

दिल्ली विश्वविद्यालय
UNIVERSITY OF DELHI

B. Sc. (Program) Life Sciences

(Effective from Academic Year 2019-20)



Revised Syllabus as approved by

Academic Council

Date:

No:

Executive Council

Date:

No:

**Applicable for students registered with Regular Colleges, Non Collegiate
Women's Education Board and School of Open Learning**

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Preamble

The objective of any Program at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its Programs in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under-Graduate Programs.

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

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

The University of Delhi hopes the LOCF approach of the program B.Sc. (Prog.) Life Sciences will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

1. Introduction

The learning outcomes-based curriculum framework for B. Sc. (Program) Life Sciences is structured to offer a broad outline within which a holistic biology program could be developed. The course is advanced with respect to the students' aspirations and the ever changing learning environment. The courses within zoology have been reconsidered to include current innovations and laboratory techniques to skill the students. The revised structure is expected to upgrade the understanding levels of students and to maintain the requisite standard of Life Sciences/Biology Programs across the country. Efforts have been made to incorporate use of MOOCs to assist learning-teaching processes among stakeholders. This structure allows the review of the learning outcomes, qualification descriptors, and course-level learning outcomes periodically. Further, it offers innovation and flexibility in designing the syllabi and methods to be adopted facilitating learning assessment. Prime objective is to enhance the subject knowledge, encouraging the students to be critical thinkers and have a problem-solving approach. Overall, this modified course has been concerted to upgrade skills related to biological science giving the students' a competitive edge in securing a career in industry, academia, pharmaceutical research, and as an entrepreneur.

2. Learning Outcome

2.1 Nature and Extent of B.Sc. Program (Life Sciences)

Zoology is a comprehensive subject encompassing both classical and modern biology. The scope of zoology as a subject is wide-ranging but the students of Life Sciences are provided with a flavour of the major areas of zoology in the form of Discipline Core Courses: Diversity of Non-chordates and Chordates; Comparative Anatomy and Development Biology of Vertebrates; Physiology and Biochemistry, Genetics and Evolutionary Biology. Diversity of Non-chordates and Chordates deals with the classification and adaptive diversity of animals from diverse phyla; Comparative Anatomy of Vertebrates deals with structural comparisons among all vertebrates. Physiology gives us knowledge about the functions of all the parts and systems of the body. It is also of central importance in medicine and related health science. Biochemistry deals with the study of biomolecules; their structures and functions in the living organisms. Genetics deals with the molecular structure and function of genes, and gene behaviour in context of a cell or organism; while evolutionary biology discuss the evolutionary processes that gave rise to biodiversity on earth.

In the fifth and sixth semester the students can opt for one Discipline Specific Elective per semester from: Reproductive Biology, Wild Life Conservation and Management, Biotechnology, Immunology, Applied Zoology or Dissertation. Further, the curriculum also includes applied topics like Apiculture, Aquarium Fish Keeping, Medical Diagnostics, Public Health and Hygiene, Sericulture and Environment Audit, etc., that are designed for developing skills of the students with an aim to explore employment opportunities. It also includes visits to industries, fields or commercial culture units to get in-depth knowledge of the subject.

2.2 Aims of the Bachelor's Degree Program in Life Sciences

Zoology is one of the most fundamental branch of biology to be studied at undergraduate level. It is required to learn and understand about animal diversity and to appreciate their variability in relation to their morphology, anatomy and behaviour. The course will also provide an opportunity to learn and understand about evolution. Students will be able to appreciate evolutionary parameters using various bioinformatics and computational tools used in modern sciences. The course further enhances understanding of classical genetics to comprehend distribution of various traits among populations, their inheritance, ethnicity and students can correlate these aspects with contemporary and modern subjects like genomics, metagenomics and genome editing tools. Skills gained in practical and theory will be helpful in designing holistic public health strategies for social welfare. Studying zoology as a part of life science course, further enhance knowledge of applied subjects to hone students' skills to build a career and become an entrepreneur in the field of aquatic biology, sericulture, apiculture etc. After completion of this course, students could contribute as policy makers in wild life conservation, and environment protection.

3. Characteristic Attributes of a Graduate in Life Sciences

Some of the characteristic attributes of a B.Sc. (Program) graduate who has pursued Zoology as part of Life Science discipline may include the following.

Disciplinary knowledge: Capable of demonstrating (i) comprehensive basic knowledge of major concepts, theoretical principles and experimental findings in zoology and its different sub-fields including biodiversity, physiology, biochemistry, biotechnology, genetics, evolutionary biology, and immunology and some of the other applied areas of study such as wildlife conservation and management, apiculture, sericulture, aquatic biology, etc. (ii) interdisciplinary knowledge of allied biological sciences, environmental science and chemical science; (iii) learning of the various techniques and computational softwares used for analysis of animal's forms and functions.

Effective communicator: Ability to grasp the complex zoological information effectively and efficiently.

Logical thinking and reasoning: Develop the capability to seek solutions logically, resolving them by experimentation and processing the data either manually or through software.

Team spirit: Trained to be interdisciplinary and possess the ability to work effectively in a heterogeneous team.

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

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

4. Qualification Descriptors

The qualification descriptors for a Bachelor's Degree Program in Life sciences may include the following:

Demonstrate logical and consistent understanding of the broad concepts in zoology and its applications in related interdisciplinary subjects.

Inculcate in-depth knowledge to help students pursue varied types of professions in research and development, academia, government, public sector service and even entrepreneurship sector.

Use wide-range knowledge, logical thinking and skills for evaluating problems and issues related to animals.

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

Apply one's subject knowledge and skills to innovate and address complicated problems with evidence-based well-defined elucidations.

Demonstrate subject-related skills relevant to zoology-related jobs and employment opportunities.

5. Program Learning Outcomes

Students enrolled in B.Sc. (Program) Life Sciences will study and acquire complete knowledge of disciplinary and allied biological sciences. At the end of graduation, they would have expertise which will provide them competitive advantage in pursuing higher studies from India and abroad or seek jobs in academia, research or industries.

Students should be able to identify, classify and differentiate in types of chordates and non-chordates based on their morphological, anatomical and systemic organization. This will create a curiosity and awareness among them to explore the animal diversity and take up wildlife photography or wildlife exploration as a career option. The procedural knowledge about identifying and classifying animals will help students professional advantages in teaching, research and taxonomist jobs in various Government organizations, such as Zoological Survey of India or National Sanctuaries.

Acquired practical skills in biochemistry and biotechnology can be used in pursuing career as a scientist in pharmaceutical industry in India or abroad.

Students will be gaining basic experimental skills in genetics, biotechnology, qualitative and quantitative microscopy, and also enzymology that will give them an edge to pursue higher studies.

The skill enhancement courses will hone skills in rearing fish, bees and silk moth for generating self-employment.

Students can acquire expertise to join clinical and research laboratories for diagnostic assays, haematology, histopathology, staining procedures etc.

They will be able to examine and assess some basic physiological functions and interpret physiological charts.

5.1 Course-Level Learning Outcomes of B.Sc. (Program) Life Science

Detailed course-learning outcomes of B.Sc. (Program) Life Sciences are described in following sections.

Discipline Core Course I: Animal Diversity (Semester I)

The course would provide an insight about different life forms on Earth, and appreciate the diversity of animal life. The course makes the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature. Choosing this course will help students to have the following learning outcomes:

- Understand the importance of taxonomy and structural organization of animals from Protista to Mammalia to appreciate the diversity of non-chordates and chordates living in varied habitats.
- Meticulously analyze the complexity and characteristic features of non-chordates and chordates by familiarization with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the evolutionary history and relationships of different non-chordates and chordates through functional and structural affinities.
- Realize the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- Appreciate the diverse habitats, including marine, freshwater and terrestrial.
- Understand similarities and differences in life functions among various chordates.

Discipline Core Course II: Comparative Anatomy and Developmental - Biology of Vertebrates (Semester II)

This course conveys the knowledge base for appreciating the vertebrate anatomy. Students will learn to critically analyze and evaluate the structure and functions of vertebrate systems comparatively.

Students will develop the necessary skill to draw a connection between anatomical changes, the differences between homologous and analogous structures, adaptation to habitat and the pattern of evolutionary diversification of the vertebrates.

Students will value the contribution of comparative anatomy to the society by learning how the adaptations of vertebrate structures like wings of birds, gills in fishes and mammalian eye help the engineers to mimic the design and develop various devices including wings of aircraft, optics, countercurrent exchange etc.

The importance of comparative vertebrate anatomy to discern human biology will be emphasized. By learning about the organization, functions, strength and weaknesses of various life systems, students' can critically think how the evolution has shaped these traits in human body.

The core course 'Comparative Anatomy of Vertebrates' aims at providing the following critical learning outcomes.

- Critically think and analyse the significance of morphological traits that vertebrates possess and understand the position of humans in evolutionary history.
- Understand the events that lead to formation of a multicellular organism from a single fertilized egg, the zygote. The students acquire basic knowledge of the cellular processes of development and the molecular mechanisms underlying these.
- Able to describe the general patterns and sequential developmental stages during embryogenesis. The students understand how the developmental processes lead to establishment of body plan of multicellular organisms.
- Discuss the general mechanisms involved in morphogenesis and explain how different cells and tissues interact in a coordinated way to form various tissues and organs.
- Learn the importance of latest techniques like stem cell therapy, *in vitro* fertilization and amniocentesis etc. to be applied for human welfare.
- Become aware of teratogens responsible for the rise of congenital abnormalities globally.
- Comprehend the concept of gene activation, determination, induction, differentiation, morphogenesis, intercellular communication, cell movements and cell death.

Discipline Core Course III: Physiology and Biochemistry (Semester III)

This particular course of zoology is aimed on building knowledge of basic physiological principles as well as introducing latest concepts in line with the research developments in physiological sciences.

The students will have a clear knowledge of basic fundamentals as well as understanding of advanced concepts in human physiology and biochemical processes. They will learn about an integrative approach to understand the interactions of various organ systems resulting in the complex overall functioning of the body; for example, cardiovascular and respiratory systems to meet the oxygen demand of the body. They can develop a strong foundation that will help them to acquire skills and knowledge to pursue advanced degree courses and research institutes..

The core course 'Physiology and Biochemistry' aims at providing the following critical learning outcomes.

- Comprehend and analyze problem based questions.
- Develop investigative, communicative, analytical and personal skills with respect to the subject. Recognize and explain how all physiological systems work in unison to maintain homeostasis in the body and feedback loops control the same.
- Synthesize ideas to make connection between knowledge of physiology and real world situations, including healthy life style decisions and homeostatic imbalances i.e. how physiological mechanisms adapt in response to various external and internal stimuli in order to maintain health.
- Know the role of regulatory systems *viz.* endocrine and nervous systems and their amalgamation in maintaining various physiological processes.
- Understand the concepts of biochemistry and interaction of biomolecules with each other to bring about life processes.
- Appreciate the role of enzymes in metabolic pathways.
- Learn control of enzyme activity, its mechanism of action and how a drug might inhibit the enzyme.

- Develop practical learning skills; like qualitative estimation of carbohydrates, chromatography and interpretation of results.

Discipline Core Course IV: Genetics and Evolutionary Biology (Semester V)

This course aims to provide an overview of genetics; starting from the work of Mendel to the current understanding of various phenomena like recombination, transposition, sex determination and mutation. The course will help in building sound fundamental knowledge of the principles of genetics to be used as a stepping stone for higher studies and research in this field.

The course has been designed with an aim that knowledge of the principles of inheritance is essential for a deeper understanding of the varied branches of the biological sciences like microbiology, evolutionary biology, genomics and metagenomics. Analysis of pedigree will lead to development of analytical skills and critical thinking enabling the students to present the conclusion of their findings in a scientific manner. Field studies can be conducted and case histories of families can be collected. This will not only help the students in hypothesis formulating and testing but will also teach them an essential skill of data collection. Students can prepare reports and present their findings in posters or oral presentations. This will help them to upgrade their data presentation and communication skills.

Knowledge of the mechanisms of mutations and the causative agents will lead to an increase in awareness of the students about the harmful impact of various chemicals and drugs being used in day to day life. These students will, in turn, make people aware of the impact of indiscriminate use of such compounds. Students can work to find out the effects of indiscriminate use of various chemicals, drugs or insecticides in nature by studying their effects on various bacterial species in soil and water samples collected from different industrial or polluted areas. This will help to enhance the organizational and experimental skills of the students.

This course emphasizes on the development of evolutionary thought by dealing in general with the process and pattern of biological evolution. It aims at providing the following critical learning outcomes.

- Development of problem solving and high order analytical skills by attempting numerical problems as well as performing simulation studies of various evolutionary forces in action.
- Application of knowledge gained on populations in real time, while studying speciation, behaviour and susceptibility to diseases.
- Utilization of knowledge gained from study of variations, genetic drift to ensure that conservation efforts for small threatened populations are focused in right direction.
- Predict the practical implication of various evolutionary forces acting on the human population in the field of human health, agriculture and wildlife conservation.
- Be interested towards the field of bioinformatics and coding used in programming language by using various software.

Discipline Specific Elective Zoology

Discipline Specific Elective-1: Reproductive Biology

This course is meant for making the students learn about the various aspects of reproductive biology in humans. Students are also made aware of new technologies in assisted reproduction as well as contraceptive methods. It aims at providing the following critical learning outcomes.

- In-depth understanding of morphology, anatomy and histology of male and female reproductive organs.
- Knowledge of the different processes in reproduction starting from germ cell formation to fertilization and consequent pregnancy, parturition and lactation.
- Comparison of estrous and menstrual cycles and their hormonal regulation.
- Comprehension of the interplay of various hormones in the functioning and regulation of the male and female reproductive systems.
- Knowledge of the diagnosis and management of infertility, including latest methods, technologies and infrastructure in assisted reproduction.
- Practical understanding of modern methods in contraception and their use in family planning strategies.
- Ability to translate this understanding into development of products; like non-hormonal contraceptives, contributing to drug discovery programs as well as neonatal and maternal health programs, working with family planning teams to understand the needs and preferences of individuals belonging to lower socioeconomic groups.

Discipline Specific Elective-2: Wild Life Conservation and Management

The discipline specific paper on, Wildlife Conservation and Management' is designed to acquaint students with varied aspects of wildlife conservation, including its importance, major threats, management of their habitats and populations. This course will motivate students to pursue career in the field of wildlife conservation and management.

It aims at providing the following critical learning outcomes.

- Awareness about the importance of wildlife in general, and its conservation and management, in particular.
- Comprehend the application of the principles of ecology and animal behaviour to formulate strategies for the management of wildlife populations and their habitats.
- Understand the management practices required to achieve a healthy ecosystem for wildlife population along with emphasis on conservation and restoration.
- Understand the key factors for loss of wildlife and important strategies for their *in-situ* and *ex-situ* conservation.
- Understand the techniques for estimation, remote sensing and global position tracking for wildlife.
- Awareness about the wildlife diseases and the quarantine policies.
- Knowledge about the protected area networks in India, ecotourism, ecology of perturbation and climax persistence.
- Perform critical thinking, literature review; scientific writing as well as presentations; and participation in citizen science initiatives with reference to wildlife.

Discipline Specific Elective-3: Immunology

This course is designed to enable understanding the molecular and cellular basis of the development and function of the immune system and identification of its biological, clinical and therapeutic implications. This course aims at providing the following critical learning outcomes.

- Describe the basic mechanisms, distinctions and functional interplay of innate and adaptive immunity,

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

Discipline Specific Elective-4: Animal Biotechnology

Biotechnology is the advanced branch of biological sciences which mostly deals with technological application on biological systems. This course is designed to equip the students with basic tools of biotechnology, so that they can use it in future research. It aims at providing the following critical learning outcomes.

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

Discipline Specific Elective-5: Applied Zoology

This particular course deals with the applied fields of zoology and emphasizes on the role of biological principles in medicine, economic zoology, agriculture, poultry, etc. It aims at providing the following critical learning outcomes.

- Understand the concept of host, definitive host, intermediate host, parasitism, symbiosis, commensalism, reservoir, zoonosis.
- Know about epidemiology of diseases; *i.e.*, transmission, prevention and control of diseases. Understand pathogenicity of Protozoan and parasitic helminths.
- Learn about the concept of pest and pest status.
- Understand the difference between various types of pests and extent of damage caused by them.
- Gain knowledge about important pests of crops, fruits, vegetables, stored grains and insects of medical importance.
- Analysis of varied types of control measures for management of pest populations and list suitable control measures, specific for every pest.
- Preservation and artificial insemination in cattle; Induction of early puberty and synchronization of estrus in cattle.
- General idea about poultry farming.

Skill Enhancement Courses

Skill Enhancement Course-1: Apiculture

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

- Learn about the various species of honey bees in India, their social organisation and importance.
- Be aware about the opportunities and employment in apiculture – in public, private and government sector.
- Gain thorough knowledge about the techniques involved in bee keeping and honey production.
- Know about various products obtained from beekeeping sector and their importance.
- Develop entrepreneurial skills necessary for self-employment in beekeeping sector.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Skill Enhancement Course-2: Aquarium Fish Keeping

The main aim of Skill Enhancement Course in Aquarium Fish Keeping is to impart basic knowledge of ornamental fish Industry and inculcate its scope as an avenue for career development in Entrepreneurship or as an Aquariculturist as well as to promote skill capacity building of students by teaching the techniques of aquarium constructions, feed formulation and preparation, transportation, maintenance and management of the system. At the end of this course students are expected to demonstrate following skills.

- Know about different kinds of fishes, their compatibility in aquarium.
- Recognize the role of aquarium in commercial, decorative and scientific studies.
- Development of personal skill - maintenance of aquarium.
- Understand the basic needs of an aquarium, *i.e.* dechlorinated water, reflector, filters, scavenger, aquatic plants etc.
- Know how to set an aquarium and make it cost-effective.
- Development of skill after visiting any farm and know about the preparation of fish feed.

Skill Enhancement Course-3: Medical Diagnostics

This paper is aimed to provide students a unique opportunity to study how doctors or clinicians diagnose a disease, prevent and conduct optimal treatment regimens. Students will learn about multiple diagnostic tools, techniques and technologies used in medical practices. The emphasis is on how to select an appropriate diagnostic technique, methods and technologies to conduct analyses to understand the results and their implications in patient diagnoses. The course essentially aims to impart training to students in:

- Gain knowledge about various infectious, non-infectious and lifestyle diseases, tumors and their diagnosis
- Understand the use of histology and biochemistry of clinical diagnostics and learn about the molecular diagnostic tools and their relation to precision medicine.

- Develop skills in various types of tests and staining procedure involved in hematology, clinical biochemistry and the basics of instrument handling.
- Learn the scientific approaches/techniques used in the clinical laboratories to investigate various diseases.
- Acquire knowledge about common imaging technologies and their utility in the clinic to diagnose a specific disease.

Skill Enhancement Course-4: Public Health and Hygiene

This course is multidisciplinary in nature which can be opted by students from all science courses. Starting from the basic concepts of Environmental science, it gives a deep insight into the factors causing environmental degradation and its outcome in form of increasing number of diseases leading to deterioration of public health.

The paper has the following learning outcomes.

- Familiarisation with various aspects of environmental risks and hazards.
- Be sensitized about the climate change due to human activities.
- Be aware about the various impacts of environmental degradation on human health through case studies and modes of prevention.
- Learn about the nuclear and chemical disasters and their after effects through cases studies.
- Know about the various waste management technologies and their utility.
- Learn about diagnosis of various diseases and methods to prevent them.
- Be sensitized enough to understand the importance of conservation of nature for betterment of human race and all living beings.

Skill Enhancement Course-5: Sericulture

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

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

Skill Enhancement Course-6: Environmental Audit

The students will be able to develop the appropriate documentation for an environmental impact statement and respond appropriately to an environment audit or Environmental Management System (EMS). It will provide students with information in order to obtain competencies for

environmental auditing. Further apprise them on the environmental commitments that an industry has and how it can be monitored and audited. It will help them understand the potential environmental impacts that are described in Environmental Impact Assessments (EIA)

- how industry controls their environmental impacts through EMS?
- how environmental management systems are audited?
- how waste is generated and controlled?
- other environmental management initiatives such as product life cycle analysis and sustainability Programs
- To develop ability to plan, execute and document the environmental audit.
- To develop entrepreneurial skills

6. Teaching-Learning Processes

Life Sciences as a program has been structured to impart all-inclusive knowledge of animal sciences (both disciplinary allied biological subjects) and to provide a competitive advantage to students in academia, research and development and industrial jobs. Information will be shared between teacher and students through two-way communication and students learning will be enabled by using multimedia, quiz-based platform, smart class-based teaching, simulation and animation videos. Advancement of practical skills is a significant aspect of teaching and learning process. Hence, interactive lectures, computer-aided methods for displaying virtual dissection, seminars, presentations, field trip or project-based learning, as well as *in-silico* experiments will be implemented to facilitate learning process. Students would be encouraged to access e-learning resources like SWAYAM, MOOC, CourseSra, MIT OpenCourseWare etc. to make them self-learners and facilitate them to understand the concepts. The above mentioned research-based tools and approaches will enhance problem solving, peer reviewing, and inculcate team work spirit.

Assessment Methods

Assessment will be flexible and designed depending upon the requirement of course being taught. Students will be continuously assessed for their learning and corrective measures would be taken to enhance their learning outcome periodically. Students will be assessed from time to time through class tests to judge their grasp on the topics taught in the classroom. Regular projects, assignments and presentations will be given to students to inculcate analytical skills, confidence and competencies among them. Their presentations will be assessed based on the content, novelty through plagiarism check and response to queries raised by peers.

- (a) Students will typically undergo two forms of assessment to fulfil the underlined points of learning outcome. Formative assessment is an important part of learning assessment. Continuous assessment will be made through problem solving exercises, practical assignments, closed and open book class tests and *viva-voce* etc. to assess the retention abilities of our students.
- (b) Summative assessment: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained

by each student comparatively. Hence, towards the end of semester, written tests, presentations and practical are carried out as per university guidelines.

Students will be assessed on basis of their performance in theory as well as practical.

Theory – 100 marks

End semester exam- 75 marks

Internal Assessment- 25 marks (Assignment-10; Mid-term test-10; Attendance-5)

Practical - 50 marks

End semester exam 25 marks

Continuous Evaluation- 25 (Records - 10, Project/viva- 5, Attendance-5, Total number of practical performed- 5)

6. Structure of B.Sc. (Program) Life Sciences with Zoology

| | DISCIPLINE CORE COURSE DSC (12) | Ability Enhancement Compulsory Courses AECC (2) | Skill Enhancement Courses SEC (4) | Discipline Specific Elective DSE (4) |
|-----|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------|
| I | DSC 1- Zoology I: Animal Diversity DSC 2 – Paper I DSC 3- Paper I | English/Hindi/MIL Communication/E nvironmental Science | | |
| II | DSC 1- Zoology II: Comparative Anatomy and Developmental Biology of Vertebrates DSC 2 – Paper II DSC 3- Paper II | English/Hindi/MIL Communication/E nvironmental Science | | |
| III | DSC I- Zoology III: Physiologyand Biochemistry DSC 2 – Paper III DSC 3- Paper III | | SEC-I | |
| IV | DSC 1- Zoology IV: Genetics and Evolutionary Biology DSC 2 – Paper IV DSC 3- Paper IV | | SEC-II | |
| V | | | SEC-III | DSE-Zoology Paper I DSE-Discipline 2- Paper I DSE- Discipline 3- Paper I |
| VI | | | SEC-IV | DSE-Zoology Paper II DSE-Discipline 2- Paper II DSE- Discipline 3- Paper II |

Discipline Core Courses: Zoology

1. Animal Diversity
2. Comparative Anatomy and Developmental Biology of Vertebrates
3. Physiology and Biochemistry
4. Genetics and Evolutionary Biology

Discipline Specific Electives: Zoology (Any two)

1. Reproductive Biology
2. Wild Life Conservation and Management
3. Animal Biotechnology
4. Immunology
5. Applied Zoology
6. Dissertation

Skill Enhancement Courses: Zoology

1. Apiculture
2. Aquarium Fish Keeping
3. Medical Diagnostics
4. Public Health and Hygiene
5. Sericulture
6. Environmental Audit

6.1 Course Credit

| Semester | Course Opted | Course Name | Credits |
|----------|------------------------------------------------|-----------------------------------------------------------------|---------|
| I | Ability Enhancement Compulsory Course-I | English/Hindi/MIL Communication/ Environmental Science | 4 |
| | Discipline Core Course-I | Animal Diversity | 4 |
| | Discipline Core Course-I Practical | | 2 |
| | Discipline Core Course-I Botany | | 4 |
| | Discipline Core Course-I Botany Practical | | 2 |
| | Discipline Core Course-I Chemistry | | 4 |
| | Discipline Core Course-I Chemistry Practical | | 2 |
| II | Ability Enhancement Compulsory Course-II | English/Hindi/MIL Communication/ Environmental Science | 4 |
| | Discipline Core Course-II | Comparative Anatomy of Vertebrates | 4 |
| | Discipline Core Course-II Practical | | 2 |
| | Discipline Core Course-II Botany | | 4 |
| | Discipline Core Course-II Botany Practical | | 2 |
| | Discipline Core Course-II Chemistry | | 4 |
| | Discipline Core Course-II Chemistry Practical | | 2 |
| III | Discipline Core Course-III | Physiology and Biochemistry | 4 |
| | Discipline Core Course-III Practical | | 2 |
| | Discipline Core Course-III Botany | | 4 |
| | Discipline Core Course-III Botany Practical | | 2 |
| | Discipline Core Course-III Chemistry | | 4 |
| | Discipline Core Course-III Chemistry Practical | | 2 |
| | Skill Enhancement Course-I | SEC-1 | 2 |
| | Discipline Core Course-IV | Genetics and Evolutionary Biology | 4 |
| | Discipline Core Course-IV Practical | | 2 |
| | Discipline Core Course-IV Botany | | 4 |

| Semester | Course Opted | Course Name | Credits |
|----------|-----------------------------------------------------|-----------------|---------|
| IV | Discipline Core Course-IV Botany Practical | | 2 |
| | Discipline Core Course-IV Chemistry | | 4 |
| | Discipline Core Course-IV Chemistry Practical | | 2 |
| | Skill Enhancement Course-II | SEC-II | 2 |
| V | Discipline Specific Elective -1 Zoology | DSE-1 Zoology | 4 |
| | Discipline Specific Elective -1 Zoology Practical | | 2 |
| | Discipline Specific Elective -1 Botany | DSE-1 Botany | 4 |
| | Discipline Specific Elective- 1 Botany Practical | | 2 |
| | Discipline Specific Elective -1 Chemistry | DSE-1 Chemistry | 4 |
| | Discipline Specific Elective- 1 Chemistry Practical | | 2 |
| | Skill Enhancement Course-III | SEC-III | 2 |
| VI | Discipline Specific Elective -2 Zoology | DSE-2 Zoology | 4 |
| | Discipline Specific Elective -2 Zoology Practical | | 2 |
| | Discipline Specific Elective -2 Botany | DSE-2 Botany | 4 |
| | Discipline Specific Elective- 2 Botany Practical | | 2 |
| | Discipline Specific Elective -2 Chemistry | DSE-2 Chemistry | 4 |
| | Discipline Specific Elective- 2 Chemistry Practical | | 2 |
| | Skill Enhancement Course-IV | SEC-IV | 2 |

| Theory+Practical | Theory+Practical | Theory+Practical |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|
| I. <u>Core Centre</u> (12 papers) 04 courses from each of the 03 disciplines of choice | 12X4=48 | 12X4=48 |
| Core course Practical/ Tutorial* (12 Practical/ Tutorial*) 04 courses from each of the 03 disciplines of choice | 12X2=24 | 12X2=24 |
| II. <u>Elective Course</u> (6 Papers) Two papers from each discipline of choice Including paper of interdisciplinary nature. | 6X4=24 | 6X5=30 |
| Elective Course Practical/ tutorials* (6 Practical/ Tutorial*) Two papers from each discipline of choice Including paper of interdisciplinary nature. | 6X2=12 | 6X1=6 |
| <ul style="list-style-type: none"> • Optional Dissertation or project work in place of one Discipline elective paper(6 credits) in 6th Semester | | |
| III. <u>Ability Enhancement Course</u> | | |
| 1. Ability Enhancement Compulsory (2 Papers of 2 credits each) Environment Science English/ MIL Communication | 2X2=4 | 2X2=4 |
| 2. Ability Enhancement Elective (Skill Based) (4 papers of 2 credits each) | 4X2=8 | 4X2=8 |
| | <hr/> Total credit=120 | <hr/> Total credit=120 |

7. Courses for B.Sc. (Prog.) Life Sciences

LS Core I: Animal Diversity

Course Learning Objective:

The main purpose of introducing this course is to teach the students the Morpho-taxonomy, and evolutionary relationships among and between non-chordates and chordates along with creating awareness and concern towards importance of animal diversity for human survival and its socio-economic significance. In addition to this, the course is aimed at nurturing skills of conducting scientific inquiry and experimentation in the field of animal diversity to acquire knowledge of fundamental concepts and theories of animal diversity.

Course Learning Outcome:

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

- Learn Morpho-taxonomy and structural organization of non-chordate and chordate groups.
- Acquire knowledge of diversity of non-chordate and chordate groups.
- Learn evolutionary relationships and phylogeny of non-chordates and chordates through functional and structural similarities.
- Understand the economic importance of non-chordates and chordates and their significance in the ecosystem.
- Promote shared learning through practical classes, class room presentations and projects.

Course Content:

Theory [Credits: 4]

60 hrs

Unit 1: Protista

3 hrs

General Characteristics and Classification up to classes; Locomotory Organelles and locomotion in Protozoa.

(Chapter1-3: Barnes)

Unit 2: Porifera

3 hrs

General characteristics and Classification up to classes; Canal system in *Sycon*

(Chapter 5: Barnes)

Unit 3: Cnidaria

3 hrs

General characteristics and Classification up to classes; Polymorphism in Hydrozoa

(Chapter7: Barnes)

Unit 4: Platyhelminthes

3 hrs

General characteristics and Classification up to classes; Life cycle of *Taeniasolium* and its parasitic adaptations

(Chapter10: Barnes)

Unit 5: Nematelminthes

4 hrs

General characteristics and Classification up to classes; Life cycle of *Ascarislumbricoides* and its parasitic adaptations

(Chapter11: Barnes)

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|-----------------------------------------------------------------------------------------------------------------------------------------|-------|
| <u>Unit 6: Annelida</u> | 3 hrs |
| General characteristics and Classification up to classes; Metamerism in Annelida (Chapter13: Barnes) | |
| <u>Unit7: Arthropoda</u> | 7 hrs |
| General characteristics and Classification up to classes; Vision in Arthropoda, Metamorphosis in Insects. (Chapter16 and 21: Barnes) | |
| <u>Unit8: Mollusca</u> | 3 hrs |
| General characteristics and Classification up to classes; Torsion and detorsion in Gastropoda; Pearl Formation. (Chapter12: Barnes) | |
| <u>Unit 10: Echinodermata</u> | 3 hrs |
| General characteristics and Classification up to classes; Water-vascular system in Asteroidea. (Chapter28: Barnes) | |
| <i>Note: Classification to be followed from “Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.”</i> | |
| <u>Unit 11: Protochordata</u> | 3 hrs |
| General characteristics and Classification of Protochordata, Retrogressive metamorphosis (Chapter29: Barnes) | |
| <u>Unit 12: Agnatha</u> | 3 hrs |
| General characteristics and outline classification of cyclostomes up to classes (Chapter 4: Young) | |
| <u>Unit 13: Pisces</u> | 3 hrs |
| General characteristics and Classification up to order. Migration, Osmoregulation and Parental care in fishes (Chapter 5: Young) | |
| <u>Unit 14: Amphibia</u> | 4 hrs |
| General characteristics and classification up to order; Parental care in Amphibians (Chapter 11 and 12: Young) | |
| <u>Unit 15: Reptilia</u> | 4 hrs |
| General characteristics and classification up to order; Biting mechanism in snakes (Chapter 10 and 14: Young) | |
| <u>Unit 16: Aves</u> | 6 hrs |
| General characteristics and classification up to order; Flight adaptations and Migration in birds. (Chapter 15, 16 and 17: Young) | |

Unit 16: Mammals

4 hrs

General characteristics and classification up to orders; Origin of mammals.

(Chapter 18: Young)

Practical [Credits: 2]

1. Study of following specimens:

Amoeba, Euglena, Paramecium, Sycon, Hyalonema, Euplectella, Obelia, Physalia, Aurelia, Tubipora, Metridium, Taeniasolium, Male and female Ascaris lumbricoides, Aphrodite, Nereis, Heteronereis, Chaetopterus, Pheretima, Hirudinaria, Palaemon, Cancer, Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Chiton, Dentalium, Pila, Unio, Sepia, Octopus, Pentaceros, Ophiothrix, Echinus, Cucumaria, Antedon, Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo, Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla, Chelone, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Any three common birds from different orders, Bat, Funambulus, Loris.

2. Study of following permanent slides:

- T.S. and L.S. of *Sycon*.
- Study of larval stages of *Taenia solium*

3. Key for Identification of poisonous and non-poisonous snakes

4. A visit to Biodiversity parks and Zoological Museum

5. Study of Digestive, Reproductive and Nervous system of Cockroach.

6. Study of Urinogenital and Nervous system of Rat.

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of animals will be imparted not only through classroom lectures to inculcate a conceptual base among the students about the subject but also through observations in nature and through real animals/preserved specimens/models which will create interest among students and enhance their understanding. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of animal biology would be created to not only ensure effective learning and understanding of the concepts, but also inculcate confidence in the students. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:

- Continuous Evaluation: To keep a check on progress of student's learning in order to find out their weak areas so that appropriate remedial measures can be taken timely.
- Class Tests: Taking regular class tests will provide information on knowledge of the students.
- Presentations, Projects and Assignments: Regular Presentations, assignment and projects will instil independent thinking among the students.

- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

Keywords:

Protista, Porifera, Cnidaria, Annelida, Arthropoda, Classification, Echinodermata, Mollusca, Structural organization, Protochordata, Chordata, Cyclostomata, Pisces, Tetrapoda, Amphibia, Reptilia, Aves, Mammalia.

Recommended Books:

- Barnes, R.D. (2006) *Invertebrate Zoology*. VII Edition, Cengage Learning, India.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002) *The Invertebrates: A New Synthesis*. III Edition, Blackwell Science
- Young, J. Z. (2004) *The Life of Vertebrates*. III Edition. Oxford university press.

Suggested Readings:

- Barrington, E.J.W. (2012) *Invertebrate Structure and Functions*. II Edition, EWP Publishers
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003) *Invertebrate Zoology: A Functional Evolutionary Approach*. VII Edition, Cengage Learning, India
- Pechenik, J. A. (2015) *Biology of the Invertebrates*. VII Edition, McGraw-Hill Education
- Pough H. *Vertebrate Life*, VIII Edition, Pearson International

Online tools and Web Resources:

- <https://swayam.gov.in/courses/animal-diversity>
- <https://swayam.gov.in/courses/zoology>
- <https://epgp.inflibnet.ac.in/ahl.php?csrnr>
- <http://vle.du.ac.in/course/view.php?id>

LS Core II: Comparative Anatomy and Developmental Biology of Vertebrates

Course Learning Objective:

The course offers a complete understanding about anatomy of vertebrate animals. It educates the students regarding derivatives of integuments, skeletal system and visceral arches, anatomy of digestive system and associated glands, different respiratory organs, urinogenital organs, components of nervous system and receptors in vertebrates. Thorough understanding of essential and evolutionary aspects of comparative anatomy will be developed through pictorial presentation of different anatomical details. The course will also provide a glimpse of scope and historical background of developmental biology to the students, impart knowledge regarding basic concepts of differentiation, morphogenesis and pattern formation and insight into IVF, stem cells and cloning. Detailed understanding of essential events of developmental biology will be imparted through proper explanation of gametogenesis, and stages of embryonic development and foetal formation.

Course Learning Outcome:

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

- Know about the levels of organization among different groups of vertebrates.
- Understand that different organs and organ systems integrate with each other to impart proper regulation of a particular function.
- Understand how the various organs evolved during the course of evolution through succession.
- Know the evolution of different concepts in developmental biology.
- Be able to understand the process of gamete formation from stem cell population to mature ova and sperm.
- Be able to comprehend the sequence of steps leading to the formation of gametes and development of embryo..
- Learn the mechanisms underpinning cellular diversity and specificity in animals.
- Study the methods and tools related to developmental biology which help to understand different processes of embryogenesis.

Content:

Theory (Credits: 4)

60 hrs

Unit 1: Integumentary System

Structure and function of integument, Derivatives of integument glands.

5hrs

Chapter 5: Weichert

Unit 2: Skeletal System

4 hrs

Overview of skeleton Brief account of jaw suspensorium and visceral arches

Chapter 6, 8: Weichert

Unit 3: Digestive System

3 hrs

Brief account of alimentary canal and digestive glands

Chapter 9: Weichert

Unit 4: Respiratory System 4 hrs
Brief account of gills, lungs, air sacs and swim bladder
Chapter 8: Weichert

Unit 5: Circulatory System 3 hrs
Evolution of heart and aortic arches
Chapter 12: Weichert

Unit 6: Urinogenital System 4 hrs
Succession of kidney, Evolution of urinogenital ducts
Chapter 10: Weichert

Unit 7: Nervous System 3 hrs
Comparative account of brain
Chapter 13: Weichert

Unit 8: Sense Organs 4 hrs
Types of receptors, Visual receptors in man
Chapter 15: Weichert

Unit 9: Scope and History of Developmental Biology 5 hrs
Concepts of Epigenesis, Preformation, Specification, Determination, Differentiation, Morphogenesis, Embryonic induction
Chapter 1 and 3: Gilbert

Unit 10: Early Embryonic Development 12 hrs
Gametogenesis: Spermatogenesis and Oogenesis in mammals; Fertilization: External (amphibians), Internal (mammals), blocking mechanisms to Polyspermy; Types and Patterns of cleavage; Types of morphogenetic movements; Early development of frog and human (up to formation of gastrula); Fate maps, Fate of germ layers
Chapter 3, 4, 5, 6, 7, 10: Balinsky; Chapter 8, 9 and 17: Gilbert

Unit 11: Late Embryonic Development 7 hrs
Metamorphic events in life cycle of frog and its hormonal regulation.
Implantation of embryo in human; Formation, types and functions of placenta in mammals.
Chapter 11 and 18: Balinsky; Chapter 16: Gilbert

Unit 12: Applied Aspects of Developmental Biology 6 hrs
Stem cells, Cloning, IVF
Chapter 3: Gilbert

Practical(Credits: 2)

1. Osteology:
 - a) Disarticulated skeleton of fowl and rabbit

- b) Carapace and plastron of turtle/tortoise
- c) Mammalian skulls: one herbivorous and one carnivorous animal.
- 2. Frog - Study of developmental stages - whole mounts and sections through permanent slides - cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages.
- 3. Study of the different types of placenta- histological sections through permanent slides or photomicrograph.
- 4. Temporary mount of sperm (frog/rat) *(To be approved by Animal Ethical Committee of the college)
- 5. Study visit to a IVF centre and submission of report.

Teaching and Learning Processes:

Information and concepts about morphology, anatomy and development of animals will be imparted through classroom lectures assisted with online tools and power point presentations. Hands-on exposure would be provided to the students leading to more comprehensive learning. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of animal biology would be created to not only ensure effective learning and understanding of the concepts, but also inculcate confidence in the students. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:

The learners/ students can be assessed in many different ways- such as: MCQs/Quizzes, Assignments, Projects, Paper presentations, Class tests and Continuous evaluation

Keywords:

Integument, Viscera, Gills, Bladder, Aortic, Urinogenital, Gametogenesis, Fertilization, Polyspermy, Fate map, Placenta, Metamorphosis, Stem cell, Cloning, IVF.

Recommended Books:

- Weichert C.K and William Presch (1970). *Elements of Chordate Anatomy*. Tata McGraw Hills
- Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate Structure*. John Wiley and Sons
- Wolpert, L & Tickle, C (2011) *Principles of Developmental Biology (4th edition)*. Oxford University Press, ISBN: 9780198792918
- Carlson, Bruce M (1996). *Patten's Foundations of Embryology*, McGraw Hill, Inc. ISBN: 9780070634275

Suggested Readings:

- Kent, G.C. and Carr R.K.(2000)*Comparative Anatomy of the Vertebrates*. IX Edition. The McGraw-Hill Companies
- Kardong, K.V.(2005) *Vertebrates' Comparative Anatomy, Function and Evolution*. IV Edition. McGraw-Hill Higher Education

- Gilbert, SF (2014) *Developmental Biology*. X Edition. Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA. ISBN : 9780878939787
- Balinsky, B.I. (2008). *An Introduction to Embryology*. International Thomson Computer Press.

Online Tools and Web Resources:

- KSU | Faculty Web - Vertebrate Anatomy
- <https://www.biodiversitylibrary.org/item/114889#page/23/mode/1up>
- <https://www.hhmi.org/biointeractive/human-embryonic-development>
- http://worms.zoology.wisc.edu/embryology_main
- <https://ocw.mit.edu/courses/biology/7-22-developmental-biology-fall-2005/index.htm>

LS Core III: Physiology and Biochemistry

Course Learning Objective:

The study of physiology is the study of the internal working of organisms; how organs and systems within the body work, communicate and integrate their efforts to make conditions favourable for survival. The study of biochemistry explains how inanimate constituents of living organisms *i.e.* the biomolecules interact to maintain and perpetuate life. The paper Physiology and Biochemistry for B.Sc. (Prog) Life Science Semester- III, is a course of central importance as these two have important implications in our daily life. The students after their school have an elementary knowledge with respect to structure, function and metabolism in human body. Many concepts have earlier been presented as isolated topics with little association to context and/or application. The present course aims to expand their knowledge with respect to functioning of various organ systems such as muscular, nervous, digestive, circulatory, respiratory, excretory, reproductive and endocrine in humans. The biochemistry portion is designed in a way to help the student understand fundamental metabolic pathways and their coordinated regulation in the body.

Course Learning Outcome:

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

- Have an increased knowledge of human physiology and be able to appreciate its functions.
- Understand the functions of major physiological systems in body.
- Recognise and identify principal tissue structures.
- Have understanding of the metabolic pathways of carbohydrates, proteins and fats; and appreciate how the cells harness energy.
- Understand the importance of enzymes, mechanism of working and kinetics.
- Relate how biochemical systems interact to yield integrated physiological responses.
- Understand the principles and approach to experimental design.
- Perform, analyse and interpret basic experiments and observations in physiology and biochemistry.

Course Content:

Theory [Credits: 4]

60 hrs

Unit 1: Nerve and Muscle

8 hrs

Structure of a neuron, Resting membrane potential, Graded potential, Origin of action potential and its propagation in myelinated and non-myelinated nerve fibres, Ultrastructure of skeletal muscle, Molecular and chemical basis of muscle contraction
(*Chapters 10,12: Tortora; Chapters 5, 6 and 9: Vander*)

Unit 2:

Digestion

5 hrs

Physiology of digestion in the alimentary canal; Absorption of carbohydrates, proteins, lipids
(*Chapters 24: Tortora; Chapters 15: Vander*)

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| <u>Unit 3:</u> Respiration Pulmonary ventilation, Respiratory volumes and capacities, Transport of Oxygen and carbon dioxide in blood (<i>Chapters 23: Tortora; Chapters 13: Vander</i>) | 5 hrs |
| <u>Unit 4:</u> Excretion Structure of nephron, Mechanism of Urine formation, Counter-current Mechanism (<i>Chapters 26: Tortora; Chapters 14: Vander</i>) | 5 hrs |
| <u>Unit 5:</u> Cardiovascular system Structure of Heart, Origin and conduction of the cardiac impulse, Cardiac cycle (<i>Chapters 20: Tortora; Chapters 12: Vander</i>) | 5 hrs |
| <u>Unit 6:</u> Reproduction and Endocrine Glands Physiology of male reproduction: hormonal control of spermatogenesis; Physiology of female reproduction: hormonal control of menstrual cycle. Structure and function of pituitary, thyroid, Parathyroid, pancreas and adrenal gland. (<i>Chapters 18 and 28: Tortora; Chapters 11 and 17: Vander</i>) | 7 hrs |
| <u>Unit 7:</u> Carbohydrate Metabolism Basic structure and physiological significance of Monosaccharides, Disaccharides, Homo and Heteropolysaccharides. Glycolysis (Preparatory and Payoff phases, regulation, fates of pyruvate), Krebs' Cycle (formation of Acetyl CoA, reactions of cycle, regulation), Pentose phosphate pathway (Oxidative and Non-oxidative Phases), Gluconeogenesis (Bypass reactions, regulation and reciprocal coordination of glycolysis and gluconeogenesis, Glycogen Metabolism (Glycogenolysis, Glycogenesis and its coordinated regulation), Review of Electron Transport Chain (Basics of electron transfer reactions, Universal Electron Acceptors without detailed structures, electron flow through complexes, Chemiosmotic theory, basics of ATP synthesis) (<i>Chapters 11,14,16,17,18,20,21: Stryer; Chapters 7,14,15,16 and19: Lehninger</i>) | 9 hrs |
| <u>Unit 8:</u> Lipid Metabolism Basic structure and physiological significance of fatty acids, structure and significance of storage and structural lipids. Biosynthesis (FAS and synthesis reactions, regulation) and β oxidation of palmitic acid (activation of fatty acids and oxidation with bioenergetics, regulation) (<i>Chapters 12 and 22: Stryer; Chapters 10,17and 21: Lehninger</i>) | 5 hrs |
| <u>Unit 9:</u> Protein metabolism Structure, classification and properties of amino acids, basics of protein structure; Transamination, Deamination, Glutamine formation, Glucose alanine cycle and Urea Cycle (<i>Chapters 3 and 23: Stryer; Chapters 3,4 and 18: Lehninger</i>) | 5 hrs |
| <u>Unit10:</u> Enzymes Introduction (basics of classification, properties and functions), Mechanism of action (understanding of basic concepts, Induced Fit Theory), Enzyme Kinetics (Michaelis Menten | 6 hrs |

equation for single enzyme single substrate reactions, Line Weaver Burke Plot), Inhibition and Regulation (types of Inhibition, allosteric enzymes, covalently regulated enzymes)
(*Chapters 8 and 10: Stryer; Chapter 6: Lehninger*)

Practical [Credits: 2]

1. Preparation of hemin and hemochromogen crystals.
2. Study of permanent histological sections of mammalian pituitary, thyroid, pancreas, adrenal gland.
3. Study of permanent slides of spinal cord, duodenum, liver, lung, kidney, bone, cartilage.
4. Qualitative tests to identify functional groups of carbohydrates in given solutions (Glucose, Fructose, Sucrose, Lactose)
5. Estimation of total protein in given solutions by Lowry's method.
6. Study of activity of salivary amylase under optimum conditions.

Teaching and Learning Process:

Teaching-Learning process will include delivery of lectures using boards, multimedia presentations on course contents, showing 3D molecular structure and system tutorial/videos, giving online quizzes etc.

Assessment Methods:

The students can be assessed by MCQs/Quizzes, Assignments, Projects, Oral presentations, Class tests and Continuous evaluation by biweekly topic based 'Pre-class assignment'.

Keywords:

Digestion, Absorption, Metabolism, Excretion, Respiration, Reproduction, Nerve, Muscle, Heart, Endocrine glands, Carbohydrates, Lipids, Proteins, Enzymes

Recommended Books:

- Tortora, - G.J. and Derrickson, B.H. (2009) *Principles of Anatomy and Physiology*, XII Edition, John Wiley & Sons, Inc.
- Widmaier, E.P., Raff, H. and Strang, K.T. (2008) *Vander 's Human Physiology*, XI Edition., McGraw Hill
- Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006) *Biochemistry*. VI Edition. W.H Freeman and Co.
- Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). *Principles of Biochemistry*. IV Edition. W.H. Freeman and Co.

Suggested Readings:

- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009). *Harper's Illustrated Biochemistry*. XXVIII Edition. Lange Medical Books/Mc Graw3Hill.
- Guyton, A.C. and Hall, J.E. (2011). *Textbook of Medical Physiology*, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company

Online Tools and Web Resources:

- <https://swayam.gov.in/courses/5371-jan-2019-animal-physiology>
- <https://swayam.gov.in/course/3712-animal-physiology>
- <https://swayam.gov.in/courses/5366-jan-2019-biochemistry>
- <https://swayam.gov.in/course/1405-biochemistry>
- <https://swayam.gov.in/courses/5638-biochemistry>
- <https://vle.du.ac.in>
- <https://library.palmer.edu/physiology/PhysioWeb>
- <http://med.wikidot.com/biochemistry-online-links>

LS Core IV: Genetics and Evolutionary Biology

Course Learning Objective:

The focus of first half of this course is to familiarize students with basic principles of genetics and its application in understanding of real-life hereditary conditions. The second half of the course aims at imparting fundamental understanding of evolutionary processes and how it works in context of populations.

Learning Outcome:

Students would be able to understand the fundamentals of Mendelian inheritance and its exceptions. They would be able to appreciate various other gene interactions like co-dominance, incomplete dominance, lethal alleles and pleiotropy. Further, students would be able to describe the concepts of linkage and crossing over and their usage in constructing gene maps.

- Help students understand the basic principles of pedigree analysis and will be able to construct and analyse pedigree related problems for inherited traits.
- Students would gain knowledge on chromosomal and genetic mutation.
- Students would be able to describe the chromosomal sex-determination mechanisms and dosage compensation.
- Students would be able to understand the major events in history of life and major theories of evolution.
- Students would be able to appreciate the contribution of fossil studies in evolution and the phylogeny of horse.
- Students would be able to calculate the gene and allele frequency using Hardy-Weinberg law and analyse population genetics problems. T
- Students would understand the fundamental concepts of natural selection, speciation, mass extinction and macro-evolution.

Course Content:

Theory(Credit 4)

60 hrs

Unit 1: Mendelian Genetics and its Extension

10hrs

Mendel's work on transmission of traits, principles of inheritance, chromosome theory of inheritance, incomplete dominance and co-dominance, multiple alleles, lethal alleles, epistasis, pleiotropy, polygenic inheritance, sex linked inheritance, extra-chromosomal inheritance

Chapter-3, 4, 9, 23: Klug & Cummings

Unit 2: Linkage, Crossing Over and Chromosomal Mapping

6hrs

Linkage and crossing over, recombination frequency as a measure of linkage intensity, two factor and three factor crosses, interference and coincidence, somatic cell genetics - an alternative approach to gene mapping

Chapter-5: Klug & Cummings; Chapter-7: Pierce

Unit 3: Mutations

5hrs

Chromosomal mutations (classification, types and examples), gene mutations (types and classification)

Chapter-8, 1: 5 Klug & Cummings

Unit 4: Sex Determination 2hrs

Chromosomal mechanisms, dosage compensation

Chapter-7: Klug & Cummings

Unit 5: History of Life and Introduction to Evolutionary Theories 5hrs

Major events in history of life, Lamarckism, Darwinism, Neo-Darwinism

Chapter-22: Campbell

Unit 6: Direct Evidences of Evolution 4hrs

Types of fossils, incompleteness of fossil record, dating of fossils, phylogeny of horse

Chapter-4: Futuyama

Unit 7: Population Genetics and Processes of Evolutionary Change 12hrs

Hardy-Weinberg law (statement, derivation and applications), evolutionary forces upsetting H-W equilibrium (concepts only), organic variations, isolating mechanisms, natural selection and its types, artificial selection

Chapter-25: Klug & Cummings

Unit 8: Species Concept 6hrs

Biological species concept (advantages and limitations), modes of speciation

Chapter-24: Campbell; Chapter-24: Strickberger

Unit 9: Macro-evolution 5hrs

Macro-evolutionary principles (example: Darwin's Finches)

Chapter-21: Futuyama

Unit 10: Extinction 5hrs

Mass extinction (causes, names of five major extinctions, K-T extinction in detail), role of extinction in evolution

Chapter-23: Ridley

Practical [Credits: 2]

1. Study of Mendelian inheritance and gene interactions (non-Mendelian inheritance) using suitable examples (chi-square analysis).
2. Study of linkage, recombination, gene mapping using data.
3. Study of human karyotypes (normal and abnormal).
4. Study of homology and analogy from suitable specimens/pictures.
5. Pedigree analysis of some human inherited traits.
6. Study and verification of Hardy-Weinberg Law by Chi-square analysis.
7. Visit to natural history museum and submission of report.

Teaching-Learning Process:

The whole course envisages a lot of student-teacher interactions. The real-life relevance of both genetics and evolution makes it necessary that the teaching-learning strategies should involve discussions among students, guided by the teacher. There is ample opportunity for students to analyse genetic and evolutionary data, and develop skills in various simulation exercises. Visit to a natural history museum could be suitably integrated with the course content.

Assessment Methods:

Following assessment methods are suggested:

- Summative assessment comprising of written tests and *viva-voce*.
- Formative assessment with exercises involving genetic data analyses, evolutionary processes' simulations, and linkage mapping.
- Written report on the learning of museum visit.

Keywords:

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

Recommended Books:

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

Suggested Readings:

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

Online Tools and Web Resources:

- <https://swayam.gov.in/courses/4922-genetics-and-genomics>
- <https://swayam.gov.in/course/96-genetics>
- <https://www.coursera.org/learn/genetics-evolution>
- <https://onlinelearning.hms.harvard.edu/hmx/courses/hmx-genetics/>
- <https://learn.genetics.utah.edu/>

LS DSE-1: Reproductive Biology

Course Learning Objective:

The foremost aim of a living being on this planet is to reproduce so that their species can flourish. Reproductive system is an intricate physiological system of the body and has been extensively studied in mammals. Understanding its intriguing working and regulation would be useful to address the effect of modern day's stressful life on infertility issues both in males and females. The design of the course is to understand the anatomy and functional histology of male and female reproductive systems, their cycles and regulations. The syllabi design is intended to impart the basic knowledge of male and female reproductive systems with close reference to human being.

Course Learning Outcome:

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

- Understand the functioning of male and female reproductive systems particularly in humans.
- Know about modern contraceptive devices.
- Get knowledge about assisted reproductive technologies to face the challenges of growing incidence of infertility.

Course Content

Theory [Credits:4]

60 hrs

Unit 1: Reproductive Endocrinology

10 hrs

Hypothalamo–hypophyseal–gonadal axis, gonadal and glycoprotein hormones; Steroidogenesis; Mechanism of action of gonadotropins and gonadal (steroids) hormones; Regulation of gonadotropin and gonadal (steroids) hormone secretion in male and female.

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

Unit2: Male reproduction

10hrs

Functional anatomy of male reproductive system in human; Testis (histological details): Testicular cells functions, Spermatogenesis and its regulation: Epididymal maturation of sperms; Sperm transportation in male tract.

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

Unit 3: Female reproduction

30hrs

Functional anatomy of female reproductive system in human; Structure and functions of ovary (histological details): folliculogenesis, ovulation, Corpus luteum formation and regression; Reproductive cycles and their regulation, changes in the female tract; Ovum transport in the fallopian tubes; Activation of Sperm and its transport in the female tract, fertilization; Mechanism of implantation; Hormonal regulation of gestation, Maternal recognition of pregnancy; Gestational adaptations; pregnancy diagnosis; foeto-placental Unit; Mechanism of parturition and its hormonal regulation; Lactation and its regulation.

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

Unit4: Reproductive Health

10hrs

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: Sperm banks, frozen embryos, in vitro fertilization, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST; Modern contraceptive methods.

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

Practical [Credits: 2]

1. Visit to animal house facility/animal husbandry centres to study the set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Study of estrous cycle by vaginal smear technique.
3. Principle and procedures of surgeries with respect to reproductive system (Orchidectomy, ovariectomy, vasectomy, tubectomy, hysterectomy).
4. Study the effect of cryptorchidism on sperm count and sperm motility in rats.
5. Histological study of male and female reproductive systems using microscopic slides/photomicrographs: Testes, ovary, epididymis, vas deferens, prostate gland, seminal vesicle, uterus (secretory and proliferative).
6. Study the effect of testosterone/estrogen on male/female accessory reproductive organs using hormone replacement therapy.
7. Study of modern contraceptive devices.
8. Mini projects involving survey, data collection, statistical analysis and submission of project report on reproductive health in a small human community.

Teaching and Learning Process:

Teaching-Learning process will include delivery of lectures using boards, multimedia presentations on course contents, showing 3D molecular structure and system tutorial/videos, giving online quizzes etc. Survey-based short project assignments and visit to the research institutes will clarify the concepts and enhance student's learning.

Assessment Methods:

The students can be assessed by MCQs/Quizzes, Assignments, Projects, Oral presentations, Class tests and Continuous evaluation by biweekly topic based 'Pre-class assignment'.

Keywords:

Testis, ovary, spermatogenesis, steroidogenesis, folliculogenesis, fertilization, pregnancy, gestation, lactation

Recommended Books:

- Austin, C.R. and Short, R.V. *Reproduction in Mammals*. Cambridge University Press.
- Degroot, L.J. and Jameson, J.L. (eds). *Endocrinology*. W.B. Saunders and Company.

Suggested Readings:

- Barrel et al., *Ganong's review of Medical Physiology*. 25th Edition. A Lange Medical Book.
- Knobil, E. et al. (eds). *The Physiology of Reproduction*. Raven Press Ltd.

- Hatcher, R.A. et al. *The Essentials of Contraceptive Technology*.
- Jones, R.E., and Lopez, K.H. (2014) *Human Reproductive Biology*. IV Edition. Elsevier Publication.
- Franklyn F. Bolander. *Molecular Endocrinology*. III Edition, Academic Press, USA

LS DSE 2: Wildlife Conservation and Management

Course Learning Objective:

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

Course Learning Outcome:

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

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

Course Content:

Theory [Credits: 4]

60hrs

Unit1: Introduction to Wildlife

6hrs

Values of wildlife - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies: WCS, CBD, Agenda 21
(Chapter 1, 2, 3 and 10: Singh; Chapter 1 and 3: Saha and Mazumdar)

Unit2: Evaluation and Management of Wildlife

10hrs

Habitat analysis: a) Physical parameters: Topography, Geology, Soil and water; b) Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

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

Unit 3: Management of Habitats

10hrs

Setting back succession: Grazing logging; Mechanical treatment; Advancing the successional

process: Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats.

(Chapter 11 & 12: Sutherland; Chapter 6: Singh)

Unit4: Population Estimation

12hrs

Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, and Hair identification; Pug marks and Census methods

(Chapter 2 & 4: Sutherland; Chapter 8 and 9: Singh; Chapter 6: Saha and Mazumdar)

Unit5:

8hrs

Management Planning of Wildlife in Protected Areas; Estimation of carrying capacity; Human-wildlife conflict; Eco tourism / wild life tourism in forests; Climax communities: characteristics and theories; Ecology of perturbation.

(Chapter 9: Sutherland; Chapter 1: Woodroff; Chapters 8 and 11: Singh; Chapter 9: Saha and Mazumdar)

Unit6:

6hrs

Management of Excess Population, Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and Mouth Disease, *Mycobacterium* TB, Bovine and Avian Flu

(Chapters 6, 7 and 11: Saha and Mazumdar)

Unit:7

8hrs

Protected Areas, National parks and sanctuaries; Biosphere reserves; Conservation and Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India and Management challenges in Tiger reserve.

(Chapters 11 and 12: Singh; Chapters 3 and 9: Saha and Mazumdar)

Practical[Credits: 2]

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

Teaching and Learning Process:

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

Assessment Methods:

Students will be assessed using the following methods:

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

Keywords:

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

Recommended Books:

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

Suggested Readings:

- Hudson, P.J., Rizzoli, A., Grenfell, B.T. Heestrbeek, H. and Dobson, A.P. (2002) *The Ecology of Wildlife Diseases*. Oxford University Press, Oxford.
- Banerjee, K. (2002) *Biodiversity Conservation in Managed and Protected Areas*. Agrobios, India.
- Sharma, B.D. (1999) *Indian Wildlife Resources Ecology and Development*. Daya Publishing House, Delhi.

- Primack, R.B. (1998). *Essentials of Conservation Biology*. Sinauer Associates, Inc. Sunderland, MA.
- Hossetti, B. B. (1997). *Concepts in Wildlife Management*. Daya Publishing House, Delhi.

Online Tools and Web Resources:

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

LS DSE 3:Animal Biotechnology

Course Learning Objective:

Biotechnology is the advanced branch of biological sciences which mostly deals with technologies that use living organisms or their components to produce products for specific use. The present paper attempts to give a wholesome idea of biotechnology at a basic level. It provides a tool kit in the form of a number of various techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine. It makes one aware of the scope of this field which encompasses almost every field of science like engineering, research, commercialization and academics. It equips students with basic techniques of biotechnology which are a must for everyone interested in pursuing a career in biotechnology. This paper also attempts to illustrate the role of biotechnology by giving very common examples as to how to use these tools to solve a specific problem in either of medicine, agriculture or food technology.

Course Learning Outcome:

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

- Use or demonstrate the basic techniques of biotechnology; like DNA isolation, PCR, transformation, restriction, digestion etc.
- Devise a strategy to manipulate genetic structure of an organism for the improvement in any trait or its well-being based on the techniques.
- Understand the ethical and social issues raised regarding GMOs.
- Apply the knowledge for designing a proposal for research project.

Course Content:

Theory [Credits: 4]

60 hrs

Unit1: Concept and Scope of Biotechnology
(Chapter 1: Glick & Pasternak)

4 hrs

Unit2: Molecular Techniques in Gene manipulation

28 hrs

Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics); Restriction enzymes: Overview., Nomenclature, detailed study of Type II; DNA modification enzymes: Alkaline phosphatase, Terminal transferase, Reverse transcriptase, T4 DNA kinase, ligases CRISPR Cas-9 (as genome editing tool); Transformation techniques; Calcium chloride and electroporation method; Construction of genomic and cDNA libraries and screening by colony and plaque hybridization; cDNA library screening by immunological methods; Southern, Northern and Western blotting; DNA sequencing: Sanger and NGS (illumine) methods; Polymerase Chain Reaction (RT-PCR, real time PCR), and DNA microarray
(Chapter 3 and 4: Glick & Pasternak)

Unit3: Genetically Modified Organisms

18 hrs

Production of cloned and transgenic animals: Nuclear Transplantation (cloning of dolly as an example), Retroviral Method, DNA microinjection. Applications of transgenic animals: Production of pharmaceuticals, Production of transgenic plants: *Agrobacterium* mediated transformation. Applications of transgenic plants: insect resistant plants, and edible vaccines and golden rice as examples.

(Chapter 21: Glick & Pasternak; Chapter 24: Watson)

Unit4: Applications of Biotechnology

10 hrs

Meta-genomics: an introduction, Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anaemia) Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

(Chapter 9: Glick & Pasternak; Chapter 23: Watson; Chapter 26: Primrose and Twyman)

Practical [Credits: 2]

1. Genomic DNA isolation from *E. coli*
2. Plasmid DNA isolation (pUC 18/19) from *E. coli*
3. Restriction digestion of lambda DNA with *EcoRI* and *HindIII* (Demonstration).
4. Construction of circular and linear restriction map from the data provided.
5. Preparation of competent cells and their transformation by CaCl_2 method. Calculation of transformation efficiency from the data/plate provided.
6. To study following techniques through photographs:
7. Southern Blotting (Demonstration)
8. Western Blotting
9. DNA Sequencing (Sanger's Method).
10. PCR (demonstrations).
11. DNA fingerprinting and case studies (photographs only to study crime, or paternity cases).
12. Project report on Animal Cell Culture/visit to a biotechnology laboratory or industry

Teaching and Learning Process:

Students will be taught using traditional chalk and talk method blended with e-learning tools. Paper presentations and reports by students on recent Biotechnology developments will enhance their learning. Quizzes on Biotechnology, Projects-based discussions, Hands-on experiments, Practical demonstrations and Visit to nearby Biotechnology laboratories, pharmaceutical industries and companies will help them learn about modern advancements.

Assessment Methods:

- **Theory component** would be assessed by written examination, and internal assessment based on performance in tests, class presentations and Group discussion and attendance,
- **Practical Component** would be assessed by Practical examination at the end of term which would include continuous evaluation of student, project report, *viva-voce* and Practical records.

Keywords:

Biotechnology, rDNA technology, Genetically Modified Organisms (GMOs), Transformation, Cloning vectors, Restriction endonucleases, PCR, DNA microarrays, DNA Sequencing, Gene Therapy

Recommended Books:

- Glick, B.R. and Pasternak, J.J. (2009) *Molecular Biotechnology - Principles and Applications of Recombinant DNA*. IV Edition, ASM press, Washington, USA.
- Primrose S. B. and Twyman R.M. (2006) *Principles of Gene Manipulation and Genomics*. VII Edition. Blackwell publishing
- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007) *Recombinant DNA- Genes and Genomes- A Short Course*. III Edition, Freeman and Co., N.Y., USA.

Suggested Readings:

- Brown, T.A. (1998) *Molecular Biology Labfax II: Gene Cloning and DNA Analysis*. II Edition, Academic Press, California, USA.
- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009) *An Introduction to Genetic Analysis*. IX Edition. Freeman and Co., N.Y., USA.
- Snustad, D.P. and Simmons, M.J. (2009) *Principles of Genetics*. V Edition, John Wiley and Sons Inc.

Online Tools and Web Resources:

- <http://illl.du.ac.in/>
- <https://www.coursera.org/learn/genes>
- Swayam (MHRD) Portal

LS DSE 4: Immunology

Course Learning Objective:

Immunology is a broad discipline that encompasses specialties as diverse as biochemistry, clinical biology, medicine, ecology and evolutionary biology. Basic knowledge of Immunology can be applied to understand and treat a wide range of diseases and infections. This branch has expanded into newer avenues of prophylaxis and immunotherapy thus providing new therapeutic approaches to immunodeficiency diseases, cancer therapy and autoimmune disorders. The comprehensive topics are broken down into simple and easy-to-remember steps to facilitate fruitful learning.

Course Learning Outcome:

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

- Study hematopoiesis to know the concepts of stem cells and their differentiation into progenitor stem cells and adult lineages.
- Learn the concepts of innate and acquired immunity.
- Understand adaptive immune responses and sequential phases-antigen recognition by lymphocytes, their proliferation, differentiation into effector and memory cells and elimination of pathogens.
- Learn about major histocompatibility complex and their role in transplantation immunity and autoimmunity
- Gain knowledge about the Complement system and how they interact and activate a catalytic cascade to remove immunogens.
- Study the role of various cytokines involved in cell to cell communication in the removal of pathogens.
- Understand the advent of hypersensitivities due to inappropriate innate and adaptive immune responses.
- Know the basic immunological aspects to comprehend the newer strategies in vaccine design, and efforts to treat autoimmunity, hypersensitivity and immunodeficiency.

Course Content:

Theory [Credits: 4]

60 hrs

Unit1: Overview of the Immune System

10hrs

Historical perspective, early theories of immunology, clonal selection theory. Innate immunity: defensive barriers of innate immunity, cell types and molecules involved in innate immunity.

Adaptive immune system: attributes of acquired immunity, Humoral and cellular mediated immunity, active and passive immunity, primary and secondary cellular response, cells and molecules involved in adaptive immunity.

(Chapter 1: Kuby)

Unit2: Cells and Organs of the Immune System

8hrs

Hematopoiesis, Cells of immune system, primary and secondary lymphoid organs.

Chapter 1 and 2: Kuby

Unit 3:Antigens 8hrs
Antigens and immunogens, antigenicity and immunogenicity, Factors affecting immunogenicity, Antigenic determinants (B and T cell epitopes), Concept of antigen recognition by B and T-cells, Adjuvants and haptens.

Chapter 4: Kuby

Unit4: Immunoglobulins 10hrs
Structure, different classes and function of antibodies, Antigenic determinants on immunoglobulins, Antigen-antibody interactions as tools for research and diagnosis (precipitation reaction, agglutination, immunofluorescence and ELISA), Polyclonal sera, Hybridoma technology for monoclonal antibodies in therapeutics and diagnosis.

Chapter 4 and 6: Kuby

Unit 5: Major Histocompatibility Complex (MHC I and II) 6hrs
Structure and functions of MHC

Chapter 8: Kuby

Unit6: Complement System 4hrs
Components, alternate and classical pathway, biological consequences of complement activation.

Chapter 7: Kuby

Unit7: Cytokines 4hrs
Basic properties and functions of cytokines.

Chapter 12: Kuby

Unit8: Immune System in Health and Diseases 7hrs
Hypersensitivity: Gell and Coombs' classification; Briefly discuss the concepts of Autoimmunity, Immune dysfunctions and Immunodeficiency.

Chapter 9: Kuby

Unit9: Vaccines 3hrs
General introduction and types of vaccines

Chapter 18: Kuby

Practical [Credits: 2]

1. Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/photographs.
3. Preparation of stained blood film to study various types of blood cells.
4. Ouchterlony's double immuno-diffusion method.
5. ABO blood group determination.
7. Demonstration of ELISA and Immunoelectrophoresis.

Assessment Methods:

Examinations shall be conducted at the end of each semester as per the Academic Calendar notified by the University of Delhi. Quizzes, Internal assessment, Assignments, Projects, Presentations and group discussions, Regularity and discipline.

Keywords:

Hematopoiesis, Innate immunity, Adaptive Immunity, BCR, TCR, Antigens, Immunogens, Antigen-antibody interactions, Immunoglobulins, MHC, Complement, Cytokines, hypersensitivity, vaccines

Teaching and Learning Processes:

This course is designed to will help understand the basics of immunology- how it develops, functions and sometimes malfunctions, thereby causing disease. Though not targeted exclusively towards medical students, this course provides an insight to students of Life Sciences a peek into the world of our own defense mechanisms and how our body fights against the innumerable pathogens that surround us. The course, thus aims to build-in the concepts of immunology keeping in mind the other areas of courses like biochemistry, cell and molecular biology, genetics, evolution etc. The topics were carefully chosen to acquaint the students to all aspects of immune system without overwhelming them with too much details and research on a particular topic, thus maintaining the balance for a holistic teaching–learning process.

Recommended Books:

- Kindt, T.J.,Goldsby, R. A. and Osborne B.A. (2007) *Kuby Immunology*. W.H.Freeman and Co, New York.
- Murphy, K., Travers, P.,and Walport, M. (2008) *Janeway'sImmunobiology*.Garland Science, Taylor and Francis Group, LLC

Suggested Readings:

- David, M., Jonathan, B., David, R. B. and Ivan R. (2006) *Immunology*.VII Edition, Mosby, Elsevier Publication.
- Abbas, K. Abul and Lechtman H. Andrew (2003) *Cellular and Molecular Immunology*. V Edition. Saunders Publication.

Online Tools and Web Resources:

- MOOCs courses available at Swayam portal, <https://swayam.gov.in/courses/public>
- Coursera, <https://www.coursera.org/courses?query=immunology>

LS DSE 5: Applied Zoology

Course Learning Objective:

Applied zoology paper aims to enable the students to learn different practical beneficial of zoology. It explores the students to the biology of human parasites, their transmission and method to control them. An insight into Agricultural Pests and medically important insect vector is provided and methods to manage them. The beneficial aspects and management of Dairy Technology, Poultry Farming and Aquaculture is to be explored.

Course Learning Outcome:

After completing this Course, the students will be able to contribute towards resolving serious issues pertaining to:

- Medical Zoology: Parasitology, Protozoology, Helminthology, and Entomology (especially with respect to increase in requirement for expert resource persons for containing the alarming rise in mosquito-borne diseases; Dengue and Chikungunya in Delhi)
- Animal Husbandry
- Poultry farming
- Fish farming

And, after thorough practical training skills pertaining to the commercial aspects of these studies, the students would emerge as successful entrepreneurs and establish their research enterprise and later, generate employment as well

Content:

Theory [Credits: 4]

60 hrs

Unit:1 Introduction to Applied Zoology

5-hrs

Review of the fundamental concepts and applied aspects pertaining to different parasites (spirochaetes, rickettsiae, protozoa, helminths), insect carriers and vectors studied in the previous semesters. Terminology and concepts related to Host-Parasite relationship: Host, Definitive host, Intermediate Host, Carrier, Vector, Parasitism, Symbiosis, Commensalism, Reservoir, Zoonosis (with special emphasis on Rabies)

Unit:2 Epidemiology of Diseases

5-hrs

Transmission, Prevention and control of diseases: Tuberculosis, Typhoid

Unit:3 Parasitology

10-hrs

Rickettsiae and Spirochaetes: Brief account of *Rickettsia prowazekii*, *Borrelia recurrentis* and *Treponema pallidum*; Protozoa: Life history and pathogenicity of *Entamoeba histolytica*, *Plasmodium vivax* and *Trypanosoma gambiense*; Helminths: Life history and pathogenicity of *Ancylostoma duodenale* and *Wuchereria bancrofti*

Unit: 4 Agricultural and Medical Entomology

15-hrs

Biology of the following pests of agricultural importance: *Helicoverpa armigera*, *Pyrilla perpusilla* and *Papilio demoleus*; Study of damage caused by them, and measures to manage/ control them.

Biology of the following pests of medical importance: *Pediculus humanus capitis*, *Pediculus humanus corporis*, *Anopheles*, *Aedes*, *Culex* and *Xenopsylla cheopis*. Study of damage caused by them, and measures to manage/ control them

Unit:5 Animal Husbandry and Poultry Farming

15-hrs

Study, significance and commercial prospects of the Artificial Reproductive Techniques (ART) with special emphasis on Artificial insemination in cattle, Induction of early puberty and synchronization of estrus in cattle. Study, significance and commercial prospects of Dairy technology; Principles of poultry breeding, Management of breeding stock, Processing and preservation of eggs

Unit: 6 Aquaculture and Fish Technology

10-hrs

Study, significance and commercial prospects of Aquarium and Fish keeping; Genetic improvements in aquaculture industry; Induced breeding and transportation of fish seed

Practical [Credits: 2]

1. Study of *Plasmodium vivax*, *Entamoeba histolytica*, *Trypanosoma gambiense*, *Ancylostoma duodenale* and *Wuchereria bancrofti* and their life stages through permanent slides/photomicrographs or specimens.
2. Study of arthropod vectors associated with human diseases: *Pediculus*, *Culex*, *Anopheles*, *Aedes* and *Xenopsylla*.
3. Study of insect damage to different plant parts/stored grains through damaged products/photographs. Submission of items/products damaged by insects.
4. Identifying feature and economic importance of *Helicoverpa (Heliothis) armigera*, *Papilio demoleus*, *Pyrilla perpusilla*, *Callosobruchus chinensis*, *Sitophilus oryzae* and *Tribolium castaneum*
5. Visit to poultry farm or animal breeding centre. Submission of Field visit report.
6. Maintenance of freshwater aquarium.

Teaching and Learning Process:

Teaching-learning methods for Applied Zoology paper will include the conventional ‘chalk and talk method’ which can be supplemented by using technologically advanced methods, such as use of LCD projectors to showcase videos, films and power-point presentations. The classroom teaching will be inclusive and provide ample opportunities and challenging environment for honing the soft skills of the students by way of interactive discussions, etc.

Seminars, discussions, field visits, and projects should be organized on a regular basis where the students are given an opportunity to apply the concepts learnt in the classroom. Emphasis should mainly be on putting the classroom teaching to practice in their day-to-day life for the overall progress of the society, at large.

Assessment Methods:

The scheme for the assessment of the students should broadly address two main components: Formative and Summative.

Formative assessment (Continuous Evaluation) can be made on the basis of periodic tests, presentations, assignments, attendance, etc. whereas the Summative assessment would be done at

the end of the semester or term of the course, where some weightage of the Formative assessment should also be incorporated.

Keywords:

Medical Zoology, Parasitology, Economic Entomology, Medical Entomology, Agricultural Entomology, Insect Pests, Animal Husbandry, Artificial insemination in cattle, Dairy technology, Poultry farming, Aquaculture, Fish farming

Recommend Books:

- Park, K. (2007). Preventive and Social Medicine. XVI Edition. B.B Publishers.
- Arora, D.R. and Arora, B. (2001). Medical Parasitology. H Edition. CBS Publications and Distributors.
- Metcalf, C.L. and W.L. Flint (1962). Destructive and Useful insects: their habits and control. Mc-Graw Hill publishers, 1087 p. (4th Ed. Revised by R.L. Metcalf)
- Atwal, A.S. (1986). Agricultural Pests of India and South East Asia, Kalyani Publishers.
- Hafez, E. S. E. (1962). Reproduction in Farm Animals. Lea & Fabiger Publisher
- Dunham R.A. (2004). Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI publications, U.K.

Suggested Readings:

- Pedigo, L.P. (2002). Entomology and Pest Management, Prentice Hall.
- Dennis, H. (2009). Agricultural Entomology. Timber Press (OR).

LS SEC 1: Apiculture

Course Learning Objective:

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

Course Learning Outcome:

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

- Learn about the various species of honey bees in India, their social organization and importance.
- Be aware about the opportunities and employment in apiculture – in public, private and government sector.
- Gain thorough knowledge about the techniques involved in bee keeping and honey production.
- Know about various products obtained from beekeeping sector and their importance.
- Develop entrepreneurial skills necessary for self-employment in beekeeping sector.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 2]

30 hrs

Unit 1: Biology of Bees

4 hrs

History, Classification and Biology of Honey Bees Different species of honey bees -*Apis dorsata*, *Apis cerana indica*, *Apis florea*, *Apis mellifera*, *Melipona* sp. Social Organization of Bee Colony, Behavioural patterns (Bee dance, swarming)
(Chapter 1, 2 and 3: Singh, S.; Chapter 2, 3 and 5: Mishra, R.C.)

Unit 2: Rearing of Bees

14 hrs

Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth; Bee Pasturage; Selection of Bee Species for Apiculture –*Apis cerana indica*, *Apis mellifera*; Bee Keeping Equipment Methods of Extraction of Honey (Indigenous and Modern) & processing; Apiary management – Honey flow period and Lean period
(Chapter 4, 5, 6 and 7: Singh, S.; Chapter 4, 8 and 9: Mishra, R.C.)

Unit 3: Diseases and Enemies

5 hrs

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

Unit 4: Bee Economy

3 hrs

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

(Chapter 11: Singh, S.; Chapter 11 and 12: Mishra, R.C.

Chapter 9: <https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf>)

Unit 5: Entrepreneurship in Apiculture

4 hrs

Bee Keeping Industries – Recent Efforts, Employment opportunities, Economics in small scale and large-scale beekeeping, Scope for women entrepreneurs in beekeeping sector

(Chapter 10: <https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf>)

Entrepreneurial Potential of Small-scale Beekeeping in Rural India: A Case in Kanyakumari district, Tamil Nadu. M. Esakkimuthu & VLV. Kameswari, Tropical Agricultural Research, (2017) 28: 411)

Practical [Credits: 2]

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

Teaching and Learning Process:

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

benefits of apiculture. Visit to various apiculture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

Various measures adopted will be as follows.

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

Keywords:

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

Recommended Books:

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

Suggested Readings:

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

Online Tools and Web Resources:

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

LS SEC 2: Aquarium Fish Keeping

Course Learning Objective:

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

Course Learning Outcome:

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

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

Course Content:

Theory [Credits: 2]

30 hrs

Unit 1: Introduction to Aquarium Fish Keeping

2 hrs

The potential scope of Aquarium Fish Industry as a Cottage Industry; Exotic and Endemic species of Aquarium Fishes

(Chapter 50 and 54: Pandey and Shukla)

Unit 2: Biology of Aquarium Fishes

6 hrs

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

(Chapter 3: Dawes)

Unit 3: Food and feeding of Aquarium fishes

8 hrs

Use of live fish feed organisms (Advantages and Disadvantages of live food), Use of formulated feeds, Types of formulated feed, Formulation and preparation of feed, Advantages and disadvantages of formulated feed

(Chapter 50: Pandey and Shukla)

Unit 4: Fish Transportation

8 hrs

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

Unit 5: Maintenance of Aquarium

6 hrs

General Aquarium maintenance - budget for setting up an Aquarium Fish Farm as a Cottage Industry.

(*Chapter 2: Dawes*)

Practical [Credits: 2]

1. Study of different species of Aquarium fishes and biology (Breeding, Feeding economic importance etc) of exotic and endemic fish.
2. Study of Sexual Dimorphism of Fresh water and Marine Aquarium Fish(Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish, Butterfly fish)
3. Type, composition and formulation of fish feed (using Pearson Square Methods)
4. Construction and maintenance of Glass Aquarium and Filter System Using Indigenous Locally available materials.
5. Monitoring of aquarium water quality (Temperature, pH, Dissolved Oxygen, Carbon dioxide, Ammonical N-Load) through titrimetry methods.
6. To write a project proposal for setting up a small aquarium fish keeping as a cottage industry to a funding agency for self-employment of youths or for helping poor farmers; after visiting any farm/enterprise.

Teaching and Learning Process:

Teaching Learning must include the videos, surveys, presentation to show the significance of the course - its commercial, scientific and aesthetic prospects. Learning must inculcate in students with the visit of any farm or lab. Practical exercise with the set- up of an aquarium and its maintenance; and hands-on training for the formation of feeds will develop skill among students. Students should be assigned for subject related surveys, presentation, reports so that they can be rewarded on this basis.

Assessment Methods:

The students can be assessed by MCQs/Quizzes, Assignments, Projects, Oral presentations, Problem-solving exercises, Class tests and Continuous evaluation by biweekly topic based 'Pre-class assignment', Observation of practical skills and *Viva-voce*

Keywords:

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

Recommended Books:

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

Suggested Readings:

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

LS SEC 3: Medical Diagnostics

Course Learning Objective:

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

Course Learning Outcome:

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

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

Course Content:

Theory [Credits: 2]

30 hrs

Unit 1: Introduction to Medical Diagnostics and its Importance
(Chapter: 4 K. Park, 2013)

2 hrs

Unit 2: Medical Diagnostics of Body Fluids

10 hrs

Blood composition, Blood bank, Transfusion of blood, RBC, WBC and platelet count using haemocytometer, Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.), Analysis of urine, sputum, faeces and semen(sperm count)
(Chapter 9a, 9b, 9c, 12, 19, 20, 21: Prakash, G.

Unit 3: Medical Diagnostics of Non-infectious Diseases

10 hrs

Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Diagnosis and detection of types of tumors (Benign/Malignant) and metastasis, FNAC.
(Chapter 16, 22a: Prakash, G.; (Chapter: 6 K. Park, 2013)

Unit 4: Diagnostics Microbiology

5 hrs

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

(Chapter: 5 K. Park, 2013)

Unit 5: Diagnostic Medical Imaging

3 hrs

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

Practical [Credits: 2]

1. ABO blood group typing.
2. Estimation of haemoglobin content using Sahli's haemoglobinometer.
3. Analysis of urine for abnormal constituents.
4. Total leucocytes count from blood.
5. Measurement of blood pressure under normal and stress condition.
6. Estimation of blood glucose/ cholesterol by kit.
7. Determination of bleeding time/clotting time
8. Detecting defects of colour vision by Ishihara Charts.
9. Interpretation of ECG.
10. Medical Imaging techniques: X-Ray of bone fracture, MRI, CT scan.

Teaching and Learning Process:

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

Assessment Methods:

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

Keywords:

Diagnostic methods, Infectious and Non-Infectious Diseases, Imaging Techniques

Recommended Books:

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

Suggested Readings:

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

Online Tools and Web Resources:

- <https://www.skillstat.com/tools/ecg-simulator>
- <https://www.youtube.com/watch?v=ZoGfQM5JCnI>
- https://www.youtube.com/watch?v=Qbnz4_qed9Q&t=276s
- https://www.youtube.com/watch?v=djAxjtN_7VE
- <https://www.youtube.com/watch?v=9SUHgtREWQc&t=188s>
- <https://www.youtube.com/watch?v=fHUzVqoDnts>

LS SEC 4: Public Health and Hygiene

Course Learning Objective:

This course is multidisciplinary in nature which can be opted by students from all science courses. Starting from the basic concepts of Environmental science, it gives a deep insight into the factors causing environmental degradation and its outcome in form of increasing number of diseases leading to deterioration of public health.

Course Learning Outcome:

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

- Get familiarised with various aspects of environmental risks and hazards.
- Sensitize about the climate change due to human activities.
- Be aware about the various impacts of environmental degradation on human health through case studies and modes of prevention.
- Learn about the nuclear and chemical disasters and their aftereffects through cases studies.
- Know about the various waste management technologies and their utility.
- Learn about diagnosis of various diseases and methods to prevent them.
- Be sensitized enough to understand the importance of conservation of nature for betterment of human race and all living beings.

Theory [Credits: 2] 30 hrs

Unit 1: Introduction to Public health and Hygiene 7hrs
Significance of Public health and Hygiene, Nutrition and health, Classification of foods, Major nutritional Deficiency diseases- Protein Energy Malnutrition (Kwashiorkor and Marasmus), Vitamin deficiency disorders, Iron deficiency disorders, Iodine deficiency disorders
Chapter 1 and 2: Park K.

Unit 2: Environment and Health hazards 6 hrs
Environmental degradation, Environmental Pollution – Air, water, soil and noise; Associated health hazards
Chapter 12: Park K.

Unit 3: Communicable Diseases 6hrs
Different types of communicable diseases and their control measures – Tuberculosis, Measles, Dengue, Leprosy
Chapter 5: Park K.

Unit 4: Life Style Related Non-Communicable Diseases 6hrs
Different types of Life style related non-communicable diseases - Hypertension, Coronary Heart diseases, Stroke, Diabetes mellitus, Obesity and Mental ill-health - their causes and prevention through dietary and lifestyle modifications
Chapter 6: Park K

Unit 5: Social Health Problems

5hrs

Smoking, alcoholism, drug dependence and Acquired Immuno-Deficiency Syndrome (AIDS) - their causes, treatment and prevention.

Chapter 11: Park K

Practical [Credits: 2]

1. Estimation of blood glucose level
2. Study of household pests following with reference to public health.
3. Testing potability of water for human consumption by MPN method
4. To determine the content of different pollutants in soil/water samples.
5. Calculate the BMI of students and analyse the results with suitable statistical tools.
6. Measure the blood pressure using sphygmomanometer.
7. Data collection, case studies or interviews of the individuals suffering from diseases; and Submission of report.

Teaching and Learning Process:

Different instructing strategies shall be adopted including: Lectures, interactive lectures, classroom discussions and practical based on a theory paper by analyzing blood glucose, water samples, soil samples, etc. Use of digital technologies will enable students to get a better understanding of the concepts. Hands-on experience, including diagnostics and student presentations will provide supplement to conventional text books. Field studies will include visits to laboratories for case studies or conducting interview of certain patients.

Assessment Methods:

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

Keywords:

Health, Hygiene, Deficiency disorders, Communicable diseases, Non-communicable diseases, Pollution, Smoking, Drug dependency, Hypertension

Recommended Books:

- Park, K. (2017), *Preventive and Social Medicine*, B.B. Publishers
- Brownson, R. C., Baker, E.A., Leet T.L., and Follespie K.N. (2003) *Evidence based Public Health*, Oxford University Press.

Suggested Readings:

- Guyton A.C. and Hall J.E. *Textbook of Medical Physiology*, Saunders
- Robbins and Cortan, *Pathologic basis of Disease*, VIII Edition, Saunders
- Engelkirk P.G. and Duben-Engelkirk J. (2015) *Burton's Microbiology for the Health Sciences*, 10th Edn. Wolters Kluwer Health.

Online Tools and Web Resources:

- https://swayam.gov.in/nd1_noc19_ee66/preview
- https://swayam.gov.in/nd1_noc19_ge24/preview
- https://swayam.gov.in/nd1_noc19_mg50/preview
- <https://www.coursera.org/lecture/screening/case-1-hypertension-bfOLx>
- <https://www.coursera.org/lecture/sustainable-agriculture/water-quality-and-regulations-4uCE2>
- <https://www.eawag.ch/en/department/sandec/e-learning/moocs/>

LS SEC 5: Sericulture

Course Learning Objective:

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

Course Learning Outcome:

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

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

Course Content:

Theory [Credits: 2]

30 hrs

Unit 1: Introduction

4 hrs

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

(Chapter 3, Section 3.1: Manual on Sericulture

<http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf>)

Unit 2: Biology of Silkworm

3 hrs

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

(Chapter 3, Section 3.1: Manual on Sericulture

<http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf>)

Unit 3: Rearing of Silkworms

14 hrs

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

(Chapter 3, Section 3.3, 3.4, 3.5 and 3.6: Manual on Sericulture

http://agritech.tnau.ac.in/sericulture/seri_silkworm4_lateage%20rearing.html)

Unit 4: Pests and Diseases

4 hrs

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

(Chapter 4, Section 3.1: Manual on Sericulture

http://silks.csb.gov.in/coochbehar/wp-content/themes/common_district/coochbehar/dpm-frame2.html

http://agritech.tnau.ac.in/sericulture/disease%20mgt_silkworm.html)

Unit 5: Silk Industry and Its Importance

2 hrs

Silk usage and application in Textile and non-textile industry

(Sericulture: <http://csb.gov.in/silk-sericulture/sericulture/>

<http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf>)

Unit 6: Entrepreneurship in Sericulture

3 hrs

Prospectus of Sericulture in India: Sericulture industry in different states, Employment opportunities in mulberry and non-mulberry sericulture sector, Economics in small scale and large-scale silk worm rearing, Scope for women entrepreneurs in sericulture sector,

(<http://csb.gov.in/services/training/entrepreneurship/>

<http://ministryoftextiles.gov.in/sites/default/files/note-on-sericulture-English-Jan2019.pdf>

http://www.researchjournal.co.in/upload/assignments/5_188-190.pdf)

Practical [Credits: 2]

1. Study of the life cycle of different species of silk moths - *Bombyxmori*, *Philosamiaricini*, *Anthereapaphia/Anthreamylitta*, *Anthereaassama* and silk secreted by them.
2. Study of the sexual dimorphism in caterpillar, pupae and adults of *Bombyxmori*.
3. Study of the structure of silk gland of mulberry silk worms.
4. Study of rearing house and different appliances used in rearing of mulberry silk worms.
5. Study of the different disinfectants used in silkworm rearing houses.
6. Study of different types of mountages from specimen/photographs.
7. Analysis of silk fibre quality – Visual examination, thickness, purity.
8. Study of the parasites and predators of silk worms and their control - Uzi fly, Dermestid beetle, Vertebrates.
9. Study of silkworm diseases and their control – Pebrine, Flacherie, Grasserie, Muscardine.
10. Submission of a report on visit to ‘Sericulture Institute’/ ‘Various Sericulture Centres in India’.

Teaching and Learning Process:

Information and concepts about benefits of silkworms in human life and how these benefits can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of silkworms in nature and study of rearing technology will be assisted through visits to various sericulture institutes which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make student’s learning more dynamic. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of silkworm biology will be promoted to not only ensure effective learning and

understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of worms and their rearing methods. Visit to various sericulture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

Various measures adopted will be as follows.

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

Keywords:

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

Recommended Books:

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

Suggested Readings:

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

Online Tools and Web Resources:

- Silkworm crop protection (<https://swayam.gov.in/courses/152-silkworm-crop-protection>)
- Sericulture (<http://csb.gov.in/silk-sericulture/sericulture/>)

- <http://csb.gov.in/publications/videos/>
- <http://www.fao.org/3/x2099e/x2099e02.htm>

LS SEC 6: Environmental Audit

Course Learning Objective:

An environmental audit as defined a systematic, documented verification process of objectively obtaining and evaluating audit evidence to determine whether specified environmental activities, events, conditions, management systems, or information about these matters conform with audit criteria, and communicating the results of this process. The International Chamber of Commerce defines environmental auditing as, “a management tool comprising a systematic documented, periodic and objective evaluation of how well environmental organization, management and equipment are performing with the aim of contributing to safeguarding the environment by facilitating management control of environmental practices and assessing

- To provide comprehension by the students on ethical principles of audit profession;
- To provide the understanding by the students of general chronology of audit, audit strategy, audit program and audit procedures;
- To provide the definition of the internal control system, control activity, to provide on how the financial reporting assertions are related to internal controls, and how the effectiveness of internal controls is assessed;
- To provide the view on audit risk assessment, its calculation and importance for audit strategy;
- To present to the students examples of analytical procedures and other types of substantive procedures performed on audit;
- To introduce the types of audit reports.

Course Learning Outcome:

On completion, students will be able to develop the appropriate documentation for an environmental impact statement and respond appropriately to an environment audit or environmental management system.

- To provide students with information in order to obtain competencies for environmental auditing
 - how the environmental commitments by industry can be monitored and audited
 - how potential environmental impacts are described in Environmental Impact Assessments (EIA)
 - how industry controls their environmental impacts through Environmental Management Systems (EMS)
 - how environmental management systems are audited
 - how waste is generated and controlled
 - other environmental management initiatives such as product life cycle analysis and sustainability Programs
- To develop ability to plan, execute and document the environmental audit.
- To develop entrepreneurial skills

Course Content:

Theory (Credits: 2)

30 hrs

Unit 1: Understanding Pollution

10 hrs

Definition; pollution, Air Pollution: Air pollutants-Sources, primary and secondary pollutants and particulate matter, HAPs (hazardous air pollutants), Indoor pollution- different sources. Water Pollution: Sources- direct and indirect, impact of pollution on water bodies groundwater pollution – sources and effects. Wastes: Source, characteristics, types, and fate of solid wastes. Metal pollution: Metals in soil, food and water, elementary idea on metal pollution. Noise Pollution: General features, sources, noise classification, effects of sound pollution. Radiation Pollution: Man-made radiation, radiation hazards, nuclear accidents. Pesticide Pollution: Definition; sources, categories, pesticides in water and effects; elementary idea on IPM. Soil Pollution: Sources, types, effects of soil pollution

(Chapter 1, 2, 3, 4: Liu, Zhang, Liu; Chapter 9: Vasudevan)

Unit 2: Protection of Environment

7 hrs

International concerns and efforts for environmental protection; role of United Nations; Stockholm summit; priority issues; Rio Summit: Sustainable Development; Earth day; Environment day; ecotourism

(Chapter 9: Vasudevan; Chapter 1: Barrow; CPCB Report)

Unit 3: Environmental Audit

13 hrs

Introduction: Definition; types of auditing, Features of Effective Auditing, Program planning and organization of Auditing Program, Pre visit data collection, Auditing Protocol, Onsite Audit; Data Sampling; Inspection and Evaluation and Presentation, Audit Report; Action plan, Management of Audit, Benefits of Environmental Audit, Environmental Audit Program in India. Case Study: Any one industries case study from following:- Construction, Metal Processing, Pharmaceutical, Electrical, Electronic, Fertilizer, Pesticide, any regional Industry.

(Chapter 1, 13, 14, 15, 16, 17, 18, 19 and 20: Srivastava)

Teaching and Learning Process:

The students will be able given information and concepts about benefits of environmental audits in Industries and recognise environmental impacts resulting from industrial activity. They will be taught how to how critically review an environmental management system. They will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through case studies will be assisted through visits to industries which will create interest, enhance their understanding to prepare and perform a simple environmental audit and inculcate entrepreneurial skills among students.

Assessment Methods:

The assessment of students' achievement in immunology will be aligned with the course/program learning outcomes.

- Continuous evaluation of learning by formative and diagnostic evaluation should be followed at the University.
- Efforts should be made to measure cognitive as well as applied learning.
- Project work, quiz, problem solving exercise, classroom assessment methods, closed-book and open-book tests, problem-solving exercises, practical assignment, laboratory reports, seminar presentation, viva voce interviews, computerized adaptive testing, literature surveys and summative evaluations by end-semester examination *etc.* constitute the different components of the overall assessment.

- More over, students should be provided with feedback on their work with the aim of improving their academic performance.

Keywords:

Pollutants, Environment Protection and Management, Auditing, Environmental Audit Program.

Recommended Books:

- Environmental science by S. C. Santra, New Central Book Agency London, Third Edition, 2015. Humphrey N, Hadley M (2000)
- Environmental Auditing, Palladian Law Publishing Ltd, Cambridge, Isle of Wight. Hunt D, Johnson C (1995)

Suggested Readings:

- Environmental Management Systems, McGraw Hill, London. International Chamber of Commerce (1989), Environmental Auditing, June 1989, ICC Publication No 468, International Chamber of Commerce (ICC), Paris. International Chamber of Commerce (1991), ICC Guide to Effective Environmental Auditing. ICC Publication No 483, International Chamber of Commerce (ICC), Paris Smets H (1988) The cost of accidental pollution.

Online Tools and Web Resources:

- E-content on e-PG Pathshala portal of Government of India <https://epgp.inflibnet.ac.in>
- www.gpcb.gov.in
- www.cpcb.nic.in
- www.nptel.ac.in

Acknowledgements

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