DEPARTMENT OF ZOOLOGY
MANIPUR UNIVERSITY

B. Sc. (Hons.) Zoology

(Effective from Academic Year 2022-23)

Revised Syllabus as approved by
Academic Council

Date: 31.05.2022 No:

Executive Council

Date: No:

Applicable for students registered with Regular and Private Affiliated Colleges of Manipur University

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Introduction

The learning outcomes-based curriculum framework for B.Sc. degree in Zoology is structured to offer a broad outline within which a Zoology program could be developed. The course isupgraded keeping in mind the aspirations of students, changing nature of the subject as well as the learning environment. Courses within Zoology have been revisited to incorporate recent advancements, techniques to upgrade the skills of learners. The new structure is expected to enhance the level of understanding among students and maintain the standard of Zoology degrees/program. This framework permits the review of graduate attributes, qualification descriptors, program learning outcomes and course-level learning outcomes periodically. The framework offers flexibility and innovation in syllabi designing and in methods adopted for teaching- learning process and learning assessment. The major objective is to elevate the subject knowledge of the students, making them critical thinkers and able to solve problems and issues related to Zoology logically and efficiently. The course has been modified to upgrade skills related to biological science and provide our students a competitive edge in securing a career in academia, industry, research and development sectors. The Course structure has been framed as per the Ordinance for Undergraduate programme in Science, Arts and Commerce of Manipur University (which is reproduced again here).

Learning Outcome-based Curriculum Framework

Nature and Extent of the Program

Zoology is a broad subject encompassing classical and modern systemic aspects of animal diversity, as well as contemporary subjects like Molecular Biology, Bioinformatics, Biotechnology and Medical Diagnostics to foster comprehensive understanding about various aspects of animal science. The scope of Zoology is wide-ranging. A few can be mentioned : Diversity of Non-chordates and Chordates; Comparative Anatomy of Vertebrates; Cell Biology; Biochemistry; Molecular Biology; Evolutionary Biology; Principles of Genetics; Principles of Ecology, Animal behavior and Physiology. Diversity of Non-chordates and Chordates deals with the classification and adaptive diversity of animals from diverse phyla; Comparative Anatomy of Vertebrates deals with structural comparisons among all vertebrates; Cell Biology deals with the study of structure and functions of the cell; Biochemistry deals with the study of chemical substances and vital processes occurring within the living organisms; Molecular Biology deals with the nature of biological phenomena at the molecular level; Evolutionary Biology studies the evolutionary processes that produced the diversity of life on Earth, starting from a single common ancestor; Principle of Genetics deal with the molecular structure and function of genes, and gene behavior in context of a cell or organism; Principles of Ecology studies the structure and function of nature; Physiology deals with the functions and activities of living organisms. In addition, some interdisciplinary topics and Skill enhancement courses are offered to students.

Aim of Bachelor Degree Program

Zoology is one of the most fundamental branches of biology studied at undergraduate level. It helps to learn and understand the concepts regarding animal diversity to appreciate the variability in relation to their morphology, anatomy and behaviour among different animals. Students will be able to qualitatively and quantitatively analyze evolutionary parameters using various bioinformatics and computational tools used in modern sciences. This will provide them ample opportunities to explore different career avenues.

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

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

Some of the characteristic attributes of a graduate in Zoology may include the following:
Disciplinary knowledge: Comprehensive knowledge of major concepts, theoretical principles and experimental findings in Zoology and its different subfields including biodiversity, anatomy, physiology, biochemistry, biotechnology, ecology, evolutionary biology, cell biology, molecular biology, immunology and genetics, and some of the other applied areas of study such as wildlife conservation and management, apiculture, sericulture, aquatic biology, fish and fisheries sciences, bioinformatics, Interdisciplinary knowledge of allied biological sciences, environmental science and chemical science; learning of the various techniques, instruments, computational software used for analysis of animal's forms and functions.
Effective communicator: Capability to convey the intricate zoological information effectively and efficiently.
Critical thinker and problem solver: Ability to rationally analyze and solve the problems related to animal sciences without relying on assumptions and guess work.
Logical thinking and reasoning: Capability of seeking solutions and logically solving them by experimentation and data processing either manually or through software.
Team spirit: Ability to work effectively in a heterogeneous team.
Leadership quality: Ability to recognise and mobilise relevant resources essential for a project, and manage the project in a responsible way by following ethical scientific conduct and bio-safety protocols.
Digitally literate: Capable of using computers for biological simulation, computation and appropriate software for biostatistics, and employing search tools to locate, retrieve, and evaluate zoology-related data.

Ethical awareness: Avoiding unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, as well as appreciate environmental and sustainability issues.
Lifelong learners: Capable of self-paced and self-directed learning aimed at personal and social development.

Program Learning Outcome

Students enrolled in B.Sc. (Hons.) degree program in Zoology will study and acquire complete knowledge of disciplinary as well as allied biological sciences. At the end of graduation, they should possess expertise which will provide them competitive advantage in pursuing higher studies from India or abroad; and seek jobs in academia, research or industries. Students should be able to identify, classify and differentiate diverse chordates and non- chordates based on their morphological, anatomical and systemic organization. They will also be able to describe economic,

ecological and medical significance of various animals in human life which will be a great help when applying for Jobs in Institutes such as Zoological Survey of India and National Parks/Sanctuaries. Acquired practical skills in biotechnology, biostatistics, bioinformatics and molecular biology can be used to pursue career as a scientist These methodologies will provide an extra edge to our students, who wish to undertake higher studies. In-depth knowledge and understanding about comparative anatomy and developmental biology of various biological systems; and learning about the organisation, functions, strength and weaknesses of various systems will let students critically analyse the way evolution has shaped these traits in the human body.

Skill enhancement courses shall be making Students successful entrepreneurs. Deep understanding of different physiological systems and methods available to measure vital physiological parameters and to comprehend the mechanism behind occurrence of different life threatening disease *via* laboratory examination, assessment of basic physiological functions by interpreting physiological charts will help to find their career options.

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

MANIPUR UNIVERSITY

CANCHIPUR, IMPHAL-795003

ORDINANCE FOR

UNDERGRADUATE PROGRAMMES IN SCIENCE, ARTS AND COMMERCE, 2021

[Under Section 31 of the Manipur University Act, 2005]

In exercise of the powers conferred by Section 31 and Statute 41 of the Manipur University Act, 2005 and in view of the National Educational Policy 2020 of the Government of India and the University Grants Commission's Guidelines for the Learning Outcomes-based Curriculum Framework (LOCF) under the Choice Based Credit System (CBCS), the Manipur University hereby makes this Ordinance for undergraduate academic programmes in Science, Arts and Commerce.

1. Short Title, Commencement and Scope:

1.1. This Ordinance shall be called the Manipur University's Ordinance for Undergraduate Programmes in Science, Arts and Commerce, 2021.

1.2. This Ordinance shall come into force from the Academic Session 2021-2022.

2. Scope and Coverage:

1.1. This Ordinance shall supersede the existing Ordinance for Bachelor of Arts and Bachelor of Science (Six-Semester System), 2010.

1.2. The undergraduate academic programme governed by this Ordinance shall be of four years duration with multiple exit options within this period with appropriate certifications namely,

(a) **Bachelor's Certificate** in a Discipline upon the successful completion of theFirst Year (Two Semesters);

(b) **Bachelor's Diploma** in a Discipline upon the successful completion of theSecond Year (Four Semesters);

(c) **Bachelor's Degree** in a Discipline at the successful completion of the ThirdYear (Six Semesters);

(d) **Bachelor's Degree with Honours** in a Discipline at the successful completion of the Four Year (Eight Semesters).

1.3. This Ordinance shall be applicable to the students taking admission to the undergraduate programmes from the Academic Session 2021-2022.

1.4. Those students who were admitted to the undergraduate programmes before enforcement of this Ordinance shall continue to be governed by the existing Ordinance for Bachelor of Arts and Bachelor of Science (Six-Semester System), 2010.

1.5. The curriculum for the 4-year undergraduate programme shall be based on the LOCF-CBCS system of the UGC with value addition courses which are envisaged in the NEP 2020.

3. Definitions of Key Words:

3.1 National Education Policy 2020 (NEP 2020): The NEP 2020 envisages a holistic and multidisciplinary education that aims to produce employable graduates with integrated personality. The policy envisions the undergraduate degree to be of either 3- or 4-years duration, with multiple entry and exit options within this period and with appropriate certifications e.g. a certificate after 1 year of study or a diploma after 2 years of study or a Bachelor's degree after 3 years of study. The 4-year programme will lead to either a Bachelor's degree with Honours in a discipline or a Bachelor's degree with Research, if the student completes a rigorous project in a major area of study as specified by the University.

3.2 Academic Bank of Credit (ABC): It is the platform developed by National e-Governance Division (NeGD) of the Ministry of Electronics and InformationTechnology, Government of India, having the facility/functionality of opening Academic Account by students and onboarding of eligible Higher Education Institutions (HEIs), in accordance with "The University Grants Commission (Establishment and Operation of Academic Bank of Credits in Higher Education) Regulations, 2021". ABC will digitally store the academic credits earned by students from HEIs registered with ABC for awarding degrees/diplomas/certificates taking into account credits earned by students. ABC will ensure the opening, closure and validation of Academic Bank Accounts, credit verification, credit accumulation, and credit transfer, redemption for students.

3.3 Multiple Entry and Exit Points: These are stages where the students may have options for entry and exit in the academic programmes in Higher Education Institutions to be facilitated through the facility created by the Academic Bank Credit scheme in the manner as provided in the UGC "Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions".

3.4 Learning Outcomes-based Curriculum Framework (LOCF): It is a frameworkinitiated by the UGC in 2018 for updating CBCS curriculum so as to reflect the expected learning outcomes and academic standards that are expected to be attained by graduates of a programme of study and holder of a qualification.

3.5 Choice Based Credit System (CBCS): It is the system formulated by the UGC in 2015. The CBCS provides choice for students to select from the prescribed courses (core, elective or minor or soft skill courses). Under the CBCS, the requirement for awarding a degree or diploma or certificate is prescribed in terms of minimum number of credits to be completed by the students.

3.6 Academic Year: Two consecutive (one odd + one even) semesters constitute one academic year.

3.7 Semester: Each semester will consist of 15-16 weeks of academic work equivalent to 90 actual teaching days. In a bi-semester system, an academic year consists of two semesters. The odd semesters may be scheduled from June/July to November/ December, and even semester from November/ December to April/May.

3.8 Programme: A programme, hereinafter, shall mean an academic programme leading to award of a degree, diploma or certificate. It comprises of a fixed set of core (compulsory) Courses and some choice based (optional) Courses with a minimum Credit requirement.

3.9 Course: A course, usually referred to as 'paper', is a component of a Programme, comprising one or a combination of some academic forms of instructions such as lectures, tutorials, laboratory work, field work, outreach activities, project work, vocational training, viva, seminars, term papers, assignments, presentations, self-study etc. or a combination of some of these. All courses should define learning objectives and students learning outcomes. Each course is to be identified by a unique course code and course title.

3.10 Credit: Credit defines the quantum of work-load for a course. Generally, one hour of theory or one hour of tutorial or two hours of laboratory work, per week for a duration of a semester result in the award of one credit. Credits for internship shall be one credit per one week of internship, subject to a maximum of six credits.

3.11 Grade Point: It is a numerical weight allotted to each letter grade on a 10-pointscale.

3.12 Letter Grade: It is an index of the performance of students in a course. Grades are denoted by letters O, A+, A, B+, B, C, P, F and Ab.

3.13 Credit Point: It is the product of grade point and number of credits for a course.

3.14 Semester Grade Point Average (SGPA): It is a measure of performance of work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester to the total course credits taken during that semester. It shall be expressed up to two decimal places.

3.15 Cumulative Grade Point Average (CGPA): It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters to the sum of the total credits of all courses in all the semesters. It is expressedup to two decimal places.

3.16 Transcript or Grade Card or Certificate: Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester and CGPA earned till that semester.

4. Courses of Undergraduate Programmes:

The undergraduate programmes governed by this Ordinance contain the following course components:

4.1 Core Course: This is a course which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline/subject of study. Each of the Core Courses shall contain two components: Theory and Practical/Tutorial. Theory Paper having Practical shall carry 4 Credits so that Practical carries 2 Credits. Theory Paper having Tutorial shall carry 5 Credits so that Tutorial carries 1 Credit.

4.2 Elective Course: Generally, an elective course is a course which can be chosen from a pool of courses which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill. An elective course may be three types:

(a) **Discipline Specific Elective (DSE) Course**: Elective courses offered by the main discipline/subject of study are referred to as Discipline Specific Elective Courses. This course is to advance knowledge and skill in the core domain. Each of the DSE courses shall contain two components: Theory and Practical/Tutorial. Theory Paper having Practical shall carry 4 Credits so that Practical carries 2 Credits. Theory Paper having Tutorial shall carry 5 Credits so that Tutorial carries 1 Credit.

(b) **Dissertation/Project/Internship:** An elective course designed to acquire special/advanced knowledge is termed as dissertation/project. This is considered as a special course involving application of knowledge in solving/ analyzing/ exploring a real life situation/ difficult problem. Dissertation/Project Work/Internship is optional and it may be offered in lieu of a discipline specific elective paper in 8th Semester.

(c) **Generic Elective Course (GEC):** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek a wide exposure is called a Generic Elective. A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective. Each of the GEC Courses shall contain two components: Theory and Practical/Tutorial. Theory Paper having Practical shall carry 4 Credits so that Practical carries 2 Credits. Theory Paper having Tutorial shall carry 5 Credits so that Tutorial carries 1 Credit.

4.3 Ability Enhancement Course: The Ability Enhancement Course may be of two kinds: Ability Enhancement Compulsory Courses (AECC) and Skill Enhancement Courses (SEC). AECC courses are the courses based upon the content that leads to Knowledge enhancement: (i) Environmental Science and (ii) English/MIL Communication. These are mandatory for all disciplines. SEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc. These may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge. Each of the AECC and SEC courses shall carry 4 Credits.

4.4 Value Addition Courses (VAC): These are courses that will help develop all capacities of human beings – intellectual, aesthetic, social, physical, emotional, and moral in an integrated manner. It includes subjects like Yoga, Sports, Health Care, NCC, NSS, Ethics, Culture etc. VAC courses may be chosen from a pool of courses. Each VAC course shall carry 2 Credits.

5. Course Structure:

The course structure for the 4-year UG programme shall be as under:

Course structure for 4-Year Undergraduate programmes

Semester	Core (Credit)	DSE (Credit)	GEC (Credit)	AECC (Credit)	SEC (Credit)	VAC (Credit)	Semester Credit
I	Core-1 (6) Core-2 (6)			AECC-1 (4) English/MIL	SEC-1 (4)	VAC-1 (2) VAC-2 (2)	24
II	Core-3 (6) Core-4 (6)			AECC-2 (4) Environmental Sc.	SEC-2 (4)	VAC-3 (2) VAC-4 (2)	24
Exit option with Bachelor's Certificate in a Discipline on completion of courses equal to a minimum of 46 Credits							
III	Core-5 (6) Core-6 (6) Core-7 (6)		GEC-1 (6)			VAC-5 (2)	26
IV	Core-8 (6) Core-9 (6) Core-10 (6)		GEC-2(6)			VAC-6 (2)	26
Exit option with Bachelor's Diploma in a Discipline on completion of courses equal to a minimum of 96 Credits							
V	Core-11 (6) Core-12 (6)	DSE-1 (6)	GEC-3(6)			VAC-7 (2)	26
VI	Core-13 (6) Core-14 (6)	DSE-2 (6)	GEC-4(6)			VAC-8 (2)	26
Exit option with Bachelor's Degree in a Discipline on completion of courses equal to a minimum of 140 Credits							
VII	Core-15 (6) Core-16 (6)	DSE-3 (6)	GEC-5(6)				24
VIII	Core-17 (6) Core-18 (6)	DSE-4 (6)	GEC-6(6)				24
Award of Bachelor's Degree with Honours in a Discipline on completion of courses equal to a minimum of 182 Credits							

(A) **Bachelor's Certificate**

The Bachelor's Certificate in a discipline is obtainable after 1 year (two semesters) of study. A Bachelor's Certificate in a discipline may be awarded if a student studies 4 core papers in that discipline, 2 Ability Enhancement Compulsory Courses (AECC), 2 Skill Enhancement Courses (SEC) and minimum 3 Value Addition Courses (VAC), with the completion of courses equal to a minimum of 46 Credits.

(B) **Bachelor's Diploma**

The Bachelor's Diploma in a discipline is obtainable after 2 years (four semesters) of study. A Bachelor's Diploma in a discipline may be awarded if a student studies 10 core papers in that discipline, 2 Ability Enhancement Compulsory Courses (AECC), 2 Skill Enhancement Courses (SEC), minimum 4 Value Addition Courses (VAC) and 2 Generic Elective courses (GEC), with the completion of courses equal to a minimum of 96 Credits.

(C) **Bachelor's Degree**

The Bachelor's Degree in a discipline is obtainable after 3 years (six semesters) of study. A Bachelor's degree (i.e., B.Sc./ B.A./ B.Com.) in a discipline degree may be awarded if a student studies 14 core papers in that discipline, 2 Ability Enhancement Compulsory Courses (AECC), 2 Skill Enhancement Courses (SEC), minimum 5 Value Addition Courses (VAC), 2 Discipline Specific Elective (DSE) courses and minimum 3 Generic Elective (GE) courses, with the completion of courses equal to a minimum of 140 Credits.

(D) **Bachelor's Degree with Honours**

The Bachelor's Degree with Honours in a discipline is obtainable after 4 years (eight semesters) of study. A Bachelor's degree with Honours (i.e., B.Sc. (Honours)/ B.A. (Honours)/ B.Com. (Honours)) in a discipline may be awarded if a student studies 18 core papers in that discipline, 2 Ability Enhancement Compulsory Courses (AECC), 2 Skill Enhancement Courses (SEC), minimum 5 Value Addition Courses (VAC), 4 Discipline Specific Elective (DSE) and minimum 4 Generic Elective courses (GEC), with the completion of courses equal to a minimum of 182 Credits.

6. SWAYAM Courses:

6.1 SWAYAM Courses: The University may allow up to 20% of the total courses being offered in a particular program in a Semester through the online learning courses offered through SWAYAM platform subject to the following conditions:

(a) The course contents are in compliance with the UGC (Credit Framework for Online Learning Courses through Study Webs of Active Learning for Young Aspiring Minds) Regulations, 2021 and its subsequent amendments;

(b) The courses are not offered in the University/College.

6.2 The University shall give the equivalent credit weightage to the student for the credits earned vide online learning credit courses through SWAYAM platform, in the credit plan of the programme.

7. **Mechanism for Computation of Work-load:**

The following mechanism shall be adopted for computation of work-load:

(a) 1Credit =1Theory period of one hour duration/week/semester;

(b) 1Credit =1Tutorial period of one hour duration/week/semester;

(c) 1Credit =1Practical period of two hours duration/week/semester;

(d) 1Credit = Internship of 1 week/semester.

8. Course Curriculum and Syllabus:

8. 1. The course curriculum and syllabus of every undergraduate programme shall be developed by the concerned School Board of Studies/Department Board of Studies/Board of Under-Graduate Studies of the University and they shall be implemented after obtaining approval from the Academic Council.

8. 2. The University may offer a number of choices for the papers under Generic Elective Courses (GEC), Discipline Specific Elective (DSE) courses, Skill Enhancement Courses (SEC) and Value Addition Courses (VAC), as per the availability of the courses and faculty.

8. 3. The University may evolve a system/policy about Extra Curricular Activities/ General Interest and Hobby Courses/Sports/NCC/NSS/Vocational courses/related courses, for adding them under Value Addition Courses (VAC).

8. 4. Dissertation/Project Work/Internship is optional and it may be offered in lieu of a discipline specific elective paper in 8th Semester.

8. 5. Every course/paper offered in the University shall have a unique Course Code consisting of 05 (five) alphanumeric characters in the form of *"XYpqr"* where the double alphabet characters *"XY"* shall identify the discipline/ subject to which the Course/paper belongs, *p* is a numeric character specifying the qualification level and *"qr"* are numeric characters specifying the serial number of the Course/paper under that level.

8. 6. The curriculum of every undergraduate programme shall be in conformity with the University Grants Commission's Guidelines for the Learning Outcomes-based Curriculum Framework (LOCF) under the Choice Based Credit System (CBCS).

8. 7. Every undergraduate programme shall conform with the common minimum curriculum and syllabi of the core papers as fixed by the UGC under the CBCS system. The allowed deviation from the syllabi is 30% at the maximum.

9. Multiple Entry and Exit Options:

The entry and exit options for students, who enter the undergraduate programme, shall be as follows:

1ST YEAR

Entry 1: The entry requirement for Bachelor's certificate (Level 5) programme is Secondary School Leaving Certificate obtained after the successful completion of Grade 12. A programme of study leading to entry into the first year of the Bachelor's degree is open to those who have met the entrance requirements, including specified levels of attainment at the secondary level of education specified in the programme admission regulations. Admission to the Bachelor's degree programme of study is based on the evaluation of documentary evidence (including the academic record) of the applicant's ability to undertake and complete a Bachelor's degree programme.

Exit 1: Bachelor's certificate will be awarded when a student exits at the end of 1st year (Level 5). A Bachelor's certificate requires completion of courses equal to a minimum of 46 Credits at Level 5.

2ND YEAR

Entry 2. The entry requirement for Bachelor's diploma (Level 6) is a Bachelor's certificate obtained after completing the first year (two semesters) of the undergraduate programme. A programme of study leading to the second year of the Bachelor's degree is open to those who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations. Admission to a programme of study is based on the evaluation of documentary evidence (including the academic record) of the applicant's ability to undertake and complete a Bachelor's degree programme.

Exit 2: At the end of the 2nd year (Level 6), if a student exits, a Bachelor's diploma shall be awarded. A Bachelor's Diploma requires completion of courses equal to a minimum of 96 Credits from Level 5 to Level 6.

3RD YEAR

Entry 3. The entry requirement for an undergraduate programme is a diploma obtained after completing two years (four semesters) of the undergraduate programme. A programme of study leading to the Bachelor's degree is open to those who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations. Admission to a programme of study is based on the evaluation of documentary evidence (including the academic record) of the applicant's ability to undertake and complete a Bachelor's degree programme.

Exit 3: On successful completion of three years, the Bachelor's degree shall be awarded. A Bachelor's degree requires completion of courses equal to a minimum of 140 Credits from Level 5 to Level 7.

4TH YEAR

Entry 4. An individual seeking admission to a Bachelor's degree (Honours) (Level 8) in a discipline would normally have completed all requirements of the relevant three-year bachelor degree (Level 7) in that discipline. After completing the requirements of a three-year Bachelor's degree, candidates who meet **a minimum CGPA of 7.5** shall be allowed to continue studies in the fourth year of the undergraduate programme to pursue and complete the Bachelor's degree with Honours in the discipline.

Exit 4: On the successful completion of the fourth year, a student shall be awarded a Bachelor's degree with Honours in the concerned discipline. A Bachelor's degree with Honours requires completion of courses equal to a minimum of 182 Credits from Level 5 to Level 8.

10. Qualification Levels and Credit Requirements:

Following the UGC's nomenclature, qualification titles such as certificate, diploma and degree for the undergraduate programmes are organized in a series of levels in ascending order as under:

Level 5: Bachelor's certificate;

Level 6: Bachelor's diploma;

Level 7: Bachelor's degree;

Level 8: Bachelor's degree with Honours.

The minimum credit requirements for these qualification types shall be as under:

(A) Bachelor's Certificate (**Level 5**)

Course (Credit)	Number	Course Credits	Minimum Credits
Core (6)	4	6 x 4=24	46
AECC (4)	2	4 x 2=8	
SEC (4)	2	4 x 2=8	
VAC (2)	3 (Minimum)	2 x 3=6 (Minimum)	

(B) Bachelor's Diploma (**Level 6**)

Course (Credit)	Number	Course Credits	Minimum Credits
Core (6)	10	6 x 10=60	96
GEC (6)	2	6 x 2=12	
AECC (4)	2	4 x 2=8	
SEC (4)	2	4 x 2=8	
VAC (2)	4 (Minimum)	2 x 4=8 (Minimum)	

(C) Bachelor's Degree (**Level 7**)

Course (Credit)	Number	Course Credits	Minimum Credits
Core (6)	14	6 x 14=84	140
DSE (6)	2	6 x 2=12	
GEC (6)	3 (Minimum)	6 x 3=18 (Minimum)	
AECC (4)	2	4 x 2=8	
SEC (4)	2	4 x 2=8	
VAC (2)	5 (Minimum)	2 x 5=10 (Minimum)	

(D) Bachelor's (Hons.) Degree (**Level 8**)

Course (Credit)	Number	Course Credits	Minimum Credits
Core (6)	18	6 x 18=108	182
DSE (6)	4	6 x 4=24	
GEC (6)	4 (Minimum)	6 x 4=24 (Minimum)	
AECC (4)	2	4 x 2=8	
SEC (4)	2	4 x 2=8	
VAC (2)	5 (Minimum)	2 x 5=10 (Minimum)	

11. Marks Distribution and Evaluation:

Total marks for each course shall be based on internal assessment (25%) and semester end examination (75%). The internal assessment of 25% shall be distributed as under:

(i) Test/Assignment/Seminar/Field Work/Project Work/Case Study : 20%;

(ii) Attendance: 5%.

12. Letter Grade and Grade Point:

The 10-point grading system of the UGC, as described below, will be adopted for assessment and examination of the performance of students in various courses of the undergraduate programmes. **Letter Grade** is used to signify the level of qualitative/quantitative academic achievement of a student in a Course, while the **Grade Point** is used to indicate the numerical weight of the Letter Grade on a 10-point scale. Letter Grades 'O' to 'P' indicate successful completion of a Course, while Letter Grades 'F' and 'Ab' indicate 'fail' and 'Absent' respectively.

Table: Letter Grades and Grade Points

Letter Grade	Grade Point	% of Marks	SGPA/CGPA	Description
O (Outstanding)	10	90 – 100	9.0 – 10.0	Outstanding
A+ (Excellent)	9	80 – 89	8.0 – 8.9	First ClassExemplary
A (Very Good)	8	70 – 79	7.0 – 7.9	First Class Distinction
B+ (Good)	7	60 – 69	6.0 – 6.9	First Class
B (Above Average)	6	55 – 59	5.5 – 5.9	High SecondClass
C (Average)	5	50 – 54	5.0 – 5.4	Second Class
P (Pass)	4	40 – 49	4.0 – 4.9	Pass
F (Fail)	0	00 - 39	0.0 - 3.9	Fail
Ab	0	---	---	Absent

13. Computation of SGPA and CGPA

13.1 The Semester Grade Point Average (SGPA) of a student in a Semester is the weighted average of the Grade Points secured by the student in all the Credit Courses that he/she registered in that Semester, irrespective of whether he/she could or could not complete the Courses. The SGPA of a student in a Semester shall be calculated on the UGC's 10-point scale by finding the ratio of sum of the product of the number of credits with the grade points scored by the student in all the courses in that semester and the sum of the number of credits of all the courses undergone by the student i.e.,

$$SGPA = \frac{\sum(C_i \times G_i)}{\sum C_i}$$

where, C_i is the number of credits of the ith course and G_i is the grade point scored by the student in the ith course. Conventionally, SGPA is rounded off to 2 decimal points.

13.2 The Cumulative Grade Point Average (CGPA) of a student in a Programme is the accumulated weighted average of the Grade Points secured by the student in all the Credit Courses that he/she registered, over all semesters of the programme. The CGPA of a student shall be calculated on the UGC's 10-point scale by finding the ratio of sum of the product of the number of credits with the SGPA of the student over all the semesters and the sum of the number of credits over all the semesters i.e.,

$$CGPA = \frac{\sum(C_i \times S_i)}{\sum C_i}$$

where S_i is the SGPA of the ith semester and C_i is the total number of credits in that semester. Conventionally, CGPA is rounded off to 2 decimal points.

14. Accumulation of Credits:

Every student shall open an account in the Academic Bank of Credits which will provide him/her with a unique ID and will allow access to the Standard Operating Procedure (SOP). The Credits awarded to a student for the courses pursued in the University shall be accumulated in the Academic Bank Account of the student. The procedure for accumulation of credits earned, shelf life, redemption of credits, would be as per the UGC (Establishment and Operation of Academic Bank of Credits in Higher Education) Regulations, 2021 and their subsequent amendments. The validity of credits earned will be to a maximum period of seven years or as specified by the Academic Bank of Credits.

15. Duration of the undergraduate programmes:

Every student admitted to an undergraduate programme for a qualification (Level 5 to Level 8) shall be required to complete the programme within a period of 2 (two) years from the date of admission to the programme of each qualification level.

16. Course Registration:

At the beginning of every Semester, all the students shall be required to register for the Courses specified for that Semester of the Programme in the Office of Controller of Examinations in the prescribed forms with payment of fees as prescribed by the University from time to time.

17. Admission and Examinations:

All matters pertaining to admission and examinations for the 4-year undergraduate programs shall be regulated by the Admission and Examination Regulations for the 4-Year Undergraduate Programmes of the Manipur University.

18. Power to remove Difficulties:

In case any difficulty arises in giving effect to the provisions of this Ordinance, the Vice- Chancellor may, by order, make such provisions in conformity with the Act, Statutes, Ordinances or other Regulations, as appears to be necessary or expedient to remove the difficulty, however subject to ratification of such order by the Appropriate University Authorities.

Course Structure

1.1 Credit distribution for the course

Semester	Course Opted	Course code	Name	Credit
I	Ability EnhancementCompulsory Course (AECC1XY)	**AECC 1 EC/MN/HN**	English /MIL (Manipuri/Hindi)	4
	Core Course-I	**ZOO501C**	Animalia, Non-chordates I: Protozoa to Nemathelminthes	4
	Core Course-I Practical	**ZOO501C P**	,,	2
	Core Course-II	**ZOO502C**	Principles of Classification, Approaches in Taxonomy	4
	Core Course-II Practical	**ZOO502CP**	,,	2
	Skill Enhancement Course (SEC)-I	**ZOO501S(a) or ZOO501S(b) or ZOO501S(c)**	Aquarium Fish keeping **or** Apiculture **or** Poultry farming	2
	Skill Enhancement Course (SEC)-I Practical	**ZOO501SP(a) or ZOO501SP(b) or ZOO501SP(c)**	Aquarium Fish keeping **or** Apiculture **or** Poultry farming	2
	Value addition Course (VAC) - I	**VAC - 1**	**One to be chosen from VAC list sl. no. 1 -8 of Univ order no.523 dated 20th Sept 2022 https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2**	2
	Value addition Course (VAC) - II	**VAC - 2**	**One to be chosen from VAC list sl. no. 9 - 16 of Univ order no.523 dated 20th Sept 2022 https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2**	2
				24
II	Ability Enhancement Compulsory Course (AECC2XY)	**AECC2EN**	Environmental Science	4
	Core Course-III	**ZOO503C**	Non-chordates II:Annelida to Echinodermata, Minor Phyla	4
	Core Course-III Practical	**ZOO503CP**	,,	2
	Core course-IV	**ZOO504 C**	Animal Physiology, Endocrinology	4
	Core Course-IV Practical	**ZOO504CP**	,,	2
	Skill Enhancement Course (SEC)-II	**ZOO502S(a) or ZOO502S(b) or ZOO502S(c)**	Sericulture **or** Vermicomposting **or** Organic farming	2
	Skill Enhancement Course (SEC)-II Practical	**ZOO502SP(a)**	Sericulture	2

		or ZOO502SP(b) or ZOO502SP(c)	**or** Vermicomposting **or** Organic farming	
	Value addition Course (VAC) - III	**VAC - 3**	**One to be chosen from VAC list sl. no. 17 - 24 of Univ order no.523 dated 20th Sept 2022 https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2**	2
	Value addition Course (VAC) - IV	**VAC - 4**	**One to be chosen from VAC list sl. no. 25 - 32 of Univ order no.523 dated 20th Sept 2022 https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2**	2
				24
Exit option with Bachelor's Certificate in Zoology on completion of Courses equal to a minimum of 46 Credits				

III	Core Course-V	**ZOO605C**	Diversity of Chordates I: General organization of Chordata: Hemichordata to Pisces	4
	Core Course-V Practical	**ZOO605CP**	,,	2
	Core Course-VI	**ZOO606C**	Diversity of Chordates II: General organization of Chordata: Amphibia to Mammalia	4
	Core Course-VI Practical	**ZOO606CP**	,,	2
	Core Course-VII	**ZOO607C**	Fundamentals of Biochemistry	4
	Core Course-VII Practical	**ZOO607CP**	,,	2
	Generic Elective Course (GEC) - I	**ZOO601G**	Fundamentals of Zoology – 1 ***[Students of Zoology are to choose GEC of other subjects like Chemistry/Botany]**	4
	Generic Elective Course (GEC) - I Practical	**ZOO601GP**	Fundamentals of Zoology – 1 P	2
	Value addition Courses (VAC) - V	VAC - 5	**One to be chosen from VAC list sl. no. 33 -40 of Univ order no.523 dated 20th Sept 2022 https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2**	2
				26
IV	Core Course-VIII	**ZOO608C**	Palaeozoology, Zoogeography & Evolution	4
	Core Course-VIII Practical	**ZOO608CP**	,,	2
	Core Course-IX	**ZOO609C**	Histology & Comparative Anatomy of Vertebrates	4
	Core Course-IX Practical	**ZOO609CP**	,,	2
	Core Course-X	**ZOO610C**	Ecology & Biodiversity	4
	Core Course-X Practical	**ZOO610CP**	,,	2
	Generic Elective Course (GEC) - II	**ZOO602G**	Fundamentals of Zoology – 1I ***[Students of Zoology are to choose**	4

			GEC of other subjects like Chemistry/Botany]	
	Generic Elective Course (GEC) - II Practical	**ZOO602GP**	,,	2
	Value addition Courses (VAC) - VI	**VAC - 6**	**One to be chosen from VAC list sl. no. 41 -48 of Univ order no.523 dated 20th Sept 2022 https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2**	2
				26
Exit option with Bachelor's Diploma in Zoology on completion of Courses equal to a minimum of 96 Credits				

Semester	Course Opted	Course Code	Course Name	Credits
V	Core Course-XI	**ZOO711C**	Developmental Biology & Immunology	4
	Core Course-XI Practical	**ZOO711CP**	,,	2
	Core Course-XII	**ZOO712C**	Cell Biology & Genetics	4
	Core Course-XII Practical	**ZOO712CP**	,,	2
	Generic Elective Course (GEC) - III	**ZOO703G**	Fundamentals of Zoology – III ***[Students of Zoology are to choose GEC of other subjects like Chemistry/Botany]**	4
	Generic Elective Course (GEC) - III Practical	**ZOO703GP**	,,	2
	Value addition Courses (VAC) - VII	**VAC - 7**	**One to be chosen from VAC list sl. no. 49 -56 of Univ order no.523 dated 20th Sept 2022 https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2**	2
	Discipline Specific Elective (DSE) Course - I	**ZOO701D(a) or ZOO701D(b) or ZOO701D(c)**	Wildlife & Bioresource management **or** Integrated Pest management **or** Fish & Fisheries	4
	Discipline Specific Elective (DSE) Course - I Practical	**ZOO701DP(a) or ZOO701DP(b) or ZOO701DP(c)**	Wildlife & Bioresource management **or** Integrated Pest management **or** Fish & Fisheries	2
				26
VI	Core Course-XIII	**ZOO713C**	Molecular Biology & Bioinformatics	4
	Core Course-XIII Practical	**ZOO713CP**	,,	2

	Core course-XIV	**ZOO714C**	Adaptation in Animals, Applied Zoology	4
	Core Course-XIV Practical	**ZOO714CP**	,,	2
	Generic Elective Course (GEC) - IV	**ZOO704G**	Fundamentals of Zoology – IV *[Students of Zoology are to choose GEC of other subjects like Chemistry/Botany]	4
	Generic Elective Course (GEC) - IV Practical	**ZOO704GP**	,,	2
	Value addition Courses (VAC) – VIII	**VAC - 8**	**One to be chosen from VAC list sl. no. 57 -65 of Univ order no.523 dated 20th Sept 2022 https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2**	2
	Discipline Specific Elective (DSE) Course - II	**ZOO702D(a) or ZOO702D(b) or ZOO702D(c)**	Medical microbiology & Parasitology **or** Aquatic biology **or** Ecological restoration	4
	Discipline Specific Elective (DSE) Course – II Practical	**ZOO702DP(a) or ZOO702DP(b) or ZOO702DP(c)**	Medical microbiology & Parasitology **or** Aquatic biology **or** Ecological restoration	2
				26
Exit option with Bachelor's Degree in Zoology on completion of Courses equal to a minimum of 140 Credits				

Semester	Course Opted	Course Code	Course Name	Credits
VII	Core Course-XV	**ZOO815C**	Animal Biotechnology	4
	Core Course-XV Practical	**ZOO815CP**	,,	2
	Core Course-XVI	**ZOO816C**	Biological techniques & Bioinstrumentation	4
	Core Course-XVI Practical	**ZOO816CP**	,,	2
	Generic Elective Course (GEC) -V	**ZOO805G**	Fundamentals of Zoology – V *[Students of Zoology are to choose GEC of other subjects like Chemistry/Botany]	4

	Generic Elective Course (GEC) –V Practical	**ZOO805GP**	,,	2
	Discipline Specific Elective (DSE) Course - III	**ZOO803D**	Research methodology in Zoology – I	4
	Discipline Specific Elective (DSE) Course - III Practical	**ZOO803DP**	,,	2
				24
VIII	Core Course-XVII	**ZOO817C**	BioStatistics & Computer Application	4
	Core Course-XVII Practical	**ZOO817CP**	,,	2
	Core course-XVIII	**ZOO818C**	Ethology & Chronobiology	4
	Core Course-XVIII Practical	**ZOO818CP**	,,	2
	Generic Elective Course (GEC) -VI	**ZOO806G**	Fundamentals of Zoology – VI *[Students of Zoology are to choose GEC of other subjects like Chemistry/Botany]	4
	Generic Elective Course (GEC) –VI Practical	**ZOO806GP**	,,	2
	Discipline Specific Elective (DSE) Course - IV	**ZOO804D**	Research methodology in Zoology - II	4
	Discipline Specific Elective (DSE) Course – IV Practical	**ZOO804DP**	Internship **	2
				24

**** Internship shall be for a duration of one month at an Institute other than the Parent Institute and the Student need to submit a report at the end of the Internship duly signed by the Mentor under whom the Internship has been done (1 Credit). The student needs to make a presentation of the works done during the Internship in the Parent department (1 Credit).**

Award of Bachelor's Degree with Honours in Zoology on completion of Courses equal to a minimum of 182 Credits.

***** Those wishing to receive Award of Bachelor's Degree (Honours) with Research in Zoology need to do a research project/ dissertation of two Credits during Semester VII & VIII (in their available free time) in addition to the normal syllabus of the two Semesters. However, they also need to fulfil the eligibility criteria. The total Credits shall be 184 subject to further official order.***

Courses for B. Sc. (Hons.) Zoology

SEMESTER I

Core Course -I: ZOO501C (Animalia, Non-Chordates I: Protozoa to Nemathelminthes)

Objective:

The course is aimed with the objective of providing knowledge of the diversity of animal life. Morphological and anatomical features of diverse animal groups; their significance and their relationships have been incorporated in order to create interest among the Students to explore the animal diversity in nature.

Outcome:

The outcome expected on completion of Course:

- Having knowledge of systematic position, habitat and structural organization of non-chordates.
- Understand the economic importance of non-chordates, their interaction with the environment, role in the ecosystem, evolutionary history and their relationships.
- Having enhanced knowledge of the said group and communication skills through practical sessions, group discussions, assignments and projects.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Introduction to Animalia, Protista 12 hrs/ 20 marks

General Characteristics of different Phyla of the Kingdom Animalia and Basis of Classification; General characteristics and Classification up to classes for Protista; Study of *Euglena* and *Paramecium.*Life cycle and pathogenicity of *Plasmodium vivax;* Medical importance of protozoans, Mode of Feeding, Locomotion and Reproduction in Protista.

Unit 2: Porifera 9 hrs / 15 marks

Introduction to Parazoa; General characteristics and Classification up to classes; Study of *Sycon* & *Spongilla;* Skeleton & Canal systems in sponges, Economic importance of Sponges

Unit 3: Cnidaria/ Coelenterata, Ctenophora 15 hrs/ 25 marks

Introduction to Metazoa: General characteristics and Classification up to classes; Metagenesis in *Obelia;* Polymorphism in Cnidaria; Morphology & Life Cycle of *Aurelia*; Corals and coral reefs, Structural organization and affinities in Coelenterata. General characteristics and evolutionary significance of Ctenophora.

Unit 4: Platyhelminthes 12 hrs/ 20 marks

General characteristics and Classification up to classes; Morphology, Life cycle and pathogenicity of *Fasciola hepatica, Schistosoma mansoni* and *Taenia solium;* Parasitic adaptations in Platyhelminthes & their medical importance.

Unit 5: Nemathelminthes 12hrs/ 20 marks

General characteristics and Classification up to classes; Morphology, Life cycle and pathogenicity of *Ascaris lumbricoides, Wuchereria bancrofti & Enterobius vermicularis;* Parasitic adaptations in Nemathelminthes

Core Course – I Practical: ZOO501CP

Practical [Credits 2] 30 hrs/50 marks

1. Study of the whole mounts of *Euglena*, *Amoeba, Paramecium (including* Binary fission and Conjugation), *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium*/*Adamsia, Pennatula, Fungia, Meandrina, Madrepora, Sycon, Hyalonema, Euplectella, Spongilla, Fasciola hepatica & life cycle stages*, *Taenia solium and Ascaris lumbricoides*
2. Study of T.S. of *Sycon,* L.S. of *Sycon,*T.S. of*Metridium*/*Adamsi*
3. Examination of pond water collected from different places to observe diversity in Protista
4. Study of adult and its life stages of a Nematode or a trematode (Slides/micro-photographs)
5. To submit a Project Report on any related topic on the life cycle of any one parasite of Protist, Nemathelminthes or Platyhelminthes.

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

Examination evaluation Structure:

1. Museum Specimen: 3 Numbers/ 5marks each (Identification =1, Classification= 2, Characters = 2) Total = 15 marks
2. Study of Sections (Slides): 1 number/ 3 marks (Identification with reasons = 1 + 2 = 3)
3. Life cycle stages: 1 number /2 marks (Identification with reason : 1+1=2)
4. Project report: 15 marks (Subject content, Presentation, Diagrams/Photos)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

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

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis. III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

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

Core Course -II: ZOO502C (PRINCIPLES OF CLASSIFICATION, APPROACHES IN TAXONOMY)

Objective:
The course is aimed with the objective of providing knowledge of the diversity of animal life. Identification, Nomenclature & Classification of diverse animal groups; their relationships and Concepts with new trends in taxonomy including collection & Publication have been incorporated in order to create interest among the Students to explore the animal diversity in nature.

Outcome:

The outcome expected on completion of Course:

- Having knowledge of systematic position, habitat and structural organization of non-chordates.
- Understand the economic importance of non-chordates, their interaction with the environment, role in the ecosystem, evolutionary history and their relationships.
- Having enhanced knowledge of the said group and communication skills through practical sessions, group discussions, assignments and projects.

Course Content:

Theory [Credits: 4] 60 hrs/100 marks

Unit 1: Taxonomy – Principles, Common terms, taxonomical characters, types and functions; Nomenclature, International code of Zoological nomenclature and its recent amendments. 12hrs/ 20 marks

Unit 2: Systematics, Zoological Classification – Kinds (Phenetic, Natural, Phylogenetic, Evolutionary & Onmispective), Linnean hierarchy. 12 hrs / 20 marks

Unit 3: Concept of Species – Typological, Biological, Nominalistic, Evolutionary & recognition; Difficulties in the application of different Species concepts. 12 hrs / 20 marks

Unit 4: Taxonomical publications, Taxonomic collection, Techniques of preservation, Process for identification of Specimens. 12 hrs/ 20 marks

Unit 5: Recent trends in modern taxonomy: different approaches (Morphological, Cytological, Biochemical, Numerical, Molecular etc.) 12 hrs / 20 marks

Core Course – I Practical: ZOO502CP (Principles of Classification, Approaches in Taxonomy)

Practical [Credits 2] **30 hrs/50 marks**

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1. Recent classification of animals with help of museum specimens.
2. Identification of animal species with the help of taxonomic keys, e.g., insect fauna up to order; fish fauna up to families; identification of earthworm etc
3. Methods of taxonomic collection and preservations.
4. Morphological variations in animal phyla.
5. Methods of key preparation
6. Biosystematic position of specimens: 1. Phylum protozoa to echinodermata 2. Cyclostomata to mammals
7. Studies of life cycle and morphology of selected specimens.
8. Morphometric measurements of some available specimens.

Examination evaluation Structure:

1. Museum Specimen: 5 Numbers/each 5marks (Identification =1, Classification= 2, Characters = 2) Total = 25 marks
2. Preparation of Keys from Characters of Selected Specimen provided. (5 marks)
3. Life cycle stages: 2 number /3 marks (Identification with reasons: 1 + 2 = 3)
4. Note Book: 7 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about animal taxonomy, their identification, nomenclature, Classifications will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure will 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. shall be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of Systematic biology will be created to ensure effective learning and understanding of the concepts. Study of animals in their natural habitat will improve the observation skills, datacollection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of classification. Curriculum-related assignments and key preparation will improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there shall be a doubt clearing session/Class in order to test whether the teaching imparted had been followed by the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking

as well as the team work skills among the students.

- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Recommended Books:

- Ernst Mayr (1991): Principles of Systematic Zoology. Tata Mc Graw Hill Publishing Co. Ltd., USA: New Delhi
- Kapoor, V.C (1998): Principles and Practice of Animal Taxonomy. Science Publisher
- Kapoor, V.C (2008): Theory and Practice of Animal Taxonomy. Oxford & IBH Publishing Co. Pvt Ltd
- Blackwelder, R.E. (1967): Taxonomy. John Willey & Sons Inc., New York
- Simpson, G.G. (2012): Principles of Animal Taxonomy, Scientific Publisher (India)
- Dalela, R.C. and Sharma, R.S. (2017): Animal Taxonomy and Museology. Jai Prakash Nath & Co., Meerut

Online Tools and Web Resources:

- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity), Advances in Animal diversity , Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology) Swayam (MHRD) Portal
- ePG Pathshala (MHRD)Module 184 of the paper on taxonomy https://epgp.inflibnet.ac.in/ahl.php?csrno=35

Skill Enhancement Course (SEC) -I: ZOO501S(a) (Aquarium Fish Keeping)

Objective:

The course will impart basic knowledge of ornamental fish Industry and inculcate its scope as an avenue for career development as an entrepreneur or as an aquari-culturist. It will provide a clear understanding of the basics of biology and habits of aquarium fish, so as to facilitate taking up ornamental fish keeping as an enterprise, even at the household level. The skill capacity building of students will be promoted by teaching the techniques of aquarium constructions, feed formulation and preparation, transportation, maintenance and management of the system. Students will have 'hands-on' experience by exposure to technology, production, functioning or operation of an aquarium in the 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 aboutdifferent kinds of fish , their compatibility in aquarium.
- Become aware of Aquarium as commercial, decorative items and of scientific values.
- 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/ 50 marks

Unit 1: Introduction, Biology of Aquarium Fish 12 hrs/20 marks

Aquarium Fish Industry as a Cottage Industry; Exotic and Endemic species of Aquarium Fish , biology (Breeding, Feeding economic importance etc.) , sexual dimorphism of Fresh water and marine aquarium fish such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish

Unit 2: Food and Feeding of Aquarium Fish 6 hrs/10 marks

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

Unit 3: Fish Transportation and Maintenance of Aquarium 12 hrs/20 marks

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. General aquarium maintenance - budget for setting up an Aquarium Fish Farm as a cottage industry.

Skill Enhancement Course (SEC) Practical-I: ZOO501SP(a)
(Aquarium Fish Keeping)

Practical [Credit: 2] 30 hrs/ 50 marks

1. Study of different species of Aquarium fish 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, ammoniacal N-load) through titrimetric 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.

Examination evaluation Structure:

1. Identification & Character of Specimen: 3 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3 each). Total = 9 marks
2. Monitoring of Water quality : procedure & result – 10 marks
3. Project proposal: 15 marks (Subject content, Presentation, Diagrams/Photos)
4. Note Book: 6 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

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

Assessment Methods:

Measures to be adopted for assessment are as follows-

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

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

Skill Enhancement Course (SEC) - I: ZOO501S(b) (Apiculture)

Objective:

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. It will also help the students to develop entrepreneurial skills required for self-employment in beekeeping sector specially on 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.

Outcome:

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

- Learn about the various species of honey bees, their social organization and importance.
- Share knowledge 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.

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit1: Biology of Bees 10 hrs/ 15 marks

History, Systematics and biology of Honey Bees, different species of honey, distribution & occurrence of Honey bees in North East India, Polymorphism, Social Organization of bee colony, behavioral patterns (Bee dance, swarming), Dispersal and foraging methods for Pollen and Nectar collection.

Unit 2: Rearing of Bees 10 hrs/ 15 marks

Apiculture practices, rearing methods, Artificial bee rearing (Apiary), Beehives- Newton and Langstroth; Bee Pasturage; Selection of bee species for Apiculture, Bee keeping equipment, Methods of extraction of Honey (Indigenous and Modern) and processing; Apiary management- Honey flow period and Lean period

Unit 3: Bee Economy, Diseases and Enemies 3 hrs/ 20 marks

Bee Products (Honey, Bees Wax, Propolis, Royal jelly, Pollen etc.) and their uses; Properties of Honey and economic values, Modern methods in employing artificial beehives for cross pollination in horticultural gardens. Bee diseases, control and preventive measures, Enemies of bees.

Skill Enhancement Course (SEC) - I Practical: ZOO501SP(b) (Apiculture)

Practical [Credit: 2] 30 hrs/ 50 marks

1. Study of the life history of a common honey bee - Egg, larva, pupa, adult (queen, drone, worker) from Photograph or preserved specimen.
2. Study of natural bee hive and identification of queen cells, drone cells and brood
3. Study of morphological structures of honey bee through permanent slides/photographs- mouth parts, antenna, wings, legs (antenna cleaner, mid leg, pollen basket), sting apparatus.
4. Permanent/temporary mount of antenna cleaner, mid leg and pollen basket.
5. Study of artificial hive (Langstroth/Newton), its various parts and beekeeping equipment.
6. Visit to an apiary/honey processing unit/Institute and submission of a report.

Examination evaluation Structure:

1. Identification & Character of Slides/ Specimen: 6 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3)
2. Project report: 15 marks (Subject content, Presentation, Diagrams/Photos)
3. Note Book: 7 marks (Based on the neatness, inclusiveness, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

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

Measures to be adopted for assessment are as follows-

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.

- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

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.
- David, B.V. and Anathakrishnan, T.N. (2004): General and applied entomology. Mc Graw Hill education (India) Pvt Ltd., New Delhi
- Davis, B.V. and Ramamurthy, V.V. (2013): Elements of Economic Entomology. Namrutha Publication, Chennai
- Gupta, J. K. (2016): Apiculture, Indian Council of Agricultural Research, New Delhi
- Prost, P. J. (1962): Apiculture. Oxford and IBH, New Delhi.
- Rahman, A. (2017): Beekeeping in India. Indian Council of Agricultural Research, New Delhi

Online Tools and Web Resources:

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

Skill Enhancement Course (SEC) - I: ZOO501S(c) (Poultry Farming)

Objective:

The course is aimed with the objective of providing knowledge of the Poultry farming; their significance, types & breeds. Modern system of rearing and breeding of Broilers have been incorporated in order to create interest among the Students to explore this system of practice.

Outcome:

The outcome expected on completion of Course:

- Having knowledge of different Poultry birds & rearing practices.
- Understand the economic importance of these birds, Feed preparation, Scientific rearing practices and control of diseases.

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit 1: Introduction to Poultry Industry and Diversified Poultry 12 hrs/20 marks

Importance; present status and future prospects of poultry industry; classification of chicken; introduction to ducks, geese, quails, guinea fowls and turkey; improved varieties of chicken; economic aspects of ratites, emu and ostrich

Unit 2: Feeds additives and formulation 6 hrs/10 marks

Feeds: definition; antibiotics; anti-oxidants-their roles in nutrition; supplements used; good quality feed ingredients, cost, availability, storage, etc.; mixing of feeds, different mills used (Hammer, mixture, pellet); premix preparation, raw materials, feed mill operation.

Unit 3: Scientific Poultry Keeping, Diseases 12 hrs/20 marks

Modern breeding; egg and meat production; hatchery managements; farm equipment for broilers rearing; brooding system; multiple batch system; water and feed management; sanitation litter management; performance indices and records. Diseases – types, symptoms, prevention and control. Vaccination program.

Skill Enhancement Course (SEC) - I Practical: ZOO501SP(c)

(Poultry Farming)

Practical [Credit: 2] **30 hrs/ 50 marks**

1. Demonstration of breeds of chicken, Ducks, Geese, Turkeys, Quails, Guinea Fowls, Ratite etc.
2. Nutrient required in poultry name of feed ingredient, nutritive value in term of C.P% and M.E in k.cal/kg of feeds like animal source, plant source synthetic source
3. Estimation of protein in a given sample by Kjeldal flask method.
4. Preparation of feed (Selection of ingredient, feed formulation, grinding, mixing).
5. Faecal sample examination and identification of parasites, isolation of disease causing organism.
6. Project work on Broiler management and report submission.

Examination evaluation Structure:

1. Identification & Characters of different breeds of Poultry birds (live/Photo) : 3 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3 each). Total = 9 marks

2. Monitoring of Nutritive value, Protein content: procedure & result – 5 marks

3. Faecal sample examination: Identification of Parasites with reasons & drawing of diagram (1 + 2 + 3 = 6)

2. Project Report: 15 marks (Subject content, Presentation, Diagrams/Photos)

3. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)

4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Teaching Learning must include the videos, surveys, presentation to show the significance of the course- its commercial, scientific and aesthetic prospects. Learning must include a visit toany farm or lab by students. Practical exercise and hands on experience at a farm will develop skill among students.

Assessment Methods: Measures to be adopted for assessment are as follows -

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

Reference Books:

- Nadam, R. (2015): Handbook of Poultry farming and feed formulations. Anmol publications Pvt Ltd.
- Das *et al.* (2021); Text book on Poultry management. Narendra Publishing house

Online Tools and Web Resources:

https://www.growelagrovet.com

http: //www.asci-india.com

https://dahd.nic.in

Courses for B. Sc. (Hons.) Zoology

SEMESTER II

Core Course -III: ZOO503C (Non-Chordates II: Annelida to Echinodermata, Minor phyla)

Objective:

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

Outcome:

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

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- Appreciate the diversity of non-chordates living in diverse habit and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically think about the organization, complexity and characteristic features of non-chordates.
- Getting familiarized with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Introduction to Coelomates, Annelida 12 hrs/ 20 marks

Evolution of coelom and metamerism. General characteristics and Classification up to classes for Annelida; Digestion, Excretion and Reproduction in Annelida, Trochophore larva – structure & affinities.

Unit 2: Arthropoda 12 hrs/ 20 marks

General characteristics and Classification up to classes, Structural organization in different classes, Mouth parts of Insects, Vision and Respiration in Arthropoda; Metamorphosis in Insects; Social life in bees andtermites, Larval forms of Crustacea and Insecta.

Unit 3: Onychophora, Mollusca 12 hrs/ 20 marks

General characteristics and Evolutionary significance of Onychophora, General characteristics and Classification up to classes of Mollusca; Structural organization in Pelecypoda, Gastropoda and Cephalopoda, Respiration in Mollusca; Torsion and detorsion in Gastropoda; Structure and affinities of Neopilina, Pearl formation in bivalves

Unit 4: Echinodermata 12 hrs/ 20 marks

General characteristics and Classification up to classes; Protective mechanisms in echinoderms (Dermal skeleton, evisceration, autotomy); Water-vascular system in Asteroidea; Larval forms in echinoderms.

Unit 5:, Minor Phyla 12 hrs/ 20 marks

Introduction to minor phyla. Distinguishing characters and examples of Nemertinea, rotifera, Acanthocephala, Sipunculida, Echiurida, Bryozoa (ectoprocta), Brachyopoda, phoronida etc. Morphology, Nervous system, Reproductive system in *Acanthocephalus* sp. External features, musculature, digestive system, life cycle of a typical Rotifer.

Core Course –III Practical: ZOO503CP (Non-Chordates II: Annelida to Echinodermata, Minor phyla)

Practical [Credits: 2] 30 hrs/50 marks

1. Study of *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria,* Trochophore larva
2. Study of T.S. through pharynx, gizzard, and intestine of earthworm
3. Study of *Limulus*, *Palamnaeus, Palaemon, Daphnia*, *Balanus*, *Sacculina*, *Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx*, *Periplaneta,* termites, *Apis, Musca,* Crustacean larvae , *Peripatus, Chiton, Dentalium, Pila, Doris, Helix, Unio, Patella, Ostrea, Pinctada, Sepia, Octopus, Nautilus, Pentaceros*/*Asterias, Ophiura, Clypeaster, Echinus, Cucumaria, Antedon*
4. Dissection of digestive, reproductive and excretory system of Cockroach.
5. Dissection of digestive and nervous system of *Pila*.
6. Dissection of digestive and nervous system of *Nereis*. (*Subject to UGC guidelines)
7. Temporary mounts of *Obelia* colony; Ovary, Spermatheca 7 septal nephridia of Earthworm; Parapodia of Nereis; Mouth parts of Cockroach, house fly & mosquito; Radula of *Pila*; whole mounts of *Daphnia, Cyclops*.
8. Submit a Project Report on field study of the social behaviour of any insect (bees/termites/ants/wasps) or behavioural pattern of earthworm in nature.

Examination evaluation Structure:

1. Museum Specimen: 5 Numbers/each 4 marks (Identification =1, Classification= 1, Characters = 2) Total = 20 marks
2. Dissection & display (one system) (7 + 3 = 10)
3. Preparation of a temporary mount (5 marks)
4. Project report submission (3 marks)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 7 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted not only through classroom lectures to inculcate a conceptual base among the students about the subject but also through observations in nature and through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more

comprehensive learning. Blended learning using chalk-n-talk method and e- learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of non-chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:

Measures to be adopted for assessment are as follows -

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

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
*Note: Classification to be followed from "Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India"
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

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

Core Course -IV: ZOO504C (Animal Physiology, Endocrinology)

Objective:

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

Outcome:

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

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

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Physiology of Digestion 12 hrs/ 18 marks

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinaltract.

Unit 2: Physiology of Respiration and Coordination of Nerve 13 hrs/ 22 marks

Histology of respiratory tract; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide; Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration. Structure of neuron,

Resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission, Neuromuscular junction; Physiology of hearing and vision

Unit 3: Physiology of Urinogenital System & Muscular System 10 hrs/ 20 marks

Structure of kidney and its functional Unit; Mechanism of urine formation; Regulation ofwater balance, micturition; Regulation of salt, acid-base balance; Physiology of male and female reproduction.

Muscle types, Ultrastructure of muscle, Sliding filament theory of Muscle contraction, Role of Calcium ion in muscle contraction, Characteristics of muscle twitch; Motor unit, Summation and tetanus

Unit 4: Physiology of Circulatory system 13 hrs/ 20 marks

Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis: Blood clotting system, Kininogen Kinin system, Fibrinolytic system. Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers. Origin and conduction of cardiac impulses; Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Peripheral circulation, Blood group and Rh factor, Blood pressure and its regulation.

Unit 5: Endocrine System 12 hrs/ 20 marks

Definitions of Endocrine glands and neurosecretory cells; Functions, hormones secreted by the endocrine glands- pineal, hypothalamus, pituitary, thyroid, thymus, parathyroid, pancreas, adrenal, testis, ovary and their physiological actions; Regulation of their secretion; Mode of hormone action-Signal transduction pathways for steroidal and non-steroidal hormones. Introductory ideas on the miscellaneous hormones secreted by gastrointestinal system, Kidney, Placenta and heart.

Core Course -IV practical: ZOO504CP (Animal Physiology, Endrocrinology)

Practical [Credits: 2] **30 hrs/50 marks**

Practical -

1. Demonstration of the unconditioned reflex action (Deep tendon reflex such as kneejerk reflex)
2. Preparation of temporary mounts: Squamous epithelium, Striated muscle fibres, Nervecells
3. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nervecell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
4. Demonstration of technique of microtomy to have hands-on experience and learningof the technique.
5. Enumeration of red blood cells and white blood cells using haemocytometer
6. Estimation of haemoglobin using Sahli's haemoglobinometer
7. Preparation of haemin and haemochromogen crystals
8. Interpretation of recording of frog's heart beat (*in situ*) under normal andexperimental conditions (effects of acetylcholine, atropine and epinephrine) Subject to UGC guidelines) .
9. Recording of blood pressure using a sphygmomanometer
10. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum,rectum liver, trachea, lung, kidney

Examination evaluation Structure:

1. Enumeration of RBC/ WBC/ Estimation of Haemoglobin: 10 marks (Procedure & result = 7 + 3=10)
2. Identification of slides/ spot identification: 7 numbers/ 21 marks (Identification with reasons = 1 + 2 = 3)
3. Preparation of a temporary mount and diagram (5 + 2 = 7 marks)
4. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 7 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

The Learning Outcomes-Based Approach to curriculum planning and execution requires that the teaching learning processes are oriented towards enabling students to attain the defined learning outcomes relating to the courses within a programme. This, particularly in the context of undergraduate studies, requires a significant shift from teacher centric to learner/ student centric, pedagogies and from passive to active/participatory pedagogies. Practical skills, including an appreciation of the link between theory and experiment will constitute an important aspect of the teaching-learning process specially while studying the physiological functions. Lectures shall be supported by group tutorial work; invited lectures, Practical and field-based learnings; Assignments, seminars, oral presentations

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

- Tortora, G.J. and Grabowski, S. (2006). Principles of Anatomy & Physiology. XIedition. John Wiley & Sons
- Vander, A., Sherman, J., and Luciano, D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, Mc Graw Hills
- Ganong, W.F. (2019) Review of Medical Physiology. 26th Edition, Mc Graw-Hill
- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd/W.B. Saunders Company
- Marieb, E.N. (1998) Human Anatomy and Physiology. IV Edition, Addison Wesley Longman Inc.

Online Tools and Web Resources:

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

Skill Enhancement Course (SEC) - II: ZOO502S(a) (Sericulture)

Objective:

The course will make the students aware about the significance of sericulture as a profit-making enterprise. It will help the students to understand the biology of silkworms, its nutritional requirement to secrete quality silk , the techniques of silkworm rearing, reeling of silk and various measures to be taken to maximize the benefits.

Outcome:

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

- Learn about the history of sericulture and silk routes.
- Recognize various species of silk moths in India, both 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.

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit 1: Introduction to Sericulture; Systematics and Biology of Silkworm 12 hrs/ 20 marks

Sericulture: Definition, history and present status; Silk route; Silk varieties, usage, export values, employment opportunities; Types of silkworms, Distribution and races; Univoltine and multi voltine races, Exotic and indigenous; Mulberry sericulture; Non-mulberry Sericulture, Eri, Muga, Tassar. Life cycle of *Bombyx mori, Eri, Muga, Antheraea proyli.*

Unit 2: Rearing of Silkworms 12 hrs/ 20 marks

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

Unit 3: Pests and Diseases 6 hrs/ 10 marks

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates; Diseases of silkworm, Causal factors: Bacteria, Viruses, Fungus, Protozoan, Parasitoides; Control and prevention of pests and diseases.

Skill Enhancement Course (SEC) Practical - II: ZOO502SP(a) (Sericulture)

Practical [Credits: 2] **30 hrs/ 50 marks**

1. Study of the life cycle of different species of silk moths - *Bombyx mori, Philosamia ricini, Antheraea proyli/Antheraea mylitta, Antheraea assamensis* and silk secreted by them.
2. Study of the sexual dimorphism in caterpillar, pupae and adults of *Bombyx mori.*
3. Study of the structure of silk gland of mulberry silk worms through dissection .
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 a 'Sericulture Institute'/'Various Sericulture Centres in Manipur.

Examination evaluation Structure:

1. Identification & Characters of different Silkworms (live/ Preserved specimen /Photo) : 3 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3 each). Total = 9 marks
2. Identification of appliances used for Silkworm rearing & silk threads– 3 numbers/ 9 marks (Identification = 1, Reason = 2)
3. Dissection and display of Silk gland. 7 marks (Dissection = 4, Display = 3)
4. Report submission: 10 marks (Subject content, Presentation, Diagrams/Photos)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

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

Assessment Methods:

Measures to be adopted for assessment are as follows -

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

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
- 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
- HouseYup-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

Skill Enhancement Course (SEC) -II: ZOO502S(b)
(Vermicomposting)

Objective:

The course will make the students aware about the significance of Vermicomposting as a profit-making enterprise. It will help the students to understand the biology of Earthworm, nutritive values of Vermicompost & Vermicast.

Outcome:

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

- Learn about the history of Vermiculture.
- Recognize various species of Earthworms in India, both exotic and indigenous races.
- Be aware about the opportunities and employment in rural cottage industry.
- Gain thorough knowledge about the techniques involved in Earthworm rearing and Vermicompost preparation.
- Develop entrepreneurial skills necessary for self-employment in Vericomposting.

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit 1: Introduction to Vermiculture, role & types of Eartworms. 12 hrs/ 20 marks

Introduction to vermiculture, definition, classification, history, economic importance and values in maintenance of soil structure. Role of vermiculture in biotransformation of residues, types of worms – local and exotic, usefulness of different species.

Unit 2: Biology of Earthworm, Pests & Diseases 6 hrs/ 10 marks

Biology of *Pheretima posthuma*: taxonomy, anatomy, physiology and reproduction including fecundity and annual reproduction potential. Pests and diseases of earthworms & preventive measures.

Unit 3: Vermicompost preparation & Physico-chemical parameters 12 hrs/ 20 marks

Physico-chemical parameters of vermicompost, different methods of vermicomposting – small, large-scale bed farming, pit methods, limiting methods in vermicomposting. Extraction, harvesting, processing, packaging, transport and storage of vermicompost.

Skill Enhancement Course (SEC) Practical -II: ZOO502SP(b) (Vermicomposting)

Practical [Credits: 2] 30 hrs/ 50 marks

1. Identification and Classification of earthworms
2. External morphology of earthworms
3. Dissection and internal anatomy of earthworms
4. Study of habit and habitat of earthworms
5. Establishment of vermicomposing units using locally available resources
6. Vercompost production, harvesting and packaging
7. Study of cocoon and vermicast
8. Study of pests and diseases of earthworms
9. Visit to a local Vermicomposting Unit & submission of report.

Examination evaluation Structure:

1. Identification & Characters of different Earthworms (live/ Preserved specimen /Photo): 3 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3 each). Total = 9 marks
2. Identification of appliances used for Vermicomposting – 3 numbers/ 9 marks (Identification = 1, Reason = 2)
3. Dissection and display of internal organs of Earthworm. 7 marks (Dissection = 4, Display = 3)
4. Report submission: 10 marks (Subject content, Presentation, Diagrams/Photos)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about benefits of Earthworms in human life and how the benefits of Vermicomposting can be reaped, will be imparted through classroom lectures to inculcate a conceptual base amongthe students about the subject. Learning through observations of Earthworms in nature and study of rearing technology will be assisted through visits to various Vermicomposting units, which will create interest, enhance their understanding and inculcate entrepreneurial skills among students. Blended learning including chalk-n-talk method and e-learning will be encouraged to make students' learning more dynamic. Enquiry-based collaborative learning through presentations, debates, group discussions, and roundtables on the various aspects of Earthworm 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 Vermicomposting Units will clarify their concepts about the worms and their rearing technology.

Assessment Methods:

Measures to be adopted for assessment are as follows -

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.

- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester.A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Recommended Books:

- NPCS Board of Consultants & engineers (2004): The complete technology book on Vermiculture and Vermicompost …….vermicompost production. Asia Pacific Business Press Inc.
- Panda, H (2022): The complete technology book on Vermiculture and vermicompost (earthworm) with manufacturing process, Machinery equipment, details & layout. Asia pacific Business Press Inc.
- Ismail, S.A (2005): The earthworm Book. Other India Press, Goa
- Julka, J.M. (1993): Earthworm resources and Vermiculture. ZSI, Calcutta

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Online Tools and Web Resources:

https://cals.ncsu.edu
https://www.vermico.com
https://www.researchgate.net
https://icar-nrri.in
http://agricoop.nic.in

Skill Enhancement Course (SEC) -II: ZOO502S(c) (Organic Farming)

Objective:

The course will make the students aware about the significance of Organic farming. It will help the students to understand benefits of organic nutrients and the need for conservation of age old indigenous practices.

Outcome:

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

- Learn about the history of Organic farming.
- Recognize various pre requisites of this method.
- Be aware about the opportunities and management strategies involved.
- Gain thorough knowledge about the techniques involved in Organic farming.
- Develop knowledge about quality maintenance, accreditation & marketing opportunities.

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit 1: Introduction to Organic farming 12 hrs/ 20 marks

Components and Principles of Organic farming: Definition - Scope - principles and concepts; History of organic farming - global scenario. biodiversity: importance and measure to preserve biodiversity - pre requisites for Organic farming. Soil organic carbon: status and improvement strategies; Prospects and problems in organic farming.

Unit 2: Organic sources; Soil, Crop, Weed, Pest & disease management 12 hrs/ 20 marks

Organic sources of Nutrients: Organic sources of nutrients- manures and other inputs - on farm and off farm sources - organic waste recycling - methods - Soil and crop management - inter cropping, crop rotation, green manures, cover crops, mulching - bio fertilizers. Soil, Nutrient, Water, Weed, Pests and disease management: Non-chemical weed management methods: preventive, physical, cultural, mechanical and biological measures - Bio-intensive pest and disease management.

Unit 3: Indigenous technical Knowledge, Crop production standard & Certification.
6 hrs/ 10 marks

Indigenous Technical Knowledge (ITK) in organic agriculture - scientific rationale, Certification of label Organic certification: NPOP guidelines, Certification agencies in India, crop production standards, Quality considerations, labelling and accreditation process, marketing and export opportunities.

Skill Enhancement Course (SEC) Practical -II: ZOO502SP(c)
(Organic Farming)

Practical [Credits: 2] 30 hrs/ 50 marks

1. Study on different Soil types and Soil conditioners (lime, dolomite, gypsum, slag, organic manure etc.).
2. Preparation of FYM/ Compost
3. Preparation of Seed bed (wet seed bed, Dry seed bed, manuring, soil treatment), Sowing, raising of seedlings, weeding, Watering.
4. Soil testing using laboratory method or Soil testing Kits, Calculation of different Fertilizers required for Crops as per Soil test result.
5. Identification of different Pests, Physiological disorders of Plants and control measures using eco friendly approaches.
6. Familiarization of Farm equipments and Implements
7. Visit to an organic Village within Manipur and observe the methods followed, Submission of a report.

Examination evaluation Structure:

1. Identification different Soil types. 2 numbers / 6 marks (Identification = 1, Reason = 2)
2. Identification of appliances / farm equipments/ implements & drawing (1 number / 6 marks) (identification = 1, drawing = 5)
3. Testing of Soil.(13 marks) (Testing = 5, Procedure = 5 , Result = 3)
4. Report submission: 10 marks (Subject content, Presentation, Diagrams/Photos)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about benefits of Organic farming will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of farms and study of different technologies will be assisted through visits to various farms; which will create interest, enhance their understanding and inculcate entrepreneurial skills among students. Blended learning including chalk-n-talk method and e-learning will be encouraged to make students' learning more dynamic. Enquiry-based collaborative learning through presentations, debates, group discussions, and roundtables on the various aspects of Organic farming 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 farm implements and their workings. Visit to various Organic Villages will clarify their concepts about Organic farming and the marketability of Organic products.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

- Panda S.C. 2018. Soil Management and organic farming. Agrobios
- Dahama, A.K.2009. Organic farming for sustainable agriculture, Agrobros publishers.
- SP. Palaniappan and K Annadurai. 2008. Organic Farming: Theory and Practice. Scientific Publishers.
- Panda, S.C. 2012. Principles and Practices of Organic Farming. Agribios (India), Jodhpur.
- Gehlot, D. 2010. Organic Farming- Components and Management. Agribios (India), Jodhpur.
- Dushyant Gehlot . 2010. Organic farming: Components and management. Agrobios (India), Jodhpur.
- Ranjan Kumar Biswas.2014. Organic farming in India. N.D. Publishers. New Delhi.

Online Tools and Web Resources:

http://ecoursesonline.iasri.res.in/

www.ifoam.org

www.apeda.org

Courses for B.Sc. (Hons.) Zoology

SEMESTER III

Core Course -V: ZOO605C (Diversity of Chordates I: General organization of Chordates: Hemichordata to Pisces)

Objective:

The course is designed with an aim to provide scope and historical background of chordates. It will impart knowledge regarding basic concepts of origin of chordates and make the students understand the characteristics and classification of animals with notochord. The adequate explanation to the students regarding various mechanisms involved in thriving survival of the animals within their geographic realms will create interest among students.

Outcome:

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

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

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Introduction to Chordates 12 hrs/ 20 marks

Comparison of Chordates & non-Chordates; General characteristics and outline classification of Chordates; Advancement of Chordate over other Phyla. Dipleurula concept and the Echinoderm theory of origin of chordates.

Unit 2: Protochordata 12 hrs/ 20 marks

General characteristics of Hemichordata, Urochordata and Cephalochordata; Structure & Life Cycle of *Balanoglossus, Herdmania, Amphioxus;* Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata.

Unit 3: Origin of Vertebrates 12 hrs/ 20 marks

Phylogeny or evolutionary history of Vertebrates: Salient features of Vertebrates, Diversity of Vertebrates; Comparative account between Protochordates & Vertebrates; Distinctive features of Poikilothermic & Homeothermic Vertebrates.

Unit 4: Agnatha 12 hrs/ 20 marks

General characteristics and classification of cyclostomes up to Class; Structure & Life cycle of *Petromyzon* & *Myxine*; Features & significance of the Extinct first Jawed Vertebrates.

Unit 5: Pisces 12 hrs/ 20 marks

General characteristics of Chondrichthyes and Osteichthyes, Classification up to order ;Types of Scales, Fins; Hypophysis & its role in induced breeding; Parental care; Migration, Osmoregulation and Swim bladder in Fish.

Core Course – V Practical: ZOO605CP

(Diversity of Chordates I: General organization of Chordates: Hemichordata to Pisces)

Practical [Credits 2] **30 hrs/ 50 marks**

.

1. Protochordata: *Balanoglossus, Herdmania, Branchiostoma*, Colonial Urochordata, Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slide of *Herdmania* spicules
2. Agnatha: Petromyzon, Myxine
3. Fish: Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/ Diodon, Anabas, Flat fish
4. Power point presentation on study of any two animals from two different classes by students

Examination evaluation Structure:

1. Museum Specimen / Slides: 3 Numbers/ 5marks each (Identification =1, Classification= 2, Characters = 2) Total = 15 marks
2. Power point presentation : 20 marks (Subject Knowledge, Presentation / delivery, Communication)
3. Note Book:5 marks (Based on the neatness, inclusiveness, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about morphology and anatomy of chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities can be included to create interest among the students to study and explore the biology and behavior of chordates inculcating research aptitude.

In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

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

Online Tools and Web Resources:

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

Core Course -VI: ZOO606C (Diversity of Chordates II: General organization of Chordata : Amphibia to Mammalia)

Objective:

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

Outcome:

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

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

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Amphibia 12 hrs/20 marks

Origin of Tetrapoda (Evolution of terrestrial ectotherms); General characteristics and classification up to order; Distinctive characters of Apoda, Urodela & Anura; Neoteny & Paedogenesis; Parental care in Amphibians; Defensive mechanisms in Amphibians.

Unit 2: Reptilia 12 hrs/20 marks

General characteristics and classification up to order; Affinities of *Sphenodon*; External features of *Calotes versicolor* & *Uromastix hardwickii*; Poisonapparatus and biting mechanism in snakes; Difference between Venomous and non – venomous Snakes.

Unit 3: Aves 12 hrs/20 marks

General characteristics and classification up to order; *Archaeopteryx*- a missing link; Types of feathers , their roles and types of Beaks; Distinctive characters between flightless & Flying birds; Flightmechanism & adaptations; Perching mechanism and migration in birds;

Unit 4: Mammals (Prototheria & Metatheria) 12 hrs/20 marks

General characters and classification of Mammals up to order; Distinctive characters of Prototheria and Metatheria; Affinities of Prototheria with Reptiles & Birds; Affinities of Metatheria with Prototheria & Eutheria ; Significance of marsupium or abdominal pouch; Adaptive radiation with reference to locomotory appendages.

Unit 5: Mammals (Eutheria) 12 hrs/20 marks

General characters and classification up to order; Adaptations in Toothless, Aquatic, Flying & Fossorial mammals; Types of Feet; Adaptive convergence in Mammals; Dentition in Mammals.

Core Course – VI Practical: ZOO606CP

(Diversity of Chordates II: General organization of Chordata : Amphibia to Mammalia)

Practical [Credits 2] **30 hrs/50 marks**

.

1. Study of Museum Specimen/ Models :

   Amphibia: *Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra*
   Reptilia: *Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus*
   Aves: Study of six common birds from different orders. Types of beaks and claws
   Mammalia: *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus, Loris, Herpestes, Erinaceous.*
2. Study of Weberian ossicles of *Mystus*, pecten from fowl head and brain of fowl.
3. Power point presentation on study of any two animals from two different classes by students.

Examination evaluation Structure:

1. Museum Specimen: 3 Numbers/ 5marks each (Identification =1, Classification= 2, Characters = 2) Total = 15 marks
2. Power point presentation: 20 marks (Subject Knowledge, Presentation / delivery, Communication)
3. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about morphology and anatomy of chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of chordate biology would be created to ensure effective learning and

understanding of the concepts. Field-based project activities can be included to create interest among the students to study and explore the biology and behavior of chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/ Class in order to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

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

Online Tools and Web Resources:

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

Core Course -VII: ZOO607C (Fundamentals of Biochemistry)

Objective:

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

Outcome:

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

Course Content:

Theory [Credits: 4] 60 hrs/100 marks

Unit1: Thermodynamics& Bioenergetics: 12 hrs/20 marks

Acid-Base regulation & Disorders, Energy flow, Principles & Laws of Thermodynamics, Biochemical energetics, Redox reaction, Electron transport system, ATP synthesis, Fermentation as an anaerobic respiration, Energy yielding compounds, Chemical bonding : Covalent bond, Ionic bond, Hydrogen bonds, Van der Waal's bond, Electrostatic bond, Peptide bond.

Unit 2: Carbohydrates 12 hrs/20 marks

General Structure and Biological importance of Carbohydrates-reducing and non-reducing sugars: monosaccharides, disaccharides, polysaccharides and Glycoconjugates, Biochemical Processes: - Glycolysis, Glycogenesis, Glycogenolysis, Gluconeogenesis, Citric acid cycle, Hexose monophosphate shunt.

Unit 3: Proteins & Lipids 12 hrs/20 marks

Structure, Classification and General properties of - amino acids; Proteins and Lipids. Physiological importance of essential and non-essential α-amino acids. Protein folding, Ramachandran plot, . Levels of organization in protein motifs, folds and domains; Denaturation; Transamination & deamination, Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids; β - Oxidation.

Unit 4: Nucleic Acids 12 hrs/20 marks

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

Unit 5: Enzymes 12 hrs/20 marks

Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis- Menten equation, Concept of Km and Vmax, Line weaver- Burk plot; Multi-substrate reactions; Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme reaction. Vitamin – types & functions, Vitamin as a cofactor/ Coenzyme.

Core Course –VII Practical: ZOO607CP

(Fundamentals of Biochemistry)

Practical [Credits: 2] **30 hrs/ 50 marks**

1. To understand the preparation and roles of two important biological buffer systems: phosphate and bicarbonate; Preparation of buffers and determination of pH.
2. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
3. Quantitative Tests: Determination of Ascorbic acid – DCPIP method OR Estimation of Calcium–Titrimetric method.
4. Paper chromatography of amino acids.
5. Action of salivary amylase under optimum conditions.
6. Effect of pH, temperature and inhibitors on the action of salivary amylase.

Examination evaluation Structure:

1. Experiment on preparation of one biological buffer/ Quantitative tests of functional groups in carbohydrates, proteins and lipids. 10 marks (Procedure=5,Experiment=3,Result=2)
2. Determination of Ascorbic acid – DCPIP method OR Estimation of Calcium–Titrimetric method / Action of salivary amylase under optimum conditions or Effect of pH, temperature and inhibitors on the action of salivary amylase. 10 marks (Procedure = 5, Experiment = 3, Result = 2)

3. Paper chromatography of amino acids. 12.5 marks (Procedure= 7,Experiment = 3.5, result = 2)

4. Note Book: 7.5 marks (Based on the neatness, regularity, overall presentation)

5. Viva-Voce : 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

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

Assessment Methods:

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

Recommended Books:

- Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry. V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry. VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry. XXVIII Edition, International Edition, The McGraw - Hill Companies Inc.
- Lehninger, A.L, Nelson, D.L & Cox, M.M (2008). Principles of Biochemistry. W.H. Freeman & Co,N.Y.
- Devlin, T.M (2011). Text book of Biochemistry with clinical correlation. John Wiley & Sons
- Weil, T.M (1990). General Biochemistry. New Age International Ltd.
- Stryer Lupert (2002). Biochemistry. W.H. Freeman & Co, N.Y.

Suggested Reading:

- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry. II Edition, BIOS Scientific Publishers Ltd., U.K.

- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene. VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.

Online Tools and Web Resources:

- CEC Gurukul (www.cec.nic.in)
- https://www.youtube.com/user/cecedusat/featured.
- National Institute of Science Communication and Information Resources (NISCAIR) (http://www.niscair.res.in/) and National Science Digital Library (NSDL) (www.nsdl.niscair.res.in).
- National Digital Library of India (NDL India; https://ndl.iitkgp.ac.in/).

Generic Elective Course(GEC) - I: ZOO601G

(Fundamentals of Zoology – 1: Introduction to Cells & Tissues, Chromosomes, Biomolecules)

Objective: The course will make the students aware about the Zoology subject. It is aimed at providing knowledge on the diversity of cells, tissues, and biomolecules of living animals.

Outcome:

- Provide knowledge about types of cells, cell division, cell cycle and types of tissues
- Increase knowledge on structures of different biomolecules including nucleic acids and chromosomes

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit I: Introduction to cell 12 hrs/20 marks

Introduction to Cell, historical background, cell theory, cell types, cell membrane, nucleus, cytoplasm and other cell organelles, ultrastructure of plant and animal cells.

Unit II: Tissues 12 hrs/20 marks

Tissues, types of animal tissues; description with illustrations, examples & functions of common tissues like connective, muscular, nervous, epithelial tissues etc.

Unit III: Cell Cycle 12 hrs/20 marks

Cell totipotency, Cell division - prokaryotic division, amitosis, mitosis & meiosis, cell cycle, cell differentiation.

Unit IV: Nucleic Acids and Chromosomes 12 hrs/20 marks

Introductory idea of chromosomes, variations in chromosome structure, modification in structure, preliminary ideas on the structure and replication of DNA, ideas of RNA, genes, gene mutations.

Unit V: Biomolecules 12 hrs/20 marks

Biomolecules of Cells, major groups of organic Biomolecules, introductory idea of carbohydrates, lipids, proteins, nucleic acids, nucleotides, enzymes

Generic elective course (GEC) - 1 Practical: ZOO601GP

(Fundamentals of Zoology – 1: Introduction to Cells & Tissues, Chromosomes, Biomolecules)

Practical [Credits 2] **30 hrs/ 50 marks**

1. Identification of slides showing different tissues, cell division.

2. Slide making on cell division stages either from squash preparation of onion root tip or grasshopper testis.

3. A project report submission on any type of Cell division in animals.

Examination evaluation Structure:

1. Slide identification: 4 Numbers/ 4 marks each (Identification =1, Comments = 3) Total = 16 marks
2. One experiment on cell division: 9 marks (experiment and display = 6 marks, procedure = 3 marks)
3. Project report submission: 5 marks (Subject Knowledge, Presentation)
4. Power point presentation: 10 marks (subject knowledge, presentation/delivery, communication)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about cell and tissues of animals willbe imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations through slides and experiments. 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, etc. would be used to enhance their conceptual understanding. Inquiry- based collaborative learning environment through presentations, group discussions and round tables on the various aspects of cell biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities can be included to create interest among the students to study and explore the cell organelles and cell division processes of animals inculcating research aptitude. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order

to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

- Cooper, G. M. The cell: A molecular approach. Sixth Edition.
- Verma, P. S. & Agarwal, V. K. (2016). Cell Biology (Cytology, Biomolecules and Molecular Biology). S. Chand publications.

Courses for B. Sc. (Hons.) Zoology

SEMESTER IV

Core Course –VIII: ZOO608C (Paleozoology, Zoogeography, Evolution)

Objective:

The course is aimed towards providing knowledge on the Paleozoology, Zoogeography and evolution of animals. Topics on fossils, geological time scale & fauna, Zoogeographical regions, Barriers, distribution, speciation and different forms of evolution of animals have been incorporated to create interest among the Students.

Outcome:

The outcome expected on completion of course:

- Having knowledge about the geological history, geological time scale and associated fauna.
- Understand Fossils, their significance and dating, Zoogeographical region and their characteristic FAUNA.
- Experience the characters of realms, continental drift, Barriers, Speciation etc.
- Having knowledge on the evolutions by different forms of animals.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Paleozoology 12 hrs/20 marks

Definition of Paleozoology, Geological time scale and associated fauna; Fossils and Fossilization, types of Fossils, trace fossils, living fossils; Missing link – *Archaeopteryx*; Dating of Fossils; Significance of Fossils.

Unit 2: Zoogeography 12 hrs/20 marks

Definition of Zoogeography, Zoogeographical regions of the World with characteristic fauna. Wallace line; Marine realm, its divisions and characteristics; Tectonic plate & Continental drift; brief account of the Biogeography of India – Western Ghats & Himalayan region.

Unit 3: Barriers , Distribution & Speciation 12 hrs/20 marks

Barriers – types and significance, Species concept; Speciation & its types; significance of Speciation; inheritance of acquired modifications in speciation; Continuous, Cosmopolitan, Discontinuous, Bipolar & Isolated distribution. Adaptive radiation; Role of hybridization.

Unit 4: Evolution I: 12 hrs/20 marks

History of evolution of animals, origin of life, Evidences of evolution, Theories of evolution, modern concept of organic evolution, Hardy- Weinberg law, Genetic drift /Sewall – Wright effect.

Unit 5: Evolution II : 12 hrs/20 marks

Role of mutation in evolution, Variation, Natural selection – Directional, Stabilizing and Disruptive types. Isolating mechanism and their role in evolution, Coevolution – Parasite host coevolution, Evolution of Horse & Man. Introductory idea on Evolutionary Genomics.

Core Course –VIII Practical: ZOO608CP

(Paleozoology, Zoogeography, Evolution)

Practical [Credits: 2] **30 hrs/ 50 marks**

1. Study on Fossils of different Organisms.
2. Model preparation on different forms of organic evolution using diagrams/ paper models.
3. Study of living Fossils using Museum specimen / Photographs (*Limulus*, *Balanoglossus*, *Ornithorhynchus*, *Nautilus*, *Peripatus*, *Myxine*, Komodo Dragon)
4. PowerPoint presentation on any topic under Paleozoology, Zoogeography or evolution.
5. Documentary Film show on Paleozoology, Zoogeography or evolution / Visit to Zoological Park or Sanctuary or Biodiversity Park, report preparation and Submission.

Examination evaluation Structure:

1. Fossil display & identification: 15 marks (5 nos. x 3 marks)(Identification=1,Characters=2)
2. PowerPoint presentation: 15 marks (Subject knowledge, Presentation, Communication)
3. Field visit report or Film show report: 5 marks (based on inclusiveness and overall presentation)
4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of Paleozoology, Zoogeography & Evolution would be created to ensure effective learning and understanding of the concepts. Field-based project activities or Films can be included to create interest among the students to study and explore the missing links & Fossils inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills,

data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of how animals evolved. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/Class in order to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

- Lull, R.S. (2022). Organic evolution. Creative media partners, USA
- Futuyama, D.J. (1979). Evolutionary Biology. Oxford Univ. Press
- Mark, K.P & Futuyama, D.J. (2017). Evolution. Sinauer
- Mark Ridley (2004). Evolution (Third edition). Blackwell Publishing
- Raup,D.M. & Stanley,S.M. (2004).Principles of Paleontology 2nd Edition. W.H. Freeman
- Foote,M and Miller,A.I. (2007). Principles of Paleontology. 3rd edition. W.H. Freeman
- Darlington, P.J (1957 republished June 1980). The Zoogeography: The geographical distribution of animals. Wiley Publ.,New York
- Beddard, F.E. (2008). A text book of Zoogeography. Biblobazaar
- Ward,D.J. (2021). Fossils Smith Sonian Handbooks.

Online Tools and Web Resources:

* Digitized version of Evolutionary Biology by Futuyama, D.J (2010), SWAYAM, NISCAIR, NSDL resources.

Core Course –IX: ZOO609C

(Histology & Comparative Anatomy of Vertebrates)

Objective:

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

Outcome:

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

- Explain comparative account of the different vertebrate systems
- Understand the pattern of vertebrate evolution, organization and functions of various systems.
- Learn the comparative account of integument, skeletal components, their functions and modifications in different vertebrates.
- Understand the evolution of heart, modification in aortic arches, structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and digestive system and its anatomical specializations with respect to different diets and feeding habits.
- Learn the evolution of brain, sense organs and excretory organs to a complex, highly evolved form in mammals;
- Learn to analyze and critically evaluate the structure and functions of vertebrate systems, which helps them to discern the developmental, functional and evolutionary history of vertebrate species.
- Understand the importance of comparative vertebrate anatomy to discriminate human biology.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Histology 12hrs/ 20 marks

Basic principles of histological techniques, Microscopic anatomy of the following organs of a Mammal: Skin, Stomach, Intestine, Pancreas, Liver, Lungs, Kidney, Spinal Cord, Heart, Arteries, Veins, Capillaries, Lymph nodule, Spleen, Testis and Ovary.

Unit 2: Integumentary System & Skeletal System 12hrs/ 20 marks

Structure and derivatives of integument, functions of skin. Basic plan and comparative accounts of bones of skull, girdles, ligaments and limbs. Structure of a typical vertebra, Jaw suspension, Visceral arches.

Unit 3: Digestive System & Respiratory System 12hrs/ 20 marks

Comparative account of the Alimentary canal and associated glands, dentition. Comparative account of Skin, gills, lungs and air sacs; Accessory respiratory organs.

Unit 4: Circulatory System & Urinogenital System 12hrs/ 20 marks

General plan of circulation, Comparative account of heart and aortic arches. Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

Unit 5: Nervous System, Sense Organs & Endocrine glands 12hrs/ 20 marks

Nervous system : Comparative account of brain; Autonomic nervous system, Spinal cord, Cranial nerves inmammals ; Sense organs : Classification of receptors; Brief account of visual and auditory receptors in man. Endocrine glands: Comparative account of Pituitory, Thyroid, Adrenal, Pancreas and Gonads.

Core Course –IX Practical: ZOO609CP

(Histology & Comparative Anatomy of Vertebrates)

Practical [Credits: 2] **30 hrs/50 marks**

1 Study of placoid, cycloid and ctenoid scales of fish through permanentslides/photographs / Fresh preparations.

2 Study of different types of feathers of birds.

3 Disarticulated skeleton of Frog, *Varanus*, Fowl, Rabbit (Skull, Limb bones, Vertebral Column, Sternum, Girdles, Ribs).

4 Mammalian skulls (Model): One herbivorous and one carnivorous animal.

5 Study of digestive, circulatory and urinogenital system of frog/rat through videos or dissection or through virtual dissections.

6 Study of anatomical details of any two organs (brain, heart, lung, kidney, eye and ear) through videos.

7 Project on modifications in skeletal structures/GI tract/Respiratory organs in vertebrates.

Examination evaluation structure:

1. Preparation and display of Fish Scale: 10 marks (Experiment = 3, Procedure = 3, Diagram = 3, Result = 1).
2. Dissection of digestive, circulatory and urinogenital system of frog/rat through dissection or through virtual dissections. 10 marks (Experiment / Display = 3, Procedure = 3, Diagram & labelling = 4,).
3. Specimen identification (Feathers / Disarticulated skeleton) : 15 marks (3 nos. x 5 marks) (Identification = 1, Characters = 4)
4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

In order to ensure best understanding of concepts and learning of skills by students, various strategies will be adopted to explore and compare the major vertebrate groups. Class room lectures and crossover learning will provide a conceptual foundation to the leaner and will bridge the informal learning to formal learning. Use of models and computer-assisted learning by showing photographs/diagrams/models/animations/videos will help to clarify theoretical as well as practical concepts, from referred textbooks and E-resources available in NCBI, SWAYAM etc. Project work will encourage students to undertake projects on certain topics like modifications in GI tract, appendages, respiratory organs etc. with respect to different habitats. Peer teaching including presentation and group discussions on various topics of vertebrate comparative anatomy will allow effective participation of students in class room and develop confidence in students. Actual dissection process whenever possible, Computer-aided methods by showing virtual dissections or videos of anatomy of circulatory, digestive and reproductive systems of frog and rat, will provide an understanding of animal systems. Assignments will improve the writing and abstracting skills of students.

Assessment Methods:

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

Recommended Books:

- Kardong, K.V. (2005). Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
- Kent, G.C. and Carr, R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition.The McGraw-Hill Companies.
- Leiem, C.F., Bermis W.E, Walker and W.F, Grande, L. (2001). Functional anatomy of the vertebrates, An evolutionary perspective. III Edition, Brookes/Cole, Cengage Learning.
- C.K Weichert and W. Presch (1970). Elements of Chordate Anatomy, IV Edition, McGraw-Hill.
- Pough.H. (2018). Vertebrate Life. X Edition. Pearson International.
- Gartner,L.P (2015). Textbook of Histology.Elsevier Health Sciences

Online Tools and Web Resources:

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

Core Course – X: ZOO610C (Ecology and Biodiversity)

Objective:

Ecology provides us the knowledge of the relationships among living organisms including humans and their physical environment. It is the study of abundance, biomass, distribution, life processes, interaction, adaptations, movement of energy of organisms, successional development of ecosystems, patterns of biodiversity and its effect on ecosystem processes. Ecology teach us about the judicious use of existing ecological resources for sustainable development. Study of Ecology may provide opportunities to understand practical aspects and help in solving contemporary ecological issues and also provide experiences to understand ecosystem and ecology in a better way.

Course Learning Outcome:

Upon completion of course, students will be able to:

- Understand the key concepts in Ecology including Physical factors and limiting factors.
- Comprehend the characteristics, dynamics, growth models and interactions of a Population.
- Understand the ecosystem types, concepts, development and characteristics.
- Know the food chains, food webs, energy models and ecological efficiencies.
- Evaluate Biodiversity rich areas, threats and suggest remedial measures.
- Inculcate scientific skills to evaluate experimental designs and analyze information.
- Apply basic principles of ecology in conservation and management.

Course Content:

Theory [Credits: 4] 60 hrs / 100 marks

Unit1: Introduction to Ecology 9 hrs/ 15 marks

Definition, history and scope of ecology, ecological principles, biotic and abiotic factors (major environmental factors) influencing various ecosystems, concept of limiting factors – Liebig's law of minimum, Shelford's law of tolerance, concept of habitat and Niche, Niche breadth and Niche overlap, fundamental and realized Niche.

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Unit 2 Ecosystem 15 hrs/ 25 marks

Concept of ecosystem, Structure & function of ecosystem, major ecosystem, Men made ecosystem, agro- ecosystem, Food chain & energy flow, Primary and secondary production of ecosystems, Biosphere & Biome, Ecological pyramids and Ecological efficiencies, Nutrient and biogeochemical cycle with one example e.g. Nitrogen cycle . Greenhouse gases and global warming, Acid rain, Ozone layer destruction. Southern Oscillation (ENSO), Effect of climate change on public health

Unit 3: Population 15hrs/ 25 marks

Unitary and Modular Populations, Unique and group attributes of Population :- Density, Demography, Natality, Mortality, Life tables, Fecundity tables, growth models, survivorship curves, Variations in natural Population, age ratio, Sex ratio, dispersal, dispersion; Carrying capacity. Biotic potential, Exponential and logistic growth, equation and patterns, r and k strategies; Population regulations, Density – dependent and independent factors; Gauss's principle with laboratory and field examples; Lotka - Volterra equation for competition and predation; Functional and numerical responses.

Unit 4 : Community 12 hrs/ 20 marks

Community characteristics : Species richness, dominance, abundance; ruderal, competitive & Stress tolerant organisms; Guilds, Ecotone and edge effect, Keystone species, Ecological succession with examples and types, Theories pertaining to climax community, Species interaction.

Unit 5: Biodiversity 9hrs/ 15marks

Biodiversity, types, Concept, Importance of Biodiversity, biodiversity hotspots, Threats to Biodiversity; IUCN Red list, Protected areas: National Parks, Bio reserves and Sanctuaries.

Core Course – X Practical: ZOO610CP
(Ecology and Biodiversity)

Practical [Credits: 2] **30 hrs/50 marks**

1. Determination of minimum size of quadrates necessary for the study of grassland community.
2. Determination of frequency values of grassland species. Classification of species into frequency classes. Comparison of the result with Raunkiaer's standard frequency diagram.
3. Determination of density of different species in a grassland ecosystem.
4. Determination of abundance of different species in a grassland ecosystem.
5. Studies on the population density of insect communities (above ground and below ground)
6. Primary productivity estimation of grassland and aquatic ecosystems by harvest and light bottle method respectively.
7. Temperature measurement of soil, air and water.
8. Measurement of moisture regime of air (relative humidity).
9. Basic physical and chemical properties of soil: pH, Nitrate, Carbonate, etc.
10. Estimation of dissolved Oxygen and carbon dioxide content of water samples.
11. Study of life table and plotting of survivorship curves of different types from the hypothetical / real data provided.

Examination evaluation structure:

1 Experiment on grassland community: 10 marks (Experiment = 4, Procedure = 4, Result = 2).

2 Measurement of temperature/Moisture/Physical and chemical properties. 13 marks (Experiment = 5, Principle & Procedure = 6, Result = 2).

3 Experiments on Primary productivity of aquatic ecosystem/ Estimation of dissolved Oxygen and carbon dioxide content of water samples / life table and plotting of survivorship curves of different types from the hypothetical / real data provided: 12 marks (Experiment = 4, Procedure = 5, Result = 3)

4 Note Book: 5 marks (Based on the neatness, regularity, overall presentation)

5 Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Classroom lectures, both traditional based teaching as well as Power point presentation based on text books and scientific journal readings shall create an effective understanding of the Subject. The topics on Ecology and Biodiversity can share the ways and means for us to live with nature for mutual benefit. Learning processes shall also include participatory activities like focused group discussions, presentation by Students, experience sharing, brainstorming and project writing. Laboratory works shall provide Students the much needed hands – on experience for better understanding of the Subject.

Assessment Methods:

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

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

Recommended Books:

- Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition Brocks/Cole.
- Smith, R.L. (2000). Ecology and Field Biology. Harper and Row Publisher.
- Krebs, C.J. (2001). Ecology. VI Edition. Benjamin Cummings.
- Rickilefs, R.E. (2000). Ecology. V Edition. Chiron Press.

Online Tools and Web Resources:

- e-PG Pathshala, SWAYAM, Coursera,
- BBC, Discovery, National geographic, Science Inside

Generic Elective Course(GEC) - II: ZOO602G

(Fundamentals of Zoology – 2: Introduction to Animalia)

Objective: The course will make the students aware about the Zoology subject. It is aimed at providing knowledge of the diversity of animal life, morphological and anatomical features of selected animals, their significance and roles in the environment. **Outcome:**

- Having knowledge of animal identification, their habitat, phylum and structural organization
- Understand economic importance of animals, their interaction with the environment, role in the ecosystem, evolutionary history and their relationships
- Enhanced knowledge of different groups, communication skills and parental care.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit I: Non-chordates 12 hrs/20 marks

General characteristics of Animalia, Introduction to Non chordata, General characteristics of different phyla under non chordata with representative species.

Unit II: Chordata 12 hrs/20 marks

General characteristics of Chordata, general characteristics of different phyla under Chordata with representative species.

Unit III: Introduction to Vertebrata 12 hrs/20 marks

Characters of Vertebrates, evolutionary history of Vertebrates, diversity of Vertebrates, comparative account between invertebrates & Vertebrates, features of Poikilothermic & Homeothermic Vertebrates

Unit IV: Behaviour in amphibians, reptiles and birds 12 hrs/20 marks

Parental care in vertebrates, defensive mechanisms in Amphibians & Reptiles, feathers and beak types in birds, Perching & flight mechanisms in birds, migration in birds.

Unit V: Behaviour in mammals 12 hrs/20 marks

Dentition in mammals; Adaptations in different kinds of mammals; behaviour, social system, population & community ecology of mammals; human origin.

Generic elective course (GEC) - II Practical: ZOO602GP

Practical [Credits 2] **30 hrs/ 50 marks**

1. Study on the whole mounts/ museum specimen of different phylum (Identification of species and phylum with characters)

2. To submit a project report on the life cycle of any animal using photographs or illustrations.

Examination evaluation Structure:

1. Museum Specimen: 5 Numbers/ 5 marks each (Identification =1, phylum= 1, Characters = 3) Total = 25 marks
2. Power point presentation: 10 marks (Subject Knowledge, Presentation / delivery, Communication)
3. Project report: 5 marks (knowledge and presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about morphology and anatomy of animals will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of invertebrate and vertebrate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities can be included to create interest among the students to study and explore the biology and behavior of animals inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, datacollection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of animals and the basis of classification. Curriculum- related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/ Class in order to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their

performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Recommended Books:

- Young, J. Z. (2004). The Life of Vertebrates. III Edition, Oxford university press.
- Parker, T.J. and Haswell W.A. (1972). Textbook of Zoology Vertebrates. VII Edition, Volume II
- Pough, H. (2018). Vertebrate life X Edition, Pearson International.
- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Courses for B.Sc. (Hons.)

Zoology SEMESTER V

Core Course -XI : ZOO711C (Developmental Biology & Immunology)

Objective: Developmental Biology provides knowledge on the embryonic and post embryonic developmental processes. The course is aimed to make the undergraduate students realize the aspects of developmental biology. The course explains the basic principles and concepts underlying the developmental processes at the cellular and molecular level. By understanding the developmental processes, the students shall be able to relate to the errors occurring during development leading to congenital disorders and human diseases. The course in immunology is to apprise the student with the working of the immune system in normal health and its role in fighting diseases. This course is also designed to enable understanding the molecular and cellular basis of the development and function of the immune system, identification of its biological, clinical and therapeutic implications.

Outcome:

The students shall be able to have knowledge on the followings on completion of the Course

- Acquire basic knowledge on the events that lead to formation of a multicellular organism from a single fertilized egg, the zygote including the knowledge of the cellular processes of development and the molecular mechanisms underlying these.
- Knowledge on the general patterns and sequential developmental stages during embryogenesis; the general mechanisms involved in morphogenesis; the process under which different cells and tissues interact in a coordinated way to form various tissues and organs.
- Ideas on the processes of Teratogenesis, functional interplay of innate and adaptive immunity, cellular/molecular pathways of humoral/cell-mediated adaptive responses including the role of Major Histocompatibility Complex, the cellular and molecular aspects of lymphocyte activation, homeostasis, differentiation, and memory shall be imparted.
- The molecular basis of complex, humoral (Cytokines and Complement) and cellular processes involved in inflammation and immunity, in states of health and disease, vaccination, autoimmunity,immunodeficiency, hypersensitivity, tolerance and State of the Art experimental methods and technologies shall be elaborated.

Course Content:

Theory [Credits: 4] **60 hrs/100 marks**

Unit 1: Introduction to Developmental Biology 12 hrs/20 marks

Historical perspective and basic concepts: Phases of development, cell-cell interaction, pattern formation, differentiation and growth, differential gene expression, cytoplasmic determinants and asymmetric cell division, Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Developmental biology & merits, types of development, Fertilization (External and Internal): mechanism, general sequence & molecular events during fertilization, Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Chemical changes during Cleavage, Types of Blastula; Fate maps.

Unit 2: Embryonic Development 12 hrs/20 marks

Early development of frog and chick up to gastrulation; Embryonic induction and organizers, Fate of Germ Layers; Formation of neural tube, Extra-embryonic membranes in birds;Implantation of embryo in humans, elementary concept of Transplantation, Determination, Competence, embryonic induction and organizers; Placenta (Structure, types and functions of placenta); Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration:Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories.

Unit 3: Teratogenesis and overview of Immune system 12 hrs/20 marks

Teratogenesis: Teratogenic agents and their effects on embryonic development; Teratogenesis as an environmental assault on human development;
Overview of Immune system: Historical perspective of Immunology, Early theories of Immunology, Clonal Selection Theory, Cardinal features of vertebrate immune system, Hematopoiesis, Cells and organs of the Immune system. Anatomical barriers, Inflammation, Cell and molecules involved in innate Immunity,Adaptive Immunity (Cell-mediated and Humoral), Passive immunity; Active: Artificial and natural Immunity, Immunological Tolerance.

Unit 4: Antigens, Antibodies, and Immunoglobulins: 12 hrs/20 marks

Structure of antibodies; Functional properties of antibodies. Generation of antibody diversity – molecular mechanism, role of major histocompatibility complex in immune response. Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes, Structure and functions of different classes of immunoglobulins, Antigenic determinants on Immunoglobulins, Antigen-antibody interactions (Precipitation reactions, Agglutination reactions, Immunofluorescence and ELISA), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis.

Unit 5: MHC, Cytokines, Complement system, Diseases: 12 hrs/20 marks

Structure and functions of Major histocompatibility complex (MHC) molecules (MHC I and II), Endogenous and exogenous pathways of antigen processing and presentation, concept of Cytokines, Properties and functions of cytokines, Complement system, Components and pathways of complement activation, biological consequences of complement activation. Tumor immunology, Immunization, Immunodeficiency diseases – Primary, Combined, severe combined, acquired, secondary immunodeficiency diseases; Hypersensitivity; recent developments in antibodies and immune therapy.

Core Course -XVII Practical : ZOO711CP (Developmental Biology & Immunology)

Practical [Credits: 2] 30 hrs/ 50 marks

Part A

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

Part B

5. Histological study of spleen, thymus and lymph nodes through slides/photographs.
6. Preparation of stained blood film to study various types of blood cells.
7. Basic patterns of precipitation by Ouchterlony's double immuno-diffusion method.
8. ABO Blood group antigen determination by hemagglutination.
9. Demonstration of: ELISA, Immunoelectrophoresis

Examination evaluation Structure:

1. Identification of Slides with Characters (at least three Characters) : 3 each from Part A & B : 6 (1 + 3) = 24
2. Whole mount of Part A : Characters & Identification (only 2) : (1 + 2) 2= 6
3. Blood smear to show blood components or blood group : Procedure = 3, experiment = 2
4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce : 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand & Company

Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition,International Thompson Computer Press.

Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-HillPublishers.

David, M., Jonathan, B., David, R. B. and Ivan, R. (2006). Immunology, VII Edition,Mosby, Elsevier Publication.

Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc.Publishers, Sunderland, Massachusetts, USA

Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006). Immunology,VI Edition, W.H. Freeman and Company.

Suggested Reading:

- Abbas, K. Abul and Lechtman H. Andrew (2003) Cellular and Molecular Immunology.V Edition, Saunders Publication.
- Kalthoff, K. (2001). Analysis of Biological Development. II Edition, McGraw Hill Publishers.
- Kenneth Murphy and Casey Weaver (2016). Janeway's Immunobiology, IX Edition, Garland Science
- Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell
- Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.

Online Tools and Web Resources:

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

e-PG Pathshala portal of Government of India: https://epgp.inflibnet.ac.in Fundamentals of immunology;https://www.coursera.org/specializations/immunology.

Core Course -XII: ZOO712C (Cell Biology & Genetics)

Objective:

This course provides a comprehensive understanding of Cell Biology, emphasizing the cell as the fundamental unit of life and Genetics as the basis of inheritance. Students will explore the structure and function of cellular organelles, regulatory mechanisms, and genetics, from Mendelian principles to contemporary insights like epigenetics and gene regulation. The course prepares students for higher studies & research in Genetics and related fields.

Outcome: Upon completion of the course, students shall be able to:

- Understand core concepts of cell biology and genetics, including genomics and metagenomics.
- Explain the structure and functions of cellular organelles involved in key processes.
- Grasp how cells grow, divide, signal, and regulate vital functions.
- Analyze the principles of inheritance and how they extend beyond Mendel's laws.
- Understand genetic regulation, mutations, and chromosomal abnormalities in diseases.
- Develop critical thinking and data analysis skills in genetics and cell biology research.
- Explore model organisms and their role in advancing genetics research.
- Gain insight into epigenetics and gene regulation in health and disease.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Overview of Cells, Cellular Organelles and Membrane Dynamics 12 hrs/20 marks

Overview of prokaryotic and eukaryotic cell types and their key differences. Comparative structure of plant and animal cells. An overview of structure and function of the following cellular components: Plasma Membrane, Mitochondria, Nuclear Membrane, Cytoskeleton, Endoplasmic Reticulum (ER types), Golgi Apparatus, Lysosomes, Peroxisomes, Mitochondria, Nucleus, Nucleolus, Vacuoles, Chloroplasts, Ribosomes, Centrosomes and Centrioles. Structure and functions of microtubules, microfilaments and intermediate filaments; Transport across membranes: diffusion, osmosis, ion channels; ion pumps, active & passive transport, facilitated transport.

Unit 2: Chromosome Structure & Types, Cell Division and Cell signaling & communication 12 hrs/20 marks

Structure and types of chromosomes, Specialized chromosomes – Polytene and Lamp brush chromosomes, nucleosome organization: DNA – histone complex, higher order chromatin folding. Chromosomal variations and abnormalities. Cell Division: Phases of Mitosis and Meiosis: Key steps and regulation of the processes. Overview of Cell Cycle and mechanisms of cell cycle control. Cell-Cell junctions and general principles of cell communication, Cell adhesion, roles of different adhesion molecules, gap junctions, integrins, neurotransmission & its regulation, Apoptosis.

Unit 3: Principles of Inheritance – Mendelian Genetics 12 hrs/20 marks

Mendelian Genetics: Mendel's laws of segregation and independent assortment. Monohybrid and dihybrid crosses, test crosses, and backcrosses. Concepts of dominance, recessiveness, and co-dominance. Concept of gene, allele, pseudo allele, multiple alleles. Extensions of Mendelian Genetics: Incomplete dominance, co-dominance, multiple alleles, lethal alleles. Penetrance and expressivity, epistasis, pleiotropy. Sex-linked, sex-influenced, and sex-limited traits. Polygenic Inheritance: Traits controlled by multiple genes (e.g., skin color, height). The role of multiple genes in producing continuous variation in traits.

Unit 4: Non-Mendelian & Extra-nuclear Inheritance, Gene Regulation & Epigenetics

12 hrs / 20 marks

Non-Mendelian and Extra-nuclear Inheritance: Cytoplasmic Inheritance and Genomic Imprinting: Maternal effects and genomic imprinting (e.g., shell coiling in *Limnaea*). Organelle Inheritance: Mitochondrial inheritance, antibiotic resistance in *Chlamydomonas*, mitochondrial mutations in *Saccharomyces* and related human disorders. Infective Heredity: Inheritance patterns in *Paramecium*. Prokaryotic and Eukaryotic Gene Regulation: Mechanisms of gene regulation in prokaryotes (e.g., lac operon) and eukaryotes. Epigenetics: DNA methylation, histone modifications, and chromatin remodeling. Epigenetic Control of Gene Expression: Epigenetic mechanisms in development and diseases (e.g., cancer, imprinting disorders). Environmental Influence on Epigenetic Traits: Impact of environmental factors on epigenetic modifications and the heritability of epigenetic traits.

Unit 5: Linkage, Chromosomal Mapping, Mutations, Sex Determination and Quantitative genetics

12 hrs/20 marks

Linkage, Crossing Over, and Chromosomal Mapping. Gene mapping techniques, including somatic cell hybridization. Mutations – physical and chemical mutagens, types of mutations and their detection methods. Chromosomal aberrations. Sex Determination: Genetic and environmental mechanisms of sex determination in *Drosophila* and humans. Dosage compensation mechanisms: X-inactivation in mammals, hyperactivation of the X chromosome in *Drosophila*. Mechanism of Sex Reversal in Animals such as fish and amphibians and the factors influencing sex reversal. Pedigree analysis, Karyotypes, genetic disorders, polygenic inheritance, heritability and its measurements.

Recommended Books:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). ***Molecular** Biology of the Cell*, 6th Edition. Garland Science, Taylor & Francis Group.
- Becker, Kleinsmith and Hardin (2009): The world of the Cell, VIII Edition. Benjamin Cummings Publishing, San Francisco.
- Cooper,G.M. and Hausman,R.E. (2009): The Cell : A molecular approach, V edition, ASM Press and Sinauer associates.
- Klug, W.S., Cummings, M.R., Spencer, C.A., & Palladino, M.A. (2018). *Concepts of Genetics*, 12th Edition. Pearson Education.
- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. (2016). *Molecular Cell Biology*, 8th Edition. W.H. Freeman & Company.
- Snustad, D.P., & Simmons, M.J. (2015). *Principles of Genetics*, 7th Edition. John Wiley & Sons.
- Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., & Doebley, J. (2020). *Introduction to Genetic Analysis*, 12th Edition. W.H. Freeman & Company.

Suggested Readings:

- De Robertis, E.D.P., & De Robertis, E.M.F. (2018). *Cell and Molecular Biology*, 9th Edition. Lippincott Williams & Wilkins.
- Karp, G. (2018). *Cell and Molecular Biology: Concepts and Experiments*, 8th Edition. John Wiley & Sons Inc.
- Pierce, B.A. (2017). *Genetics: A Conceptual Approach*, 6th Edition. W.H. Freeman & Company.
- Becker, W.M., Kleinsmith, L.J., & Hardin, J. (2018). *The World of the Cell*, 9th Edition. Pearson Education.
- Russell, P.J. (2016). *Genetics: A Molecular Approach*, 3rd Edition. Pearson Education.

Online Tools and Web Resources:

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology
- https://www.khanacademy.org/science/biology/crash-course-bio-ecology/crash-course-biology-science/v/crash-course-biology-123
- https://opentextbc.ca/biology2eopenstax/chapter/chordates/

Core Course – XII Practical: ZOO712CP
(Cell Biology & Genetics)

Practical [Credits 2] 30 hrs/50 marks

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
2. Simulation exercises using beads or seeds to study the Mendel's laws and gene interactions.
3. Study of various stages of meiosis.
4. Verification of Mendelian ratios using Chi-square analysis/test, Pedigree analysis.
5. Preparation of temporary stained mount to show the presence of Barr body in human femaleblood cells/ cheek cells.
6. Linkage maps based on data from conjugation.
7. Cytochemical staining and preparation of permanent slide to demonstrate:
   (a) DNA by Feulgen reaction
   (b) Mucopolysaccharides by PAS reaction
   (c) Proteins by Mercuric Bromophenol Blue/Acid Fast Green.

Examination evaluation Structure:

1. Temporary slide preparation : 2 numbers (Procedure = 05, Slide = 04, Display = 03) Total = 24 marks
2. Identification of Meiotic stages (2 slides) (Identification : 01, Character = 02) Total = 06
3. Cytochemical staining and preparation of permanent slide (Procedure = 03, Display/result = 02) Total = 5 marks
4. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, powerpoint presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium willbe adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questionson start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Generic Elective Course (GEC) -III : ZOO703G

(Fundamentals of Zoology – 3: Protozoa & Phyla of Invertebrates)

[**NOTE** : Zoology discipline offers six generic elective courses titled " Fundamentals of Zoology 1 to 6 for six semesters of UG course (Semester III to VIII). GEC in Zoology shall be opted by Students of other Subjects other than those of Zoology (Zoology students are not allowed to take GEC in Zoology). Based on the ordinance for UG programs, GEC is a course chosen generally from an unrelated discipline/ Subject with an intention to seek a wide exposure. A core subject offered in a subject may be treated as a GEC. However, as per resolution of the Deans' committee meeting held on 4.3.2024 and subsequent circular of the Registrar MU/4-133/2024/1266 dated the 5th March 2024 GEC syllabi may be formed in the line of the CBCS in Master's course.]

Objective: The course will make the students aware about the different groups of Animals. It is aimed at providing knowledge on the diversity of animals right from the simple Poriferans up to the highest form i.e. Man

Outcome:

- **Provide knowledge about types of animals, their characters and representative Species**
- Increase knowledge on the relationships between the different groups.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit I: Protozoa & Porifera 12 hrs/20 marks

General Characters and different classes of Protozoans with examples, Structure, life Cycle and clinical significance of *Plasmodium* sp. General Characters and different classes of Poriferans with examples, Canal system in Sponges, integumentary system in Sponges.

Unit II: Cnideria & Platyhelminthes 12 hrs/20 marks

General Characters and different classes of Cnideria with examples, Polymorphism in Coelenterates, Corals & Coral reef formation; General Characters and different classes of Platyhelminthes with examples, Life cycle of *Fasciola hepatica* and *Taenia solium*.

Unit III: Nemathelminthes & Annelida 12 hrs/20 marks

General Characters and different classes of Nematodes with examples, Life cycle of *Ascaris lumbricoides,* its parasitic adaptation and medical importance. General Characters and different classes of Annelida with examples, Significance of medicinal Leeches.

Unit IV: Mollusca & Echinodermata 12 hrs/20 marks

General Characters and different classes of Mollusca with examples, Torsion in Gastropods. General Characters and different classes of Echinodermata with examples, Water vascular system in Asteroidea.

Unit V: Arthropoda & Hemichordata 12 hrs/20 marks

General Characters and different classes of Arthropoda with examples, metamorphosis in Insects, Economic and medical importance of Insects. General Characters of Hemichordata , Affinities of Balanoglossus with Chordates and non-Chordates.

Generic Elective Course (GEC) -III Practical : ZOO703GP

(Fundamentals of Zoology – 3: Protozoa & Phyla of Invertebrates)

Practical [Credits 2] 30 hrs/ 50 marks

1. Identification of slides of Protozoans and museum specimen representing the Invertebrates.
2. Slide making of free living Protozoans / Blood smears to show malarial parasites.
3. Visit on foot to a place near the Institute to get familiarized with different invertebrates available in the area & submission of a report.

Examination evaluation Structure:

1. Slide identification: 2 Numbers/ 4 marks each (Identification =1, Comments = 3) Total = 8 marks
2. Museum Specimen identification: 6 Numbers/ 3 marks each (Identification =1, Comments = 2) Total = 18 marks
3. One slide preparation: 9 marks (experiment and display = 6 marks, procedure = 3 marks)
4. Field report submission: 5 marks (Subject Knowledge, Presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about cell and tissues of animals willbe imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations through slides and experiments. 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, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of cell biology would be created to ensure effective learning and

understanding of the concepts. Field-based project activities can be included to create interest among the students to study and explore the cell organelles and cell division processes of animals inculcating research aptitude. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Discipline Specific Elective (DSE) Course - I: ZOO701D(a)

Wildlife & Bioresource management

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 identifyand achieve wildlife management goals. This course will motivate students to pursue career in the field of wildlife conservation and management.

Outcome:

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

- Become aware about the importance of wildlife in general, and its conservation andmanagement in particular.
- Comprehend the application of the principles of ecology and animal behaviour toformulate 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 *exsitu* conservation.
- Recognize the techniques for estimation, remote sensing and Global Position Trackingfor wildlife.
- Gain knowledge about the wildlife diseases and the quarantine policies.
- Know about the Protected Area Networks in India, Ecotourism, Ecology of perturbationand 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] **60 hrs/ 100 marks**

Unit 1: Introduction , evaluation & management of Wildlife 12 hrs/20 marks

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

Unit 2: Management of Habitats , Population estimation 12 hrs/20 marks

Setting back succession: Grazing logging; Mechanical treatment; Advancing the successionalprocess: Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats. 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

Unit 3: Excess population of Wildlife & Protected Areas– Management & Planning

12 hrs/20 marks

Estimation of carrying capacity; Human-wildlife conflict; Eco tourism / wild life tourism in forests; Climax communities: characteristics and theories; Ecology of purterbance. Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wildanimals: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and Mouth Disease, *Mycobacterium* TB, Bovine and Avian Flu

Unit 4 : Protected areas 12 hrs/20 marks

Biodiversity hotspots, Biosphere reserves, National parks and sanctuaries; Biosphere reserves; Conservation and Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India andManagement, challenges in Tiger reserve; Brow Antlered Deer conservation & Challenges

Unit 5 : Bioresource 12 hrs/20 marks

Bioresource Concepts and types – Animals, Plants, Cells, Genes, Microorganisms. Significance of Bioresources and threats faced by them, Insect resources, Fishes and Livestock, Animal products & processing, Biomass, Bioenergy and Biomaterials; basic biomolecules and Water; Antigen & antibodies, Bioremediation.

Recommended Books:

- Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHIlearning Pvt. Ltd. ISBN: 8120353137, 978-812035313
- Sinclair, A.R.E., Fryxell, J.M. and Caughley,G. (2006). Wildlife Ecology, Conservationand 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). TheEcology of Wildlife Diseases. Oxford University Press, Oxford.
- Banerjee, K. (2002). Biodiversity Conservation in Managed and Protected Areas.Agrobios, India.
- Sharma, B.D. (1999). Indian Wildlife Resources Ecologyand Development. DayaPublishing 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

Discipline Specific Elective (DSE) Course –I Practical :

ZOO701DP(a)

Wildlife & Bioresource management

Practical [Credits 2] **30 hrs/50 marks**

1. Identification of mammalian fauna, avian fauna, herpeto-fauna through direct and indirectevidences 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,Varioustypes 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.

Examination evaluation Structure:

1. Identification of Fauna from models/ Pictures/Photos: 5 numbers x 4 marks (Identification=1, Characters=3): Total = 20
2. Identification of pug marks, hoof marks, scats, nests and antlers from models/ Pictures/Photos: 5 numbers x 2 marks (Identification=1, Character=1): Total = 10
3. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)
5. Field visit report : 5 marks

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student. 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 understandingof the subject. Digital collection of pictures of pugmarks, hoof marks, bird's nests, wild faunaand flora will facilitate observation of their characteristic features with ease.
- A variety of approaches to teaching-learning process, including lectures, seminars, powerpoint presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this. Project based reports, assignments and E-posters can also form an important part of learning regime.
- Laboratory sessions will constitute an important part of the course along with its

theoretical background. The laboratory sessions will include pre-lab questions and post-lab questionson start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text. Field-based research projects will develop interest in the subject and motivate students to peruse research as a career in future. Visits to renowned institutions and 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:

Measures to be adopted for assessment are as follows.

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

Discipline Specific Elective (DSE) Course - I: ZOO701D(b)

Integrated Pest management

Objective:

The course is designed with an aim to provide the students the knowledge of balance of nature, understand the life cycles, behaviours, and interactions of pests within ecosystems. Develop the ability to accurately identify pests and beneficial organisms, Learn about the safety measures and regulatory aspects of pesticide use.

Outcome:

Upon completion of the course, students shall be able to recognize and identify various pest species and their life cycles, have Strong critical thinking and problem-solving skills tailored to addressing pest management challenges, Understand the safety protocols and regulatory requirements associated with pesticide use and to implement IPM plans effectively in real-world agricultural settings.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Introduction to IPM 12 hrs/20 marks

Introduction: Definition and Importance of IPM; Historical development of IPM; Pests definition and categories. Plant pathology, Concept of pest management, Ecological aspects as foundation for IPM; Principles of IPM, mechanical strategy for IPM.

Unit 2: **Components of IPM-I** 12 hrs/20 marks

Economic thresholds, Sampling & monitoring of Pests, Legal approach to IPM, ecological management, diverting pest population away from the crop.; managing insects with resistant plants; history, mechanism of resistance and use of plants as resistant means in pest management.

Unit 3 : **Biological and Genetic control** 12 hrs/20 marks

Biological control; predators, parasitoids and microbes. Merits & demerits of Biological control, Pest management by modifying insect development and behaviour; Sterile insect technique. Sterile Insect release method; Botanical pest management. Genetic control and transgenic plants, insect growth regulators like repellants, attractants, inhibitors etc.

Unit 4: Chemical and Innovative approaches for IPM 12 hrs/20 marks

Chemical means of pest management. Types of Insecticides, adjuvant & formulation, Chemical control with reference to organochloride, organophosphate, carbamates, synthetic pyrethroids ; Pest management through innovative approaches like biotechnological approach,; Adoption of IPM; pros and cons.

Unit 5: **IPM and sustainable agriculture** 12 hrs/20 marks

Implementation of IPM in cereals (paddy), pulses (pigeon pea and Soybean) and commercial crops (sugarcane), vegetable crops (cabbage and tomato), Pesticide in IPM & Pesticide management, Host plant resistance, Weed management

Recommended Books:

1. Handbook of Integrated Pest Management by Govt. of India Indian Council of Agricultural Research (ICAR).
2. General and Applied Entomology by David B.V and Ananthakrishnan T.N; Tata McGraw Hills, New Delhi.
3. Biopesticides and Pest management by Dhaliwal G.S and Opendro Koul. Kalyani Publishers, New Delhi.

Suggested Readings:

1. A manual of practical Entomology (field and Laboratory guide) by M.M Trigunayat. Scientific publishers (India)
2. Elements of Economic Entomology by David B.V and Ramamurthy V.V. Namrutha publication, Chennai

Online Tools and Web Resources:

1. http://www.eagri.org/eagri50/ENTO232/index.html
2. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=12468

Discipline Specific Elective (DSE) Course –I Practical :

ZOO701DP(b)

Integrated Pest management

Practical [Credits 2] 30 hrs/50 marks

Examination evaluation Structure:

Examination evaluation Structure

1. Identification of Pest, Parasitoid species. 5x4=20 Mark
2. Pesticide formulation. 5 Mark
3. Submit a report of field visit (Paddy field, Vegetable farm, Fruit Orchard). 10 Mark
4. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, powerpoint presentations, workshops, peer teaching/learning, assignments, project- based learning, simulation videos, group or co-operative learning, book reviews, research colloquium willbe adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questionson start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Discipline Specific Elective (DSE) Course - I: ZOO701D(c)

Fish & Fisheries

Objective:

The course is designed with an aim to provide the students the knowledge to learn about taxonomic identification of various cultivable fishes, basic idea of production of fish seed, rearing of spawn stage fry and fingerling, basic fish physiology, feed formulation, harvesting, processing of fishery products and marketing.

Outcome:

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

- identify various cultivable fish species,
- breed and rear cultivable fishes,
- formulate fish feed,
- harvesting and processing of fishery products and marketing.

Course Content:

Theory [Credits: 4] **60hrs/ 100 marks**

Unit1: Integrative Fish Taxonomy: Morphological, Anatomical (osteology) and Molecular Approach (Fish DNA barcoding), characteristics of Chondrichthyes & Osteichthyes, dichotomous key, type specimens, invasive species, commercially important endemic and exotic food fishes, ornamental fishes, brackish water and coldwater fishes, hill stream fishes and its adaptive modification, cultivable species of prawn. 12 hrs/20 marks

Unit2: Fish Physiology and biotechnology: Types of scales, modification of alimentary canal based on food and feeding habits, digestion of food, circulation in fish, aquatic respiration, osmoregulation in migratory fishes. Cryopreservation of milt, Hybridization, production of monosex population, transgenic fish: its merits and demerits. Feed biotechnology: Probiotics, single cell proteins, Nutraceuticals. 12hrs/20 marks

Unit3: Fish reproduction, breeding and seed production: Functional morphology of gonads, types and modes of reproduction, Fecundity, Bundh breeding, induced breeding by using pituitary extract; induced breeding by injecting commercial synthetic hormones, hatcheries: Double-walled hatching hapa, clay pots, glass jars, Chinese circular hatcheries; stages of fish seeds, conditioning, packing, and transport of brood fishes and fish seed.

12 hrs/20 marks

Unit4: Fish farming and ecological parameters: Fish farm construction and layout of different types of ponds; Pre-stocking preparation of Ponds; Post-stocking management. Physico-chemical properties of pond water and soil and their maintenance. Different types of aquaculture systems based on stocking density and management practices. Climate Resilient Aquaculture Technologies: Recirculatory Aquaculture System(RAS), Biofloc, Aquaponics 12 hrs/20 marks.

Unit5: **Fish Nutrition and health; Harvesting & preservation techniques, extension and marketing**: Components of fish feed; principle of fish feed formulation, fish food organisms. Fish diseases: Infectious and Non-infectious Pathogens (bacterial, viral, fungal, protozoan, helminth diseases of fish, nutritional disease). Inland fishing crafts and gears, Spoilage of fish and causative agents, methods of fish preservation and processing, methods of fishery extension, fish marketing channels.

12 hrs/20 marks

Recommended Books:

1. Jhingran, V.G.: Fish and Fisheries of India 3rd. En Today and Tomorrow Book Agency, New Delhi
2. Pillay, T.V.R. 1990: Aquaculture, principles and Techniques. Fishing News Bk. Ltd.
3. Edmonson, W.I.: Freshwater Biology, War and Weipel.
4. Abidi, R.: Fish Pathogen & Diseases in India.
5. Amlacher, E.: Text Book of Fish Diseases.
6. Gupta, S. K. & P.C. Gupta: General and Applied Ichthyology (Fish and Fishery), S. Chand & Co. Ramnagar, New Delhi, 110055.
7. Lagler, K. F., Bardach, J. E., Miller, R. R., & Dora, R. May Passino (1977) Ichthyology.
8. Lucas, J. S., Southgate, P. C., & Tucker, C. S. (Eds.). (2019). *Aquaculture: Farming aquatic animals and plants*. John Wiley & Sons.
9. Hoar, W. S., Randall, D. J., & Donaldson, E. M. (1983). *Fish physiology*. Academic Press.
10. Vishwanath, W. (2021). *Fishes of Eastern Himalayas*. Academic Press.
11. Darshan, A., Abujam S., & Das, D.N. (2019). Biodiversity of Fishes in Arunachal Himalaya. Academic Press.
12. Timmons, M. B., Guerdat, T., & Vinci, B. J. (2018). *Recirculatory Aquaculture System*, 4th Edition, Ithaca Publishing Company LLC.
13. Goddek, S., Joyce, A., Kotzen, B, & Burnell, G.M. (2019). *Aquaponics Food Production Systems.* Springer.
14. Wedmeyer, A.F.S.: Fish Hatchery & Management.
15. Von Brandt's: Fish Catching Techniques of the World. Blackwell Pub.
16. George Borgstrom Elsevier,: Fish as Food, Vol.I & II.
17. Chonder, S. L. (1994): Induced Carp breeding. CBS Publishers & Distributors, New Delhi-110002.
18. Roberts, R. J. (2012). Fish pathology. John Wiley & Sons.
19. Pandey, P. K., Mallik, S. K., & Yumnam, R. (Eds.). (2024). Handbook of Aquatic Microbiology. CRC Press.
20. Biswas, K. P. (1990). A Text Book of Fish, Fisheries & Technology. Narendra Publishing House.
21. Thomas, P.C., Rath, S.C., Mohapatra, K. D. (2013). Breeding and seed production of Fin Fish and Shell fish. Astral publication, Gaya.

Suggested Readings:

1. Piper, R. G., McElwain, I. B., Orme, L. E., McCraren, J. P., Fowler, L. G., Leonard, J. R. (1986). Fish Hatchery Management. US Government Printing Office.
2. Wedmeyer, A.F.S.: Fish Hatchery and Management.
3. Von Brandt's: Fish Catching Techniques of the World. Blackwell Pub.
4. George Borgstrom Elsevier: Fish as Food, Vol. I & II.

Online Tools and Web Resources:

1. Eschmeyer's Catalog of Fishes Online Database (https://www.calacademy.org/scientists/projects/eschmeyers-catalog-of-fishes)
2. Food and Agriculture Organisation of the United Nations (https://www.fao.org/home/en/)
3. Indian Council of Agricultural Research (https://icar.org.in/)

Discipline Specific Elective (DSE) Course –I Practical : ZOO701DP(c)

Fish & Fisheries

Practical [Credits 2] 30 hrs/50 marks

1. Identification and classification of endemic food fishes, weed fishes and predatory fishes using morphometric and meristic characters, and taxonomic keys.
2. Identification of exotic invasive fish species using morphometric and meristic characters.
3. Identification of predatory insects and common aquatic weeds in fish pond.
4. Identification of common fish parasites.
5. Fecundity: Estimation the number of eggs by gravimetric and volumetric methods.
6. Water and soil sampling from fish farms. Physico-chemical analysis of water - turbidity, temperature, dissolved oxygen, carbon dioxide, alkalinity, pH, BOD, TAN, Ammonia, TSS
7. Dissection of Weberian Ossicles
8. Study of food and feeding habits of fishes: Bucco-pharynx of economically important fishes, Pharyngeal teeth.

Examination evaluation Structure:

1. Identification, Classification, Types & Characters of Fishes – (1+2+1+2=6) x 4=24 marks
2. Physico-Chemical analysis of Water; Dissection of Weberian Ossicles; (Procedure=3,experiment = 3, result= 2) = 8 marks
3. Identification of Food and feeding habits of fishes (Identification=1;remark=2)=3 marks
4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce : 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

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

- A variety of approaches to teaching-learning process, including lectures, seminars, power-point presentations, workshops, peer teaching/learning, assignments, project- based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Courses for B. Sc. (Hons.) Zoology

SEMESTER VI

Core Course -XIII: ZOO713C (Molecular Biology & Bioinformatics)

Objective:

The course aims to provide students with a deep understanding of genetic material, replication mechanisms, and the flow of genetic information. Students will also be introduced to key molecular biology tools and bioinformatics. This course lays the foundation for advanced studies in genetics, molecular biology and computational biology.

Outcome: Upon completing the course, students will:

- Understand the structure and role of DNA and RNA as genetic material.
- Gain insights into DNA and RNA replication mechanisms in prokaryotes, eukaryotes, and viruses.
- Comprehend the central dogma of molecular biology and the flow of genetic information.
- Learn about molecular biology tools like PCR, electrophoresis, and CRISPR.
- Be introduced to bioinformatics and its applications, including sequence alignments and phylogeny.

Course Content:

Theory [Credits: 4] 60 hrs/100 marks

Unit1: Genetic Material; DNA and RNA as Genetic Material 12 hrs/20 marks

DNA as Genetic Material: Structure of DNA: Double helix model, base pairing, and antiparallel strands; Types of DNA: A-DNA, B-DNA, Z-DNA. Significance of DNA as the primary genetic material in most living organisms. RNA as Genetic Material, Types and Structure of RNA (mRNA, tRNA, rRNA. miRNA, siRNA, snRNA, lnRNA). Single stranded and double stranded RNAs

Unit 2: Basics of DNA & RNA Replication 12 hrs/20 marks

Models of DNA replication. Mechanisms of DNA Replication in prokaryotes and Eukaryotes. RNA Replication (in RNA Viruses). Mechanisms of RNA Replication in RNA Viruses: RNA-dependent RNA polymerase (RdRP) in viral RNA replication, Positive-sense and negative-sense RNA genomes, Replication strategies in retroviruses: Reverse transcription.

Unit 3: Central Dogma and Molecular Biology Tools: 12 hrs/20 marks

Central Dogma of Molecular Biology: Flow of Genetic Information: DNA → RNA → Protein (transcription, translation and reverse transcription in retroviruses)

Introduction to Molecular Biology Tools: Polymerase Chain Reaction (PCR), Gel Electrophoresis: Separation of DNA, RNA, or proteins based on size. CRISPR-Cas9, DNA Sequencing: Sanger sequencing (basic method) and Next-Generation Sequencing (NGS) for faster, high-throughput analysis**.**

Unit 4: Introduction to Bioinformatics and Biological Databases 12 hrs/20 marks

Introduction to Bioinformatics: Definition, branches, aim, scope, and research areas. Biological Databases: Overview and types of biological databases, key sequence databases, types, classification of formats. Database Retrieval Systems: How to retrieve information from biological databases.

Unit 5: Sequence Alignments, Phylogeny, and Applications of Bioinformatics 12 hrs/20 marks

Sequence Alignments: Concepts of sequence alignment, multiple sequence alignment (MSA) using CLUSTALW, scoring matrices (PAM, BLOSUM). Molecular Phylogeny: Methods for phylogenetic analysis and software used in phylogenetics. Applications of Bioinformatics - Structural bioinformatics in drug discovery; Quantitative structure-activity relationship (QSAR) techniques in drug design; Microbial genome applications; Crop improvement techniques using bioinformatics.

Core Course -XIII Practical: ZOO713CP
(Molecular Biology & Bioinformatics)

Practical [Credits: 2] **30 hrs/ 50 marks**

- Chromosome demonstration from onion root tip and/or *Chironomus* Larvae
- DNA isolation from onion and/or *Chironomus* larvae/animal tissues
- Gel electrophoresis to separate DNA samples
- Use of bioinformatics tools for sequence alignment and phylogenetic tree construction.
- Phylogenetic tree construction using software tools.
- Phylogenetic tree construction using UPGMA.
- Phylogenetic tree analysis and interpretation.

Examination evaluation Structure:

1. Chromosome demonstration/Gel electrophoresis/DNA isolation – 20 marks
2. Bioinformatics - Sequence Alignment and Phylogenetic Tree Construction- 13 marks
3. Note Book: 7 marks (Based on the neatness, regularity, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Robert Keith, and Watson James (2008). *Molecular Biology of the Cell*. V Edition, Garland Publishing Inc., New York, and London.
- Cooper, G.M., Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition, ASM Press and Sinauer Associates.
- Becker, Kleinsmith, and Hardin (2009). *The World of the Cell*. VIII Edition, Benjamin Cummings Publishing, San Francisco.
- Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition, John Wiley & Sons Inc.

Suggested Reading:

- De Robertis, E.D.P. and De Robertis, E.M.F. (2009). *The Cell and Molecular Biology*. Lippincott Williams & Wilkins, Philadelphia.
- Russell, P. J. (2009). *Genetics: A Molecular Approach*. III Edition. Benjamin Cummings.
- 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.
- Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons Inc

Online Tools and Web Resources:

Swayam Courses:

- *Cell Biology*: https://swayam.gov.in/course/150-cell-biology
- *Biochemistry and Cell Biology*: https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology

JoVE Science Education Library:

- *Cell Biology educational videos*: https://www.jove.com/science-education-library/9/cell-biology

OpenStax Textbooks:

- *Free online biology textbooks and resources*: https://opentextbc.ca/biology2eopenstax/chapter/chordates/

Teaching and Learning Process:

- Lectures: Classroom teaching using multimedia presentations, animations, and diagrams to explain complex molecular biology processes (e.g., replication, transcription, translation, CRISPR).
- Seminars and Discussions: Interactive group discussions on the latest developments in molecular biology and bioinformatics, encouraging peer-to-peer learning.
- Practical Laboratory Sessions: Hands-on experiments, pre-lab discussions, and post-lab analysis to reinforce theoretical knowledge.
- Problem-Based Learning (PBL): Case studies and project work to develop critical thinking and problem-solving skills.
- Workshops: Sessions focusing on the practical applications of bioinformatics tools, including hands-on software training.
- Peer Teaching: Encouraging students to present specific topics to enhance their understanding and communication skills.

Assessment Methods:

- **Class Tests and Quizzes**: Regular short tests to assess ongoing understanding of key concepts.
- **Practical Assessment**: Evaluation based on laboratory work, including accuracy in conducting experiments, proper use of bioinformatics tools, and maintaining lab notebooks.
- **Project Work**: Group or individual projects focused on the application of bioinformatics tools or molecular biology research.
- **Assignments**: Assignments based on recent developments in molecular biology or data analysis in bioinformatics.
- **Oral Presentations**: Students will present on selected topics, assessed based on content accuracy, delivery, and responses to peer queries.
- **Viva-Voce**: Oral examination to assess comprehensive knowledge of both theoretical and practical aspects of molecular biology and bioinformatics.
- **Final Examination**: A semester-end exam to evaluate the complete understanding of the

Core Course –XIV: ZOO714C

(Adaptation in Animals, Applied Zoology)

Objective:

This course aims to provide the undergraduate students a thorough knowledge of how animals survive and thrive in diverse environments, maintaining the delicate balance of nature, showing how species evolve over time to meet environmental demands and the myriad ways animals adapt fosters a deeper appreciation and respect for the natural world.

Outcome:

Upon completion of the course, students should be able to understand the concept of Adaptation, identify different types of Adaptation, adaptation by animals in different habitats and evaluate evolutionary process.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Introduction to Animal Adaptation, Adaptations in Specific Habits and Habitats:

Definition and importance of adaptation; Types of adaptations with relevant examples: Structural Adaptations; Behavioural Adaptations; Physiological Adaptations. Aquatic adaptations; Fossorial Adaptation; Cave Adaptation; Parasitic adaptations in Helminths. Volant adaptations in Birds and Bat; Cursorial Adaptations in Horses; Desert Adaptation. **12hrs/ 20 marks**

Unit 2: Evolutionary aspects of adaptation ; Colouration and Mimicry in Animals:

Natural selection and adaptation; Genetic basis of adaptation; Adaptive Radiation, Adaptive Convergence, Adaptive Divergence. Evolutionary adaptations e.g. camouflage, Reasons for Colouration in Animals; Mechanism of colour production in Animals; Mimicry: Defensive, Aggressive and Reproductive; different models of mimics – Batesian, Mullerian, Mertensian, Peckhamian, Bakerian, Vavilovian, Automimicry.

12hrs/ 20 marks

Unit 3: Introduction to Pathogens, Parasites of medical importance :

Hosts, animal associations, Life cycle & epidemiology of the causal organisms of Tuberculosis, Typhoid; brief account of *Rickettsia prowazwkii, Borrelia recurrentis*; Life cycle & medical importance of *Entamoeba histolytica, Plasmodium vivax, Ancylostoma duodenale, Strongyloides stercoralis, Paragonimus westermani, Hymenolepis nana, Echinococcus granulosus.* **12hrs/ 20 marks**

Unit 4 : Arthropods of medical & Economic importance :

Types, medical importance and control of Mosquitoes, Lice, Ticks and Mites; Vector borne diseases with special reference to Diarrhoea, Cholera, Dysentery, Typhoid. Economic importance of Arthropods; Biology, damages caused & control of *Pieris canidia*, *Spodoptera frugiperda*, ; Life cycle and uses of *Bombyx mori, Kerria lacca, Apis cerana.* **12hrs/ 20 marks**

Unit 5: Animal husbandry, Poultry farming and Fish rearing :

Important exotic and local breeds of Cattle, Buffalo and Pig. Role of livestock in the national economy, General information on artificial insemination, Housing & Feeds for Cattle, Care and management of animals, Important breeds of Poultry, Systems of rearing, Feeding management, hatching of egg; Introduction to livestock & Poultry diseases and Prevention. Types of Fish farming & rearing methods. **12hrs/ 20 marks**

Core Course -IX Practical: ZOO714CP

(Adaptation in Animals, Applied Zoology)

Practical [Credits: 2]. **30 hrs/50 marks**

1. Study Volant adaptation in Bat, Birds (Diagram and description). Study of Adaptation in Stick insects, Tape worm, Dolphin, Camel, Mole.(Identification, Systematic position and Characters). (2+3 = 5)+(1+2+3 = 6 x 2 = 12) =17 Marks

2. Study of Batesian mimicry in **Hoverfly** and Mullerian mimicry in bees and Wasps. Definition and Characters of Mimic and Model. (2+2= 4 Marks)

3. Study of Protozoan, Nematode, Helminth parasites, Insect pests & Insect Vectors (Identification, systematic position, Characters, medical/economical importance). 1 + 2 + 2 + 2 = 7 x 2 = 14 marks

4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)

5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Examination evaluation structure:

1. Diagram and descriptions of parts of Bat/ Birds to show Volant adaptations (2+3 = 5 marks)

Identification, Systematic position and Characters of Stick insects, Tape worm, Dolphin, Camel, Mole using permanent specimen or models. (1+2+3 = 6 x 2 = 12 marks)

2. Exhibition of Batesian mimicry in **Hoverfly** or Mullerian mimicry in bees and Wasps (2+2= 4 Marks)

3. Identification, systematic position, Characters, medical/economical importance of a commonly available Protozoan/ Nematode/ Helminth / Insect pest / Insect Vectors .(1 + 2 + 2 + 2 = 7 x 2 = 14 marks)

4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)

5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

1. Banerjee ,T.K. (2016) Applied Zoology, New Central Book Agency
2. Jabde, PV (2008). Text Book Of Applied Zoology. Discovery Publishing House PVT LTD
3. Masih SC and Bhat RA (2021). Basic and Applied Zoology. Narendra Publishing House
4. Saxena RK and Saxena S (2015). Animal Adaptions (Evolutions of Forms and Functions). Viva Books
5. Suhasini, G. (2017) Applied Zoology, Book Enclaves

Suggested Reading:

1. Douglas, J. Futuyma (2006). Evolutionary Biology. Sinauer Associates Inc.,US.; III Revised Edition
2. Ridley,M (2004). Evolution. III Edition Blackwell publishing
3. Hall, B.K. and Hallgrimson, B (2008). Evolution. IV Edition. Jones and Barlett Publishers.

Teaching and Learning Process:

- Lectures: Classroom teaching using multimedia presentations, animations, and diagrams to explain complex molecular biology processes (e.g., replication, transcription, translation, CRISPR).
- Seminars and Discussions: Interactive group discussions on the latest developments in molecular biology and bioinformatics, encouraging peer-to-peer learning.
- Practical Laboratory Sessions: Hands-on experiments, pre-lab discussions, and post-lab analysis to reinforce theoretical knowledge.
- Problem-Based Learning (PBL): Case studies and project work to develop critical thinking and problem-solving skills.
- Workshops: Sessions focusing on the practical applications of bioinformatics tools, including hands-on software training.
- Peer Teaching: Encouraging students to present specific topics to enhance their understanding and communication skills.

Assessment Methods:

- **Class Tests and Quizzes**: Regular short tests to assess ongoing understanding of key concepts.
- **Practical Assessment**: Evaluation based on laboratory work, including accuracy in conducting experiments, proper use of bioinformatics tools, and maintaining lab notebooks.
- **Project Work**: Group or individual projects focused on the application of bioinformatics tools or molecular biology research.
- **Assignments**: Assignments based on recent developments in molecular biology or data analysis in bioinformatics.
- **Oral Presentations**: Students will present on selected topics, assessed based on content accuracy, delivery, and responses to peer queries.
- **Viva-Voce**: Oral examination to assess comprehensive knowledge of both theoretical and practical aspects of molecular biology and bioinformatics.
- **Final Examination**: A semester-end exam to evaluate the complete understanding of the Subject.

Generic Elective Course (GEC) -IV : ZOO704G

(Fundamentals of Zoology – 3: Urochordata,Cephalochordata & Phyla of Vertebrates)

[**NOTE** : Zoology discipline offers six generic elective courses titled " Fundamentals of Zoology 1 to 6 for six semesters of UG course (Semester III to VIII). GEC in Zoology shall be opted by Students of other Subjects other than those of Zoology (Zoology students are not allowed to take GEC in Zoology). Based on the ordinance for UG programs, GEC is a course chosen generally from an unrelated discipline/ Subject with an intention to seek a wide exposure. A core subject offered in a subject may be treated as a GEC. However, as per resolution of the Deans' committee meeting held on 4.3.2024 and subsequent circular of the Registrar MU/4-133/2024/1266 dated the 5th March 2024 GEC syllabi may be formed in the line of the CBCS in Master's course.]

Objective: The course will make the students aware about the different groups of Animals. It is aimed at providing knowledge on the diversity of animals from Urochordate to Mammals.

Outcome:

- Provide knowledge about types of animals, their characters and representative Species
- Increase knowledge on the relationships between the different groups.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit I: Urochordata, Cephalochordata 09 hrs/15 marks

General Characters of Urochordata, metamorphosis in Ascidian larva/ Herdmania. General characters of Cephalochordata, Feeding behavior of *Amphioxus*. Difference between Urochordata and Cephalochordata.

Unit II: Agnatha, Gnathostomata 09 hrs/15 marks

Main characters of Fishes; General Characters and different classes of Agnatha with examples, General Characters and different classes of Gnathostomata with examples, Difference between Chondrichthyes and Osteichthyes.

Unit III: Tretapods : Amphibia 12 hrs/20 marks

General Characters and different classes of Amphibia with examples, Batrachology & its relevance to their conservation; Life cycle of a Frog/ Toad. Parental care in Amphibians; Defence mechanisms in Amphibians.

Unit IV: Reptiles & Birds 18 hrs/30 marks

General Characters and different classes of Reptiles with examples, difference between Venomous & non Venomous Snakes with their representatives; Poison gland in Snakes; General Characters and classification of Aves upto Orders with examples, Flight & Perching mechanisms in Birds; Introductory ideas of different types of Feathers in Birds.

Unit V: Mammals 12 hrs/20 marks

General Characters; Characters & examples of Eutheria, Prototheria and Metatheria ; Hair types & Functions; Odor in mammals & its role in Rodent reproduction; Body plan of Primates; Feeding types in Chiroptera.

Generic Elective Course (GEC) -IV Practical : ZOO704GP

Practical [Credits 2] **30 hrs/ 50 marks**

1. Identification of Museum Specimen/ Models of Fishes, Amphibians, Reptiles, Birds, and Mammals.
2. Permanent Slides of *Amphioxus / Ascidian larva/ TS of Animal organs (Ones with Special diagnostic Characters)*
3. Submission of a report on a self-study made in One's own locality about the Vertebrate animals available. The Report may contain Photographs of Animals found with their diagnostic Characters.

Examination evaluation Structure:

1. Slide identification: 2 Numbers (Identification =1, Comments = 3) x 2; Total = 8 marks
2. Museum Specimen identification: 6 Numbers/ 4 marks each (Identification =1, Class name = 1, Characters = 2) Total = 24 marks
3. Report submission: 8 marks (Subject Knowledge, Presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

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

Online Tools and Web Resources:

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

Teaching and Learning Process:

Information on animals will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations through slides and permanent Specimen. 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, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of Chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities can be included to create interest among the students to study and explore the animals inculcating research aptitude. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Discipline Specific Elective (DSE) Course - II : ZOO702D(a)
Medical Microbiology & Parasitology

Objective:

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

Outcome:

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

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

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Introductory ideas on Bacteria :

Morphology, metabolism of a typical Bacteria; media for Bacterial growth, General characters, Laboratory diagnosis, medical importance, Treatment / Vaccination steps against *Mycobacterium tuberculosis, Vibrio cholerae.* Type and importance of Typhus fever group caused by *Rickettsiae.* 09hrs/15 marks

Unit 2: Introductory ideas on Viruses & Fungus :

General characteristics of Viruses; Enteric,Respiratory, Arbo Viruses; DNA & RNA

Viruses, Structure and properties of HIV; Classification of medically important Fungi; Laboratory tests for Candidiasis, Coccidiodomycosis etc ; Antifungal drugs. 09 hrs/15 marks

Unit 3: Introduction to Parasitology

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors (mechanical and biological vector), Host parasite relationship, Ecology of parasites, Population dynamics of parasite andestablishment of parasite population in host body, evolution of parasitism, evolution and co-evolution of parasite with respect to host strategy, Important case studies in the field of Parasitology including some historical events such as the role of the mosquito control and the successful completion of the construction of the Panama canal. 15 hrs/25 marks

Unit 4: Protozoan,Platyhelminths & Nematodes

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Entamoeba histolytica, Trypanosoma gambiense, Leishmania donovani, Plasmodium vivax*. Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Schistosoma haematobium, Taenia solium* and *Hymenolepis nana.* Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides*, *Ancylostoma duodenale* and *Wuchereria bancrofti.* 15 hrs/25 marks

Unit 5: **Parasitic Arthropoda and Vertebrates**

Biology, importance and control of ticks, mites, *Pediculus humanus* (Head and Body louse),*Xenopsylla cheopis* and *Cimex lectularius.* A brief account of parasitic vertebrates; Cookiecutter Shark, Candiru, Hood Mocking bird and Vampire bat. 12 hrs/20 marks

Recommended Books:

- Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications and Distributors
- Ananthanarayan and Paniker (2024) Textbook of Microbiology, Universities Press (India) Pvt. Ltd., 13th Edition
- Chatterjee, K. D. (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBS Publishers & Distributors (P) Ltd.
- Gupte, S, (1995) Medical microbiology. Jaypee, N.D.
- Joanne W. Willey, Linda M. Sherwood, Christopher (2019) Prescott's Microbiology, McGraw- Hill Education, 11th Edition
- Noble, E.R. and Noble, G.A. (1982) Parasitology: The Biology of Animal Parasites. V Edition, Lea & Febiger

Suggested Readings:

- Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and Francis Group
- Parija, S. C. (2004).Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers,Chennai, Delhi
- Ichhpujani, R.L. and Bhatia, R. Medical Parasitology. III Edition, Jaypee Brothers

Medical Publishers (P) Ltd., New Delhi
- Murray, D. Dailey. Meyer, Olsen & Schmidt's Essentials of ParasitologyW.C. Brown Publishers
- Thomas C. Cheng (1986). General Parasitology. II Edition, Academic Press Inc

Online Tools and Web Resources:

https://www.cdc.gov

https://library.viu.ca

https://www.parasite-journal.org

https://pmc.ncbi.nlm.nih.gov

Discipline Specific Elective (DSE) Course –II Practical : ZOO702DP(a) Medical microbiology & Parasitology

Practical [Credits 2] **30 hrs/50 marks**

1. Study of life stages of *Entamoeba histolytica*, *Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani* and *Plasmodium vivax* through permanentslides /microphotographs.
2. Study of adult and life stages of *Fasciolopsis buski, Schistosomahaematobium, Taenia solium* and *Hymenolepis nana* through permanent slides/microphotographs/ Museum specimen.
3. Study of adult and life stages of *Ascaris lumbricoides, Ancylostoma duodenale, Wuchereria bancrofti* and *Trichinella spiralis* through permanent slides/microphotographs.
4. Study of *Pediculus humanus* (Head louse and Body louse), *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.
5. Study of monogenea from the gills of fresh/marine fish [Gills can beprocured from fish market as by product of the industry.
6. Study of nematode/cestode parasites from the intestines of Poultry bird through dissection [Intestine can beprocured from poultry/market as by product]
7. Submission of a brief report on parasites of vertebrates including writeup & Photographs/ Images. (if taken from external means, Sources need to be acknowledged).
8. DNA extraction of parasite/s and molecular identification using universal and specific markers

Examination evaluation Structure:

1. Study of Museum specimen/ Slides (Identification – 1, Classification- 2, Characters – 3, medical importance – 2) x 3 = 24
2. Dissection and display of Parasites from Poultry Intestine (Dissection = 3, Display & identification = 2 + 1 = 3)
3. Report on Parasites of Vertebrates (5 marks)
4. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student. Classroom teaching using power point presentations enabled with related photographs of parasites their life stages and disease diagnosis will help students to understand the subject. Case studies of epidemics caused by different parasites will clarify concept and create interest in the field. Visit to local diagnostic center will provide an overview of various medical tests conducted to detect and confirm parasitic diseases.
- A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Discipline Specific Elective (DSE) Course - II : ZOO702D(b)
Aquatic Biology

Objective:

The course is designed with an aim to provide the students the knowledge to learn all life forms like plants, animals and chemicals prevalent in the waters from different sources such as lakes, rivers, streams, wetlands, marine environments etc. The Program shall help students to know about aquatic life and equip students with skills that can later lead into a profession in aquatic biology.

Outcome:

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

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

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Aquatic Biomes 12 hrs/20 marks

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

Unit 2 :Aquatic Resources 12 hrs/20 marks

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

Unit 3: Freshwater Biology 15 hrs/25 marks

Lakes: Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico–chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids,

Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.

Unit 4: Marine Biology 09 hrs/15 marks

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

Unit 5: **Management of Aquatic Resources** 12 hrs/20 marks

10hrs Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication,Management and conservation (legislations), Sewage treatment Water quality assessment-BOD and COD.

Recommended Books:

Goldman. Limnology.II Edition
Odum and Barrett. Fundamentals of Ecology.V Edition
Pawlowski. Physicochemical Methods for Water and Wastewater Treatmen.I Edition
Trivedi and Goyal. Chemical and Biological Methods for Water Pollution Studies
Wetzel. Limnology. III edition

Online Tools and Web Resources:

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

Discipline Specific Elective (DSE) Course –II Practical : ZOO702DP Aquatic Biology

Practical [Credits 2] **30 hrs/50 marks**

Examination evaluation Structure:

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lakeecosystem.
3. Determine the amount of turbidity/transparency, dissolved oxygen, free carbon dioxide, alkalinity (carbonates & bicarbonates) in water collected from a nearby lake/ water body.
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter,Turbidity meter, PONAR grab sampler) and their significance.
5. A Project Report on a visit to a Sewage treatment plant/Marine bio-reserve/FisheriesInstitutes.
6. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
7. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite

knowledge, skills and learning attitude of the student.

- A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.
- For enhanced practical/field driven knowledge of students, they would be taken to laboratories or Aquaticresearch institutes/industries.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Discipline Specific Elective (DSE) Course - II : ZOO702D(c)

Ecological restoration

Objective:

The course is designed with an aim to provide the students the knowledge to learn and experience in Ecological restoration. The scopes, principles involved, different theories and Philosophies shall be studied. Knowledge on different restoration methods, tools and techniques including case studies shall be imparted.

Outcome:

Upon completion of the course, students shall be able to:
Have knowledge on degradation of land and suggest Restoration steps.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Foundations of Ecological Restoration : Definitions and scope, Historical context and development of the field. Ecosystem Degradation and Causes: Natural and anthropogenic drivers of ecosystem degradation. Principles and Theories: Ecological succession, Disturbance and resilience theory**.** Ethics and Philosophy of Restoration: Human perspectives on nature, The role of indigenous knowledge in ecological restoration 12 hrs/20 marks

Unit 2: Restoration Planning and Methods : Baseline data collection and ecological assessments, Setting restoration goals and success criteria. Restoration Techniques: Reforestation, wetland restoration, and aquatic system restoration, Soil stabilization and erosion control. Restoration Project Design: Planning frameworks and stakeholder involvement, Policy and legal considerations in restoration projects. Monitoring and Adaptive Management: Techniques for monitoring restored ecosystems, Adaptive management principles and practices. 15hrs/25 marks

Unit 3: Tools and Technologies in Restoration : Modern Restoration Tools: Use of GIS and remote sensing for planning and monitoring, Role of drones and automated equipment. Plant and Animal Reintroduction: Criteria for selecting species for reintroduction, Best practices for managing populations. Ecotechnological Approaches: Bioengineering and green infrastructure, Phytoremediation and bioremediation techniques. Community-based Restoration: Engaging local communities in restoration projects, Case studies of community-led initiatives. 15 hrs/25 marks

Unit 4 : Challenges, Case Studies : Challenges in Ecological Restoration: Climate change impacts and mitigation, Socio-economic barriers and funding issues. Case Studies: Case studies of degraded ecosystems, Successes and failures from different biomes (e.g., forest, wetland, marine), Detailed analysis of global restoration Projects. 9 hrs/15 marks

Unit 5: **Future of Ecological Restoration:** The role of international agreements (e.g., UN Decade on Ecosystem Restoration), Policy development and implementation for sustainable practices. Emerging trends and research directions, the concept of rewilding and landscape-scale restoration.

9 hrs/ 15 marks

Recommended Books:

1. J.S. Singh, S.P.Singh,S.R.Gupta : Ecology Environment and Research conservation , Anamaya Publishers, New Delhi .
2. William D. Bowman, Sally D. Hacker, Michael L. Cain (2017) : Ecology, Fourth Edition. Sinauer Associates, Inc. Publishers Sunderland, Massachusetts, U.S.A.
3. Mishra G.P.and Gupta A. (2013) : Ecorestoration and Biodiversity Conservation Aavishkar
4. Jelte Van Andel and James Aronson (2006) : Restoration Ecology, Blackwell Science Ltd.
5. Smith, R.L (1996).: Ecology and Field Biology, 5th En. West Virginia University, DVS Publishers A.T.Road Ghy-9 .
6. Freedman B (1989): Environmental ecology, Acad.Press.
7. Alan Beeby, Anne-Maria Brennau : First Ecology – Ecological principles and environmental issues, (2nd Ed.)., Oxford University Press.
8. Peggy L Fielder and Peter M Kareiva (1998) : Conservation Biology, Chapman & Hall, International Thomson Inc.

Discipline Specific Elective (DSE) Course - II Practical : ZOO702DP(c) Ecological restoration

Practical [Credits 2] **30 hrs/50 marks**

1. Field Survey : Visit to a nearby degraded ecosystem (Forest, Riverbank, Wetland); identify the causes of degradation; Document through Sketches, Photographs & Sampling datas.
2. GIS mapping for Ecological assessment : Mapping of land cover changes in a degraded area using GIS software; Analyze before and after restoration scenarios.
3. Case Study analysis of Restoration Projects : Research and present a case study of a successful or failed restoration Project, identify the key challenges, solutions and lessons learned, Suggest Policy improvements based on the findings.
4. Restoration Project Proposal : Develop and submit a Project plan for restoration of a degraded site.

Examination evaluation Structure:

1. Submission of Field Survey report (10 marks)
2. Report submission of Case Study analysis of a restoration Project (10 marks)
3. Submission of Project Plan for restoration of a degraded site (10 marks)
4. Presentation on the analysis made before and after restoration scenarios based on GIS mapping. (10 marks)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, the restoration projects and studies will constitute an important part of the course that will make the Student accustomed to the degradation and reclamation of Land.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.

Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester.A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each

Courses for B.Sc. (Hons.) Zoology

SEMESTER VII

[**In addition to the Syllabi for Semester Vii & Viii provided, Students who score 75 % & above in the last 6 Semesters , who has maintained a strong academic performance throughout the honours program and who wish to opt for B Sc. Honours with Research degree shall choose a research project or dissertation under a Guide/ Mentor (who need to be a PhD degree holder & has Published not less than two papers in refereed Journals) of the Parent Institute or any other Institute in the same State or outside the State*. *The Project/ Dissertation has to be taken up during Vacations/ free time of the Student. The Project report / Dissertation shall have to be submitted to the Parent department before the completion of the end exam of Semester VIII. The Project report/ Dissertation shall be of 2 Credits and shall carry 50 marks*]

Core Course -XV: ZOO815C (Animal Biotechnology)

Objective: Biotechnology is the advanced branch of biological sciences which mostly deals with technological application on biological systems. It is basically the management of biological processes for industrial and other human welfare purposes. The present paper on biotechnology attempts to give a wholesome idea of biotechnology at a basic level. It provides a tool kit in the form of a number of various techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine. It will equip the students with basic tools of biotechnology which are a must for everyone interested in pursuing a career in biotechnology. It makes one aware of the scope of this field which encompasses almost every field of science like engineering, research, commercialization and academics.

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

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

Course Content:

Theory [Credits: 4] 60 hrs/100 marks

Unit1: Introduction

Introduction to Biotechnology, Brief history of Biotechnology, Types, Concept and scope of biotechnology; principles of biotechnology, origin of modern Biotechnology, genetic Engineering, Bioprocess Engineering, application of Biotecnology. 9 hrs/15 marks

Unit 2:BasicTools for Gene Manipulation

Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics). Restriction enzymes: Nomenclature, detailed study of Type II, DNA modifying enzymes. Transformation techniques: Calcium chloride method, electroporation and biolistic method. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization. 15 hrs/25 marks

Unit 3:Advance Tools and Techniques

Southern, Northern and Western blotting DNA sequencing: Sanger method, Next generation sequencing (Illumina), Polymerase Chain Reaction, DNA Finger Printing and DNA microarray,

Gene Editing Tools: Zinc finger nucleases (ZFNs), transcription activator-like effector- based nucleases (TALEN) and the clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system. 15 hrs/25 marks

Unit 4: Genetically modified organisms : Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection; Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock out mice. Production of transgenic plants: Agrobacterium- mediated transformation. Applications of transgenic plants: insect and herbicide resistant plants. 15 hrs/25 marks

Unit 5:Applications of Genetic Engineering

Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia), Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy. 6 hrs /10 marks

Core Course -XV Practical : ZOO815CP (Animal Biotechnology)

Practical [Credits: 2] **30 hrs/ 50 marks**

1. Genomic DNA isolation from *E.coli*
2. Plasmid DNA isolation (pUC 18/19) from *E.coli*
3. Demonstration of Restriction digestion of Plasmid/Lambda DNA.
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from calcium chloride method.
6. To demonstrate following techniques: (Optional)
   Southern/ Northern/Western blotting (Any one)
   PCR

   DNA fingerprinting
   DNA Sequencing (Sanger's Method)
7. Project report on animal cell culture OR on a visit to any biotechnology Institute

Examination evaluation Structure:

1. Experiment (two numbers) : 5x2 ; procedure : 5x2; result : 2x2 . Total = 24
2. Demonstration of techniques : 5x2 = 10

3. Note Book: 6 marks (Based on the neatness, regularity, overall presentation)

4. Viva-Voce : 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

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

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Recommended Books:

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

- Primrose, S.B., and Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics.VIIEdition, Blackwell publishing (Oxford, UK) ISBN: 13: 978-1-4051-3544-3.

Suggested Readings:.

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

Online Tools and Web Resources:

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

Core Course –XVI: ZOO816C (Biological techniques & Bioinstrumentation)

Objective:

This course aims to provide the undergraduate students a thorough knowledge of the Principles and application of instruments in Zoology.

Outcome:

Upon completion of the course, students should be able to understand the application and significance of Instruments in everyday use specially in agriculture and Health.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Microscopy :

Principles and Techniques of Microscopy; Bright field, Dark field; Magnification and Resolution Parameters of Light, Compound, Fluorescent, Phase Contrast, & Electron Microscope, Numerical aperture and limits of resolution; Principle and procedure of tissue Microtome and a cryostat microtome. 12hrs/ 20 marks

Unit 2: Spectroscopy & Chromatography :

Principles and biological applications of spectroscopy (mass, Raman, FTIR, NMR). Principles and biological applications of chromatography (Paper chromatography, Thin layer chromatography, Column chromatography, GCMS, HPLC). 12hrs/ 20 marks

Unit 3: Electrophoresis :

Types & Principles of Electrophoresis**,** Agarose and Polyacrylamide Gel Spectrophotometry; Principles and Instrumentation of UV- Visible Spectrophotometer; Flame Photometer; Atomic absorption and Nuclear magnetic resonance Spectrophotometer. 12hrs/ 20 marks

Unit 4: Other Diagnostic techniques :

Radioactivity Measurement; Tracer techniques; Autoradiography, Radioimmunoassay, Enzyme Linked Immunosorbent Assay (ELISA), Immunoprecipitation, Blotting: western, northern, southern and Dot; Indirect Hemagglutination Assay (IHA). 12hrs/ 20 marks

Unit 5: Other Advanced Molecular techniques :

PCR, DNA micro assays; Genome sequencing technologies: Sanger and next generation sequencing. DNA fingerprinting, Basic of Gene Therapy: CRISPR-cas9, molecular cloning

12hrs/ 20 marks

Core Course –XVI Practical: ZOO816CP (Biological techniques & Bioinstrumentation)

Practical [Credits: 2] **30 hrs/50 marks**

Practicals:

1. Demonstration of Light and Compound Microscopes. (5 marks)
2. Demonstration/Tissue section in microtome. (10 marks)
3. Principles, procedure and demonstration of Paper chromatography using available extracts. (Principles = 5, procedure = 5 and demonstration/ result = 5) (15 marks)
4. Demonstration of Gel electrophoresis/ any other available diagnostic instrument. (5 marks)
5. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Daniel, M.(2011). Basic Biophysics for biologists, Agrobios
- Kammermeyer, K., and Clark, V. L. (2019). *Genetic Engineering Fundamentals: An Introduction to Principles and Applications.* CRC Press.
- Katoch, R. (2014). *Analytical Techniques in Biochemistry and Molecular Biology*. Springer.
- Narayanan P. (2000). Essentials of Biophysics, New Age International Pvt Ltd.
- Pattabhi V and Gautham N.(2002). Biophysics, Kluwer Academic Publishers.
- Rastogi, S. C. (2019). *Bioinformatics Concepts Skills And Applications* (2nd edition). CBS Publishers & Distributors Pvt. Ltd.
- Scopes,K. R. (1994). Protein Purification - Principles and Practices. Springer Verlag.
- Volkenshtein, M.V. (1983). General Biophysics Academic Press, Inc.
- Wilson, K. and Walker, J.(2005). Principles and Techniques of Practical Biochemistry, Cambridge University Press.
- Wilson, K., Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.

Teaching and Learning Process:

Upon achieving the objectives related to Bio-instrumentation and Biotechniques, students will acquire the ability to apply principles and techniques of microscopy, histological staining, spectroscopy and chromatography techniques and radioisotopes hybridization techniques. They

will also develop skills in utilizing various blotting methods for research, analysis, and diagnostic purposes in the field of biology.

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium willbe adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Generic Elective Course (GEC) -V : ZOO805G
Fundamentals of Zoology-5

(Applied Zoology)

Objective:

This course aims to provide the undergraduate students of other Subjects other than Zoology, a thorough knowledge of the use and application of animals.

Outcome:

Upon completion of the course, students should be able to understand the concept of applied Zoology.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Introduction to Applied Zoology :

Definition of Applied Zoology, Practical applications of applied Zoology, Introduction to Concept of Transgenic animals and Genetically modified Organisms as Food for Man, Interdisciplinary nature of Applied Zoology, Role of Zoology in conservation, sustainable agriculture & Biotechnology. 12hrs/ 20 marks

Unit 2: Microbiology, Pathogens & Parasites of medical importance :

Causal organisms, Symptoms caused and Precautions to be taken against of Tuberculosis & Typhoid; morphology, Life cycle, pathological symptoms, and prophylaxis of *Entamoeba histolytica, Plasmodium vivax, Enterobius vermicularis, Fasciola hepatica* and *Echinococcus granulosus.* 12hrs/ 20 marks

Unit 3: Fishery and Aquaculture :

Types of Fish culture/Pisciculture, setting up and maintenance of Aquarium, Induced breeding, Aquaponics, Biofloc technology, Recirculating Aquaculture system, Cage culture system; Pearl culture. 12hrs/ 20 marks

Unit 4 : Arthropods of medical & Economic importance :

Types, medical importance and control of Mosquitoes, Lice, Ticks and Mites; Economic importance of Arthropods; introductory ideas on the Biology, damages caused & control of *Pieris canidia*, *Spodoptera frugiperda*; Edible insects, Pollinator insects; Economic importance of Silkworms and Honeybees; Basic ideas of Apiculture, sericulture & Lac culture; Store grain Pests & Control. 12hrs/ 20 marks

Unit 5: Animal husbandry and Poultry farming :

Important exotic and local breeds of Cattle, Buffalo and Pig. Role of livestock in the national economy, General information on artificial insemination, Housing & Feeds for Cattle, Care and management of animals, Important breeds of Poultry, Systems of rearing, Feeding management, hatching of egg; Introduction to livestock & Poultry diseases and Prevention. 12hrs/ 20 marks

Generic Elective Course (GEC) -V Practical : ZOO8056GP
Fundamentals of Zoology-5

(Applied Zoology)

Practical [Credits: 2]. **30 hrs/50 marks**

1. Identification, Systematic position and Characters of Insects, Parasites, Pesta etc using Permanent Specimen, Slides or models (as per Theory Syllabus)

2. Life cycle studies using models/ diagrams of Parasites / Pests.

3. Study of a nearby Centre having Fish culture/ Pearl culture/Apiculture/Sericulture/Parasite culture lab/ Poulty/ Cattle rearing (Preference should be given for a place within walking distance from the Institute) & submission of a report.

Examination evaluation structure:

6. Identification, Systematic position and Characters of Specimen. (Identification = 1, Systematics = 2, Characters = 2) (Total = 5 x 5 = 25 marks)
7. Identification of a lifecycle diagram (Identification = 1, Characters = 2) (Total= 3 Marks)
8. Field report : 7 marks
9. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
10. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

Banerjee ,T.K. (2016) Applied Zoology, New Central Book Agency
Jabde, PV (2008). Text Book Of Applied Zoology. Discovery Publishing House PVT LTD
Masih SC and Bhat RA (2021). Basic and Applied Zoology. Narendra Publishing House
Suhasini, G. (2017) Applied Zoology, Book Enclaves

Teaching and Learning Process:

- Lectures: Classroom teaching using multimedia presentations, animations, and diagrams to explain complex molecular biology processes (e.g., replication, transcription, translation, CRISPR).
- Seminars and Discussions: Interactive group discussions on the latest developments in molecular biology and bioinformatics, encouraging peer-to-peer learning.
- Practical Laboratory Sessions: Hands-on experiments, pre-lab discussions, and post-lab analysis to reinforce theoretical knowledge.
- Problem-Based Learning (PBL): Case studies and project work to develop critical thinking and problem-solving skills.
- Workshops: Sessions focusing on the practical applications of bioinformatics tools, including hands-on software training.
- Peer Teaching: Encouraging students to present specific topics to enhance their understanding and communication skills.

Assessment Methods:

- **Class Tests and Quizzes**: Regular short tests to assess ongoing understanding of key concepts.
- **Practical Assessment**: Evaluation based on laboratory work, including accuracy in conducting experiments, proper use of bioinformatics tools, and maintaining lab notebooks.
- **Project Work**: Group or individual projects focused on the application of bioinformatics tools or molecular biology research.
- **Assignments**: Assignments based on recent developments in molecular biology or data analysis in bioinformatics.
- **Oral Presentations**: Students will present on selected topics, assessed based on content accuracy, delivery, and responses to peer queries.
- **Viva-Voce**: Oral examination to assess comprehensive knowledge of both theoretical and practical aspects of molecular biology and bioinformatics.
- **Final Examination**: A semester-end exam to evaluate the complete understanding of the

Discipline Specific Elective (DSE) Course - III : ZOO803D
(Research methodology in Zoology-1)

Objective:

The course is designed with an aim to provide the students the knowledge to learn and have a hands-on- training on the Principles, procedures and operation of equipment required for Biological analysis besides providing ideas on the framing and reporting of research findings , measurement of Physico- Chemical characteristics of Water & Soil and precautions in the Laboratory.

Outcome:

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

- Prepare scientific reporting and make a presentation.
- Measure the Ohysico- Chemical Characters of Water & Soil.
- Have knowledge about the Principles and application of Biological techniques
- Operate Sophisticated instruments and take precautions in the Laboratory including Biosafety labs.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Scientific research, reporting & Presentation : Concept of Scientific research, Choice of research topic, preparation of review of literature, hypothesis, Materials and methods, discussion and writing of references. Scientific reporting: Writing of thesis /research paper . Scientific presentation : Poster/LCD/OHP/MS-Powerpoint. 12 hrs/20 marks

Unit 2: Measurement of Physico- Chemical characters of Water & Soil : Measurement of DO, CO2, total hardness, turbidity, alkanity, PH ; Soil- field capacity, water holding capacity, Soil texture, Soil porosity & respiration; NPK content, organic Carbon. 12 hrs/20 marks

Unit3: Principles and application of techniques : Microscopy, Scanning & transmission microscope; Isolation of Nucleic acids, electrophoretic separation of DNA fragments; principles & application of PCR,RAPD,RFLP,DNA fingerprinting, DNA sequencing. ELISA 12 hrs/20 marks

Unit 4: Principles & operation of Instruments : Pipettes, Centrifuges (High speed, Ultra & Microcentrifuges); incubators & Biological safety cabinets, Electrophoresis systems (Gel/ Capillary systems); Spectrophotometer like Atomic Absorption Spectrophotometer, GCMS, HPLC, NMR, Stat PCA, SPSS, Multivarient analysis, ANOVA, Microsoft excel . 12 hrs/20 marks

Unit 5: **Biosafety issues in the Laboratory** : Choosing the right instrument, Guidelines for precaution and Biosafety issue in the handling of sophisticated instruments, Lab items, Toxic chemicals, Glasswares. First aids. Personal protective equipments, safe handling of infectious agents. 12 hrs/20 marks

Recommended Books:

1. Ajibade, V & Ajenifuja,O. (2019). Instrumentation in biology. Lambert Aca. Publishing

2. Arumugam, N. (1994) Bioinstrumentation. Saras publication

3. Baruah,T.C. & Barthakur, H.P. (1997). A textbook of Soil analysis. Vikas Pub. House Pvt. Ltd, Delhi

4. Bajwa, D.R. & Ahuja, Sh. (2023) Research Methodology Theory and Practice, Nation Press, 1st Edition

5. Kothari,C.R. & Garg, G. (2024). Research Methodology-methods and techniques. New Age International Publishers

6. Rao,K.H. & Pasumarti , S.S. (2012) Research Methodology: Techniques and Applications

7. Salerno, R.M. & Gaudiosa,J. (2015). Laboratory Biorisk management. CRC Press

8. Salerno, R.M. & Gaudiosa,J. (2007). Laboratory biosecurity handbook. CRC Press

9. Sarma, M. (2012). Research Methodology – assignment, Seminar paper & Project. EBH publishers, Ghy

10. Thomas, C. G. (2021) Research Methodology and Scientific Writing, Ane Books Pvt. Ltd. 2nd Edition

11. Zou, P. and Xu, X. (2023) Research Methodology and Strategy- Theory and Practice, John Wiley & Sons Ltd.

Discipline Specific Elective (DSE) Course –III Practical : ZOO803DP (Research methodology in Zoology-1)

Practical [Credits 2] **30 hrs/50 marks**

1. Preparation of Scientific data using MS- Powerpoint & presenting the same in the form of a Poster.
2. Measurement of Acidity, alkanity of Water/ Soil; turbidity/ DO of Water, NPK/ Organic carbon of Soil.
3. Principles and application of ELISA/PCR/ GCMS/ HPLC/ Gel Electrophoresis

Examination evaluation Structure:

1. Preparation of Scientific data using MS- Powerpoint & presenting the same in the form of a Poster. (Preparation = 5 marks, Presentation = 10 marks) Total = 15 marks

2. Measurement of Acidity, alkanity of Water/ Soil; turbidity/ DO of Water, NPK/ Organic carbon of Soil. (procedure = 5 marks, result = 5 marks) x 2 = 20 marks

3. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)

4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium willbe adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Courses for B.Sc. (Hons.) Zoology

SEMESTER VIII

Core Course -XVII: ZOO817C (Biostatistics & Computer application)

Objective:

The course is designed with an aim to provide knowledge on the application of Statistics and Computer in biological studies. It will impart knowledge regarding basic concepts of Statistics and Computer. The study shall make the students understand the Sample sizes, experimental designs, analysis & interpretation of data.

Outcome:

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

- Understand Biostatistics for use in design studies, sample sizes and interpret data.
- Knowledge of Statistical analysis, Probability, Variables, Experimental designs, analysis of Variance etc.
- Gain basic knowledge about computer and internet
- Develop computational methods to utilize expression data of cellular biology and the inherent structure of biological information.
- Analyze the gene and protein sequences to reveal protein evolution.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Introduction to Biostatistics 12 hrs/ 20 marks

Introduction, history, Scope , application of biostatistics in Bio-Sciences, Variables, attributes, Population and Sample, Types of data, Classification, Summarization, Diagrammatic and graphic presentation of data; measurement of central tendency, measure of dispersion, Coefficient of variation, Skewness and Kurtosis.

Unit 2: Probability,Variables, Distribution, Sampling, Standard error & Statistical tests

12 hrs/ 20 marks

Introduction to probability and application of probability laws in Biology; Random variable & Probability distribution, Normal, Binomial and Poisson distribution, their application in Biology; Sampling methods in Biology, Sampling distribution and Standard error, testing of Hypothesis, chi-square rest, t-test and F-test.

Unit 3: Experimental designs,analysis of variance,ANOVA, Correlation & regression analysis, non- parametric test 12 hrs/ 20 marks

Basic principles of experimental design, completely randomized design, randomized block design; analysis of variance – one and two way, interpretation of ANOVA results, simple correlation and regression analysis; Introduction to non-Parametric test.

Unit 4: Computer application I 12 hrs/ 20 marks

Basic concepts of Computer : Hardware, Software, I/Q devices, organization of Computer, Operating

systems, Basics of Computer programming languages, Binary number system, e – learning, Programmes used in Biostatistics : SPSS, Minitab etc. Networking, Internet – History, Uses connections : web page, modem, internet service providers, e mail, voice mail & creating e -mail addresses

Unit 5: Computer application II 12 hrs/ 20 marks

Computer application in Biological Sciences, biological databases – NCBI, GenBank, EMBL, DDBJ; Phylogenetic study, modelling etc., computational methods – Nucleic acid and protein sequence databases, data mining methods for sequence analysis and web- based tools for sequence searches, sequence alignments, structural classification of protein – PDB, Swiss – PROT, SCOP, CATH; Protein visualization tools – RASMOL, Swiss PDB viewer.

Core Course – XVII Practical: ZOO817CP (Biostatistics & Computer application)

Practical [Credits 2] 30 hrs/ 50 marks

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1 Biostatistics : (i) Construction of frequence distribution tables and diagrammatic & graphic representation of data

(ii) Computation of various measures of Central tendency and measures of dispersion with example from Biology

(iii) Practical use of Random numbers and randomization technique for assignment of treatments in experimental designs (CRD & RBD)

(iv) Practical application of Probability laws and goodness of fit test for binominal and Poisson probability distributions in biology.

(v) Computation and tests of significance for correlation & regression coefficients.

(vi) Tests of hypothesis for small samples and two population variances, Computation of one way and two way ANOVA with data from Biology.

2 Computer application : Components of Computer, Preparation of tables, sorting of data, creating chart and calculation of average using MS – Excel, Elements of Windows operating system, Statistical analysis of data using MS- word; Collection & analysis of Biological data bases using internet, Web browser and e - mail.

Examination evaluation Structure:

1. Biostatistics : 3 experiments from among the VI provided in Syllabus (Procedure =3, representation/ computation= 2, result = 2) Total = 7 x 3 = 21 marks

2. Computer application : Preparation of tables, Data analysis – 7 marks x 2 numbers = 14 marks (Presentation= 02, procedure = 03, result/ comment = 02)

3. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)

4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Whitlock, M. and Schluter, D (2004). The analysis of Biological data. 2nd edition, Macmillan
- Zar, J.H. (2009) . Biostatistical analysis,5th edition, Pearson
- Rosner,B. (2015). Fundamentals of Biostatistics, 8th edition, Brooks Cole
- Richard C. Sprinthall (2011). Basic Statistical analysis.9th edition, Pearson
- Sundaralingam,R., Arumugam,N., kumaresan,V.,Gopi,A and Meena,A. (2015) : Biostatistics, Computer application and Bioinformatics. Saras Publication
- Raman, K. (2023). An introduction to Computationalsystems Biology : systems- Level modelling of Cellular works. Chapman & Hall

Suggested Readings:

- Gupta, S,C, (1992). Fundamentals of Statistics. Himalaya Publishing house
- Das, N. G. (2022) . Statistical methods, MC Graw Hill
- Jagiraju,D.V.L.N, Srikala,C. & Rajkumar, L.P. (2022). Descriptive Statistics and Probability. Kalyani Publishers
- Bairam,R. (2021) . A textbook of Biostatistics and Research methodology. SIA Publishers and distributors Pvt.Ltd.
- Tucker,A.B. (2004). Computer Science Handbook. CRC Press
- Balagurusamy, E (2009). Fundamentals of Computer. MC Grew Hill

Online Tools and Web Resources:

- https://whitlockschluter.zoology.ubc.ca
- http://assets.vmou.ac.in
- https://brainly.in
- https://apps.dtic.mil>sti>pdf

Teaching and Learning Process:

Information and concepts about Statistics and Computer will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations through experimental models. 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, group discussions and round tables on the various aspects of biostatistics and computer modelling would be created to ensure effective learning and understanding of the concepts. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the students. Power point presentation on any

topic of the Unit (both theory and practical syllabi) are suggested for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Core Course –XVIII: ZOO818C (Ethology & Chronobiology)

Objective:

This course aims to provide the undergraduate students a thorough knowledge of Animal Behaviour is the scientific study of the wild and wonderful ways in which animals interact with each other, with other living beings, and with the environment in which they live in. One important aspect pertaining to the studies on Animal Behaviour is that it can be conducted anywhere and at any time, depending on the interest of the researcher. Moreover, it is not confined to the four walls of the classroom or the laboratory. The behavioural biology has high applied value and currently linked to conservation biology, molecular biology, behavioural ecology and integrated pest management. The chronobiology addresses some periodic and cyclic nature of various life phenomena occurring in living beings in nature. They often correlate with the external environmental factors. Chronopharmacology, chronomedicine and chronotherapy are some of the direct applications of chronobiology in human health. This course aims to provide an overview of animal behaviour and chronobiology starting from historical prospective to types of behaviours and their evolutionary significance. The course also highlights types, mechanisms and importance of the biological rhythms and biological clocks operating in the living organisms. This course will help the learners to understand and appreciate different types of animal behaviours, their adaptive, evolutionary and practical significance.

Outcome:

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

- Understand types of animal behaviour and their importance to the organisms.
- Enhance their observation, analysis, interpretation and documentation skills by taking short projects pertaining to Animal behaviour and chronobiology.

- Relate animal behaviour with other subjects such as Animal biodiversity, Evolutionarybiology, Ecology, Conservation biology and Genetic basis of the behaviour.
- Understand various process of chronobiology in their daily life such as jet lag.
- Learn about the biological rhythm and their application in pharmacology and modernmedicine.
- Realize, appreciate and develop passion to biodiversity; andy will respect the nature andenvironment.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Introduction to Animal Behaviour

Origin and history of Ethology; Pioneers of Modern Ethology: Karl *von* Frisch, Ivan Pavlov,Konrad Lorenz, Niko Tinbergen; Proximate and ultimate causes of behaviour; tools, techniques and methods used in studying animal behaviour 12hrs/ 20 marks

Unit 2:Patterns of Behaviour

Stereotyped behaviours (Orientation, Reflexes); Kinesis, Tropotaxis, Klinotaxis, menotaxis, Individual behavioural patterns; Instinct *versus* Learned behaviour; Associative learning, Classical and Operant conditioning, Habituation, Imprinting. Animal bonds (Parent-Parent, Parent-Child etc). 12hrs/ 20 marks

Unit 3:Social and Sexual Behaviour

Social Behaviour: Concept of Society, Communication and the senses (Chemical, Tactile, Auditory, Visual); Altruism, Inclusive fitness, Hamilton's rule; Insects' society (Example: Honey bee); Foraging in honey bee and advantages of the waggle dance. Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Courtship behaviour; Parental care, sexual conflict in parental care. 12hrs/ 20 marks

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Unit 4:Introduction to Chronobiology & Biological Clocks

Historical developments in chronobiology, Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks. Relevance of biological clocks; Chronopharmacology, Chronomedicine, Chronotherapy 12hrs/ 20 marks

Unit 5: **Biological Rhythm**

Characteristics of biological rhythms; Short-and Long-term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non- photic zeitgebers; Circannual rhythms; Photoperiod and regulation of seasonal reproduction of vertebrates; Role of melatonin and serotonin. 12hrs/ 20 marks

Core Course –XVIII Practical: ZOO818CP (Ethology & Chronobiology)

Practical [Credits: 2] **30 hrs/50 marks**

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

Examination evaluation structure:

1. Procedure and result of any two Studies made (to be given during exam) out of sl. No. 1 to 7 (20 marks) (Procedure = 5, Result=5)x 2 = 20
2. Report submitted on the Visit to Forest/Wild life Sanctuary/Biodiversity Park/Zoological Park to study and record the behavioural activities of animals (5 marks)
3. Submission of a Photo of the Student performing the activity of constructing a nest either using wood or twigs in his/ her locality. The name of the type of Bird for whom the nest is made should be mentioned on the Photo. [Activity (importance of the activity should be emphasised) – 5 marks, Photo (display and writeup with the photo must be given preference while marking) – 5 marks] Total = 10
4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Alcock J. (2013). Animal Behaviour. Sinauer Associate Inc., USA.
- Dunlap J. C, Loros J. J, DeCoursey P. J. (2004) Chronobiology Biological Timekeeping.Sinauer Associates, Inc. Publishers, Sunderland, MA, USA

- Manning, A. and Dawkins, M. S. (2012). An Introduction to Animal Behaviour. Cambridge, University Press, UK.
- McFarland D. Animal Behaviour. (1982). Pitman Publishing Limited, London, UK.
- Vinod Kumar (2002) Biological Rhythms. Narosa Publishing House, Delhi/ Springer-Verlag, Germany

Suggested Readings:

- Paul W. Sherman and Alcock J. (2013). Exploring Animal Behaviour. Sinauer Associate Inc., Massachusetts, USA.
- Saunders D. S. (2002). Insect Clocks. III Edition, Barens and Noble Inc. New York, USA

Teaching and Learning Process:

In order to ensure best understanding of concepts and learning of skills by students, various strategies will be adopted to explore Animal behaviour and chronobiology. The animal behaviour in the wild can be shown to the student with the help of videos and short films. The classroom teaching should be inclusive, have opportunities for the students to participate in the class discussion and the students should be encouraged to observe various live animal behaviours in their immediate surrounding environment and interpret them. There should be ample scope for field visits and visit to the research laboratories. Seminar should be arranged at the departmental level for the student, where student can have paper presentation on various themes of animal behaviour and chronobiology. Quizzes and debates can be arranged to make the teaching learning more innovative. Students should be advised to use e resources along with standard text books and reference books. They should take short project work and case study on the animal behaviour. They should relate various concepts in chronobiology taught in the classroom with their daily life.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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

Generic Elective Course (GEC) -VI : ZOO806G
Fundamentals of Zoology – 6

Objective:
This course aims to provide the undergraduate students of other Subjects other than Zoology, a thorough knowledge of the use and application of Instruments.

Outcome:
Upon completion of the course, students should be able to understand the concept of Instruments in Zoology.

Course Content:
Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Microscopy :

Basic principles and types of Microscopes, Bright field, Dark field, Phase contrast, Fluorescence, Transmission and Scanning electron microscopy, Numerical aperture & limits of resolution. 12hrs/ 20 marks

Unit 2: Molecular biology & Biotechnology :

Introductory ideas on Chromosome, gene, DNA, RNA; introductory ideas of gene cloning & DNA fingerprinting; Polymerase chain reaction; Cell & Tissue culture in Animals; application of rDNA technology in agriculture and medicine. 12hrs/ 20 marks

Unit 3: Chromatography :

Principles and application of Chromatography, Principles and significance of Paper & thin layer Chromatography; basic ideas on the working principle and significance of GCMS & HPLC. 12hrs/ 20 marks

Unit 4 : Electrophoresis :

Principles &Types, introductory ideas on Agarose and Polyacrylamide gel Spectrophotometry; basic ideas on the working principles and instrumentation of UV- visible Spectrophotometer; Significance of flame Photometer, Atomic absorption & nuclear magnetic resonance Spectrophotometer. 12hrs/ 20 marks

Unit 5: Radio-Tracer & Some other diagnostic techniques :

Measurement of radioactivity; Basic ideas of Tracer techniques, Autoradiography, Radioimmunoassay; Introductory ideas of Enzyme – linked Immunosorbent assay (ELISA) and Indirect Haemagglutination Assay (IHA). 12hrs/ 20 marks

Generic Elective Course (GEC) -VI Practical : ZOO806GP

Fundamentals of Zoology - 6 Practical
(Instrumentation in Zoology)

Practical [Credits: 2]. 30 hrs/50 marks

1. Identification of the Parts of a Compound Microscope . (Identification = 1, use of the part = 2) Total = 3 marks

2. Principle & Calculation of numerical aperture of different lens (4 Marks)

3. Preparation & observation of Polytene Chromosome from Chironomus larva (Preparation = 5, Display =5, Procedure & observation = 5) Total = 15 marks

4. Separation of Amino Acids using Paper Chromatography. (Principle & procedure = 5, Display = 3, Observation & calculation = 5) Total = 13 marks

4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)

5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

1. Attwood,T.K & Parry Smith, D.J (2006). Introduction to Bioinstrumentation. Pearson Education Ltd.
2. Bajpai, P.K. (2006). Biological instrumentation and methodology. S. Chand Pub.
3. Chetan, D.M. & Bommegowda, K.P. (2023). Bio-medical Instruments and its applications. IP Innovative Pub.Pvt.Ltd.
4. Veerakumari,L. (2011). Bioinstrumentation. MJP publishers.

Teaching and Learning Process:

- Lectures: Classroom teaching using multimedia presentations, animations, and diagrams to explain complex molecular biology processes (e.g., replication, transcription, translation, CRISPR).
- Seminars and Discussions: Interactive group discussions on the latest developments in molecular biology and bioinformatics, encouraging peer-to-peer learning.
- Practical Laboratory Sessions: Hands-on experiments, pre-lab discussions, and post-lab analysis to reinforce theoretical knowledge.
- Problem-Based Learning (PBL): Case studies and project work to develop critical thinking and problem-solving skills.
- Workshops: Sessions focusing on the practical applications of bioinformatics tools, including hands-on software training.
- Peer Teaching: Encouraging students to present specific topics to enhance their understanding and communication skills.

Assessment Methods:

- **Class Tests and Quizzes**: Regular short tests to assess ongoing understanding of key concepts.
- **Practical Assessment**: Evaluation based on laboratory work, including accuracy in conducting experiments, proper use of bioinformatics tools, and maintaining lab notebooks.
- **Project Work**: Group or individual projects focused on the application of bioinformatics tools or molecular biology research.
- **Assignments**: Assignments based on recent developments in molecular biology or data analysis in bioinformatics.

- **Oral Presentations**: Students will present on selected topics, assessed based on content accuracy, delivery, and responses to peer queries.
- **Viva-Voce**: Oral examination to assess comprehensive knowledge of both theoretical and practical aspects of molecular biology and bioinformatics.
- **Final Examination**: A semester-end exam to evaluate the complete understanding of the

Discipline Specific Elective (DSE) Course - IV : ZOO804D
(Research methodology in Zoology – II)

Objective:

The course is designed with an aim to provide the students the knowledge to learn and get acquainted with the different techniques and methodologies adopted in Research in the field of Zoology.

Outcome:

Upon completion of the course, students shall be able to get a thorough knowledge on the philosophies and ethics of research and publication. They will be able to understand the different criteria of calculating Impact factors, metrices and indices.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Philosophy of Research : Introduction to Philosophy, definition, nature & scope, Concepts , Branches, moral philosophy, nature of moral judgement and reactions. Conflict of interest during research and publication; authorship, Predatory publishers and Journals; Phantom publications.
9 hrs/15 marks

Unit 2: Ethics in Science & Research, Scientific misconduct: Definition of Ethics, Ethics with respect to Science & research, Intellectual honesty and research integrity; Scientific misconduct- Falsification, Fabrication and Plagiarism. Examples of Fraud in Research & publication from India & abroad. 9 hrs/15 marks

Unit 3: Publication and Ethics : Redundant publications - duplicate & overlapping publications, salami slicing, selective reporting and misrepresentation of data; Definition and importance of Publication ethics; Best practices and guidelines : COPE, WAME etc; Publication misconduct - concept, problems that lead to unethical behaviour and Vice Versa; violation of publication ethics, authorship and contributorship; complaints and appeals.
15 hrs/25 marks

Unit 4: Open Access Publishing : Open access publishing and initiatives; SHERPA/ RoMEO online resource to check publisher copyright & self archiving policies. Software tools to identify predatory publications developed by SPPU. Journal finder/ Journal suggestion tools viz. JANE, Elsevier journal finder, Springer Journal suggester etc. 12 hrs/20 marks

Unit 5: **Research metrics, Software tools** : Indexing data bases, citation databases; Web of Science, Scorpus etc; Impact factor of Journal as per Journal citation report, SNIP, SJR, IPP,

Cite score, Metrics : h-index, g-index,i10 index, altmetrics. Use of Plagiarism software like Turnitin, Urkund and other open source software tools. 15hrs/25marks

Suggested Readings:

1. Bajwa, D.R. & Ahuja, Sh. (2023) Research Methodology Theory and Practice, Nation Press, 1st Edition
2. Kothari,C.R. & Garg, G. (2024). Research Methodology-methods and techniques. New Age International Publishers
3. Rao,K.H. & Pasumarti , S.S. (2012) Research Methodology: Techniques and Applications
4. Sharma,S. (2023). Research and Publication ethics. Sultan chand & Sons.

Online Tools and Web Resources:

https://www.UGC.gov.in; https://gemini.google.com ; ChatGPT, Scite.ai, Jenni.ai, Elicit, Research Rabbit, Google Scholar, Scinapse, Semantic Scholar, Scorpus, Connected papers, Dimensions, Litmaps

Discipline Specific Elective (DSE) Course –IV Practical : ZOO804DP (Research methodology in Zoology – II)

Internship[Credits 2] 50 marks (Report : 25 marks; Presentation : 25 marks)

Under this Discipline Specific Elective practical Subject, a Student need to undergo Internship of one month duration under a qualified Mentor (Preferably of the subject Zoology or Life Sciences/ Biological Sciences/Biochemistry/ Biotechnology) in an Institute other than the parent Institute. The Mentor shall be a PhD degree holder and shall have at least published one research paper. Preference may be given to Mentors in the University system, Research Institutes & Colleges with research facilities. After the Internship, the Student need to submit a Project report with a Certificate signed by the Mentor under whom the Internship has been done. (1 Credit).

After submission of the report, the Student need to make a Power point presentation of the Works done during the internship in the Department of the Parent Institute in front of a Committee of Teachers of the Department. (1 Credit)

Examination evaluation Structure:

1. Report : 25 marks (Based on the neatness, inclusiveness, overall presentation)
2. Presentation : 25 marks (Testing of Knowledge gained during the Internship)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium willbe adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

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