will be assessed using the methods as given earlier under head 8.1 on Page No. 24.

Formative assessment is provided during practical classes where students can apply knowledge from lectures as well as seek guidance on practical skills. Students are also encouraged to ask questions during lectures to clarify issues, or even develop ideas derived from lecture material. Lecturers will also set aside time for workshops and seminars focused on key subjects, where for example students can work in groups on one of a number of topics, present their conclusions for class based debate and receive feedback from lecturers as well as peers.

Methods of assessment need to be implemented

- Thinking critically and making judgements by Essay, Report, Journal and Book review (or article) for a particular case/situation
- Identifying problems, posing problems, defining problems, analysing data, reviewing, designing experiments, planning, applying information
- Computation, taking readings, using equipment, following laboratory procedures, following protocols, carrying out instructions
- Accessing and managing information (Researching, investigating, interpreting, organising information, reviewing and paraphrasing information, collecting data, searching and managing information sources, observing and interpreting) by project, dissertation and applied problem.
- Demonstrating knowledge and understanding by written examination, oral examination, essay and report
- Communicating (One and two-way communication; communication within a group, verbal, written and non-verbal communication. Arguing, describing, advocating, interviewing, negotiating, presenting; using specific written forms) by written presentation (essay, report, reflective paper etc.), oral presentation, group work and discussion/debate/role play

11. Keywords: Zoology, Systematics, Chordates & Non-Chordates, Developmental biology, Comparative anatomy, Physiology, Genetics, Evolution. Cell Biology, Biochemistry, Molecular biology, Ecology, Behaviour, Parasitology, Immunology, Biotechniques, Bioinformatics, Applied Zoology etc.