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 formed 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. Ithelps 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 analyse 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 forthe 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 with Credit distribution for the course

Semester	Course Opted	Course code	Name	Credit
I st	Ability Enhancement Compulsory Course (AECC)-I	AECC -I	English /MIL(Manipuri/Hindi)/ Env. Sc. https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2	4
	Core Course-I	**ZOO101 -C**	Animalia,Non-chordates I: Protozoa to Nemathelminthes	4
	Core Course-I Practical	**ZOO101- C P**	,,	2
	Core Course-II	**ZOO102- C**	Principles of Classification, Approaches in Taxonomy	4
	Core Course-II Practical	**ZOO102- C P**	,,	2
	Skill Enhancement Course(SEC)- I	**ZOO103- S**	Aquarium Fish keeping/Apiculture/Poultry farming	2
	Skill Enhancement Course(SEC)- I Practical	**ZOO103- S P**	,,	2
	Value addition Course (VAC) - I	VAC - I	**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 - II	**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 nd	Ability Enhancement Compulsory Course (AECC)-II	AECC-II	English /MIL(Manipuri/Hindi)/ Env. Sc.	4
	Core Course-III	**ZOO 201-C**	Non-chordates II:Annelida to Echinodermata, Minor Phyla	4
	Core Course-III Practical	**ZOO 201- C P**	,,	2
	Core course-IV	**ZOO 202 - C**	Animal Physiology , Endocrinology	4
	Core Course-IV Practical	**ZOO 202- C P**	,,	2
	Skill Enhancement Course(SEC)- II	**ZOO 203 - S**	Sericulture/ Vermicomposting/ Organic farming	2
	Skill Enhancement Course(SEC)- II Practical, Internship/exposure trip	**ZOO 203 – S P**	,,	2
	Value addition Course (VAC) - III	VAC - III	**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 - IV	**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[rd]	Core Course-V	**ZOO 301 - C**	Diversity of Chordates I : General organization of Chordata: Hemichordata to Pisces	4
	Core Course-V Practical	**ZOO 301 - C P**	,,	2
	Core Course-VI	**ZOO 302 - C**	Diversity ofChordates II : General organization of Chordata: Amphibia to Mammalia	4
	Core Course-VI Practical	**ZOO 302- C P**	,,	2
	Core Course-VII	**ZOO 303 -C**	Fundamentals of Biochemistry	4
	Core Course-VII Practical	**ZOO 303 - C P**	,,	2
	Generic Elective Course (GEC) - I	**ZOO 304 – G I**	Core subjects of Chemistry/ Botany/ Geography or any others as notified.	4
	Generic Elective Course (GEC) - I Practical	**ZOO 304 – G I P**	,,	2
	Value addition Courses(VAC) - V	VAC - V	**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[th]	Core Course-VIII	**ZOO 401 - C**	Palaeozoology, Zoogeography, Evolution	4
	Core Course-VIII Practical	**ZOO 401 – C P**	,,	2
	Core Course-IX	**ZOO 402 -C**	Histology & Comparative Anatomy of Vertebrates	4
	Core Course-IX Practical	**ZOO 402 -C P**	,,	2
	Core Course-X	**ZOO 403 - C**	Ecology and Biodiversity	4
	Core Course-X Practical	**ZOO 403 - C**	,,	2
	Generic Elective Course (GEC) -II	**Zoo 404 – G II**	Core subjects of Chemistry/ Botany/ Geography or any others as notified.	4
	Generic Elective Course (GEC) - II Practical	**Zoo 404 – G II P**	,,	2
	Value addition Courses(VAC) - VI	VAC - VI	**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
Vth	Core Course-XI	**ZOO 501 - C**	BioStatistics & Computer Application	4
	Core Course-XI Practical	**ZOO 501 - CP**	,,	2
	Core Course-XII	**ZOO 502 - C**	Cell Biology & Genetics	4
	Core Course-XII Practical	**ZOO 502 - C P**	,,	2
	Generic Elective Course (GEC) -III	**ZOO 503 – G III**	Core subjects of Chemistry/ Botany/ Geography or any others as notified.	4
	Generic Elective Course (GEC) -III Practical	**ZOO 503 – G III**	,,	2
	Value addition Courses(VAC) - VII	VAC - VII	**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	**ZOO 504 – D I**	Wildlife & Bioresource management / Integrated Pest management	4
	Discipline Specific Elective (DSE) Course - I Practical	**ZOO 504 – D I P**	Wildlife & Bioresource management / Integrated Pest management	2
				26
VIth	Core Course-XIII	**ZOO 601 - C**	Molecular Biology & Bioinformatics	4
	Core Course-XIIIPractical	**ZOO 601 - C P**	,,	2
	Core course-XIV	**ZOO 602 - C**	Adaptation in Animals, Applied Zoology	4
	Core Course-XIVPractical	**ZOO 602 - C P**	,,	2
	Generic Elective Course (GEC) -IV	**ZOO 603 – G IV**	Core subjects of Chemistry/ Botany/ Geography or any others as notified.	4
	Generic Elective Course (GEC) -IV Practical	**ZOO 603 – G IV P**	,,	2
	Value addition Courses(VAC) – VIII	VAC - VIII	**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	**ZOO 604 – D II**	Fish & Fisheries/ Parasitology/Aquatic biology	4
	Discipline Specific Elective (DSE) Course – II Practical	**ZOO 604 – D II P**	,,	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
VIIth	Core Course-XV	**ZOO 701 - C**	Biotechnology & Bioinstrumentation	4
	Core Course-XV Practical	**ZOO 701 - C P**	,,	2
	Core Course-XVI	**ZOO 702 - C**	Environmental Biology and Diseases	4
	Core Course-XVI Practical	**ZOO 702 - C P**	,,	2
	Generic Elective Course (GEC) -V	**ZOO 703 – G V**	Core subjects of Chemistry/ Botany/ Geography or any others as notified.	4
	Generic Elective Course (GEC) –V Practical	**ZOO 703 – G V P**	,,	2
	Discipline Specific Elective (DSE) Course - III	**ZOO 704 – D III**	Ecological restoration / Animal Biotechnology/ Introductory bioremediation	4
	Discipline Specific Elective (DSE) Course - III Practical	**ZOO 704 – D III P**	,,	2
				24
VIIIth	Core Course-XVII	**ZOO 801 - C**	Developmental Biology & Immunology	4
	Core Course-XVIIPractical	**ZOO 801 - C P**	,,	2
	Core course-XVIII	**ZOO 802 - C**	Ethology & Chronobiology	4
	Core Course-XVIII Practical	**ZOO 802 - C P**	,,	2
	Generic Elective Course (GEC) -VI	**ZOO 803 - G VI**	Core subjects of Chemistry/ Botany/ Geography or any others as notified.	4
	Generic Elective Course (GEC) –VI Practical	**ZOO 803 - G VI P**	,,	2
	Discipline Specific Elective (DSE) Course - IV	**ZOO 804 - D IV**	Medical Microbiology / Computational biology / Biological techniques	4
	Discipline Specific Elective (DSE) Course – IV Practical	**ZOO 804 - D IV P**	Medical Microbiology / Computational biology / Biological techniques	2
				24
Award of Bachelor's Degree with Honours in Zoology on completion of Courses equal to a minimum of 182 Credits				

Skill Enhancement Courses (SEC)	
SEC I	Aquarium Fish Keeping/Apiculture/ Poultry farming
SEC II	Sericulture/ Vermicomposting /Organic Farming

The Department/Institute can take up any one course out of the three provided. In case the course is not possible to be opened in the Institute, the Students may join any other Institute where the course is opened.

Generic Elective Course(GEC)	
GEC I	Core subjects of Chemistry/ Botany/ Geography or any others as notified.
GEC II	Core subjects of Chemistry/ Botany/ Geography or any others as notified.
GEC III	Core subjects of Chemistry/ Botany/ Geography or any others as notified.
GEC IV	Core subjects of Chemistry/ Botany/ Geography or any others as notified.
GEC V	Core subjects of Chemistry/ Botany/ Geography or any others as notified.
GEC VI	Core subjects of Chemistry/ Botany/ Geography or any others as notified.

The Department/Institute can take up any one core course preferably from Chemistry, Botany or Geography or from any others notified by the University. The teachers of Chemistry, Botany, Geography or relevant departments shall take the responsibility of teaching the said course.

Discipline Specific Elective (DSE)	
DSE I	Wildlife & Bioresource management / Integrated Pest management
DSE II	Fish & Fisheries/ Parasitology/ Aquatic Biology
DSE III	Ecological restoration / Animal Biotechnology/Introductory bioremediation
DSE IV	Medical Microbiology / Computational biology / Biological techniques

Value addition Course (VAC)

VAC I	VAC V	**One to be chosen for each from VAC list sl. no. 1 – 65 as detailed in Univ order no.523 dated 20th Sept 2022 (refer https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2)**
VAC II	VAC VI	
VAC III	VAC VII	
VAC IV	VAC VIII	

Courses for B. Sc. (Hons.) Zoology

SEMESTER I

Core Course -I: ZOO 101 - C (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: ZOO 101 - C P

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: ZOO 102 - C (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: ZOOI02-C P (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, 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 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: ZOO 103 - S (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 andgovernment 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, behavioural 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) Practical - I: ZOO 103 – SP (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 and their rearing methods. Collection of plants and bee products will also help students to know the benefits of apiculture. Visit to various apiculture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

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: ZOO 103 - S (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: ZOO 103 - SP (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 ofthe 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: ZOO 103 - S (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) Practical - I: ZOO 103 - SP (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 ofthe 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: ZOO 201 - C (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 the features 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: ZOO 201 - CP (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: ZOO 202 - C (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: ZOO 202 – C P (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: ZOO 203 – S (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, Distributionand 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: ZOO 203 – SP (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: ZOO 203 – S
(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: ZOO 203 – SP (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: ZOO 203 – S (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: ZOO 203 – SP (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: ZOO 301 - C (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: ZOO 301-C P

Practical [Credits 2] 30 hrs/ 50 marks

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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: ZOO 302 - C (Diversity of Chordates II: General organization of Tetrapods: 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: ZOO 302-C P

Practical [Credits 2] 30 hrs/50 marks

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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: ZOO 303 - C (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 in the fundamentals of biochemical sciences, interactions and interdependence of physiological and biochemical processes.
- Get exposed to various processes used in industries and gain skills in techniques of chromatography and spectroscopy.
- Demonstrate foundation knowledge in biochemistry; synthesis of proteins, lipids, nucleic acids, 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: ZOO 303 – C P

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/).

Courses for B. Sc. (Hons.) Zoology

SEMESTER IV

Core Course –VIII: ZOO 401 - C (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: ZOO 401 – C P

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: ZOO 402 - C (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: ZOO 402 – C P

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: ZOO 403 - C (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: ZOO 403 – C P

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