COURSE STRUCTURE AND CREDIT FRAMEWORK FOR THREE YEARS UG DEGREE/ FOUR YEARS UG DEGREE (HONOURS WITHOUT RESEARCH)/ FOUR YEAR UG DEGREE (HONOURS WITH RESEARCH) IN ZOOLOGY(As per National Education Policy, 2020)

Effective from Academic Session 2023-24

DEPARMENT OF ZOOLOGY,
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Introduction

The National Education Policy (NEP), 2020 (hereinafter referred to as NEP) is enacted at the backdrop that education plays an vital role in overall promotion and development of human as well as societal well-being. Therefore, quality education is a priority that may aim to produce intelligent, thoughtful, well-rounded, and creative individuals.

The NEP 2020 states, *"Assessments of educational approaches in undergraduate education that integrate the humanities and arts with Science, Technology, Engineering and Mathematics (STEM) have consistently shown positive learning outcomes, including increased creativity and innovation, critical thinking and higher-order thinking capacities, problem-solving abilities, teamwork, communication skills, more in-depth learning and mastery of curricula across fields, increases in social and moral awareness, etc., besides general engagement and enjoyment of learning"*

Further, NEP recommends "opportunity for flexible, multidisciplinary approach, and multiple entry and exit options in higher education, in addition to a focus on the chosen major and minors as per the choices of the student" In accordance with the NEP 2020, the Rajiv Gandhi University has formulated "Curriculum and Credit Framework for Undergraduate Programmes (CCFUP)" that included major stream courses, minor stream courses, multidisciplinary courses (MDC), Ability Enhancement Courses (AEC), Skills Enhancement courses (SEC), value-added courses (VAC), and a set of courses on environmental education, language, understanding India, digital and technological solutions, health and wellness, yoga education, and sports to facilitate students to pursue their career path by choosing the subject/field of their interest

Features of the New Curriculum Framework

The new curriculum framework will have the following features:

i. Flexibility to move from one discipline of study to another;
ii. Opportunity for learners to choose the courses of their interest in all disciplines;
iii. Facilitating multiple entry and exit options with UG certificate/ UG diploma/ or degree depending upon the number of credits secured;
iv. Flexibility for learners to move from one institution to another to enable them to have multi and/or interdisciplinary learning;
v. Flexibility to switch to alternative modes of learning (offline, ODL, and Online learning, and hybrid modes of learning).

Award of UG Certificate/Diploma/Degree/ Degree (honours) with /without Research

- **UG Certificate:** Students who opt to exit after completion of the first year and have secured 40 credits will be awarded a UG certificate if, in addition, they complete one vocational course of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.
- **UG Diploma**: Students who opt to exit after completion of the second year and have secured 80 credits will be awarded the UG diploma if, in addition, they complete one vocational course of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.
- **3-year UG Degree:** Student who undergoes 3-year UG programme will be awarded UG Degree in the Major discipline after successful completion of three years and securing 120 credits.
- **4-year UG Degree (Honours):** Student who undergoes four-year UG programme without research project will be awarded UG honour in the major discipline after successful completion of four years and securing 160 credits.
- **4-year UG Degree (Honours with Research):** Students who secure 8.5 credit and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation, instead three departmental electives, under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students who secure 160 credits, including 12 credits from a research project/dissertation, will be awarded UG Degree (Honours with Research).

Definition, eligibility and duration of the programme

- **Semester:** The semester is comprise of 90 working days and an academic year is divided into two semesters.
- **Credit**: A credit is a unit by which the course work is measured. It determines the number of hours of engagement required in a module. As per NEP 2020, 1 credit for lecture = 15 hours in a semester of 15 weeks, 1 credit for tutorial = 15 hours in a semester of 15 weeks and 1 credit for practical/practicum = 30 hours in a semester of 15 weeks.
- **Summer Internship/Apprenticeship**: Students pursuing UG certificates, UG diplomas, 3-year degrees, 4-year degrees with honours, and 4-year degrees with honours with research are required to complete a summer internship or apprenticeship. However, it must be finished

during the summer break at the end of the second semester for UG certificates, during the summer break at the end of fourth semester for UG diplomas, and for other courses, it must be finished by the end of the fifth semester. The students will choose one for their internship from the varieties of occupational courses offered in the common framework.

- **Major course:** Major course is the discipline or subject of main focus and the degree will be awarded in that discipline. Students should secure the prescribed number of credits through core courses in the major discipline.
- **Minor course**: Minor course will helps a student to gain a broader understanding beyond the major discipline. The student from other major courses of allied department will be able to take zoology minor courses from the minor courses offered in the common framework.
- **Multidisciplinary course**: Student with major in zoology must choose a multidisciplinary course from the multidisciplinary course offered in the common framework.
- **Value-Added Course**: Zoology students are required to take a value-based course from the value-based courses offered in the common framework.
- **UG honours with Research**: Student with major in zoology who earned 9 CGPA or higher in the first six semesters must conduct research project in the 8^{th} semester in 4^{th} year.
- **UG Honours**: Student with major in zoology who does not complete a research project or dissertation must take three departmental electives of 12-credit courses in their place.
- **Exit and re-entry**: Students who have received an undergraduate certificate or undergraduate diploma are eligible for exit from and re-entry into the degree course in education at the second semester (first year) and fourth semester (second year), respectively. However, these students will be permitted to reapply to the degree programme within three years of their withdrawal, and they will be required to finish it within the full seven-year time frame.
- **Requirement for 4-year UG Degree (Honours with Research):** The Departments offering a 4-year UG Degree (Honours with Research) must have the required infrastructure such as the library, access to journals, computer lab and software, laboratory facilities to carry out experimental research work, and at least two permanent faculty members who are recognized as Ph.D. supervisors.
- **Programme**: The Programme of study is constitute of lectures courses, tutorial courses, practicum or laboratory work, seminar, internship, studio based activities, field practice/projects and community engagement.

Eligibility for the UG Programmes

Senior Secondary School Leaving Certificate or Higher Secondary (12^{th} Grade) Certificate obtained after successful completion of Grade 12 or equivalent stage of education.

Letter Grades and Grade Points

The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester. The SGPA is based on the grades of the current term, while the Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study. The letter grades will be as in the table:

Letter grade Table

Letter Grade	**Grade point**
O (outstanding)	10
A+ (Excellent)	9
A (Very good)	8
B+ (Good)	7
B (Above average)	6
C (Average)	5
P (Pass)	4
F (Fail)	0
Ab (Absent)	0

Computation of SGPA and CGPA

The following procedure shall be used to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

i. **Semester Grade Point Average (SGPA) calculation**: The SGPA is the ratio of the sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e.
The formula to calculate:

$$\textbf{SGPA (Si)} = \sum(\textbf{Ci x Gi}) / \sum\textbf{Ci}$$

Where Ci is the number of credits and Gi is the grade point scored by the student in the i^{th} course.

Example for Computation of SGPA

Semester	Course	Credit	Letter Grade	Grade point	Credit Point (Credit x Grade)
I	Course 1	3	A	8	3 X 8 = 24
I	Course 2	4	B+	7	4 X 7 = 28
I	Course 3	3	B	6	3 X 6 = 18
I	Course 4	3	O	10	3 X 10 = 30
I	Course 5	3	C	5	3 X 5 = 15
I	Course 6	4	B	6	4 X 6 = 24
I		20			139
SGPA=139/20= 6.95					

ii. **Cumulative Grade Point Average (CGPA) calculation:** The Cumulative Grade Point Average (CGPA) is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programme, i.e.

$$\mathbf{CGPA = \sum(Ci \times Si) / \sum Ci}$$

where Si is the SGPA of the ith semester and Ci is the total number of credits in that semester.

Example for Computation of CGPA

Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6
Credit:20 SGPA:6.9	Credit: 20 SGPA:7.8	Credit:20 SGPA:5.6	Credit:20 SGPA:6.0	Credit:20 SGPA: 6.3	Credit: 20 SGPA 8.0
CGPA= (20 x 6.9)+ (20 x 7.8)+ (20 x 5.6)+ (20 x 6.0)+ (20 x 6.3)+ (20 x 8.0)/120 **CGPA=** 138+156+112+120+126+160= 812/120=**6.76**					

The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

Committees

The following committees were involved in the framing of the Course Curriculum and credit framework of the presented UG programme.

1. **Drafting Committee (DC)**

S.N.	Name and Designation	Member
1	Dr. Daniel Mize (Head, in-charge), Associate Professor	Chairman
2	Dr. Hiren Gogoi, Assistant Professor	Member
3	Dr. Gunjan Kumar Saurav, Assistant Professor	Member
4	Dr. Munendra Kumar, Assistant Professor	Member

2. Departmental Research Council (DRC)

S.N.	Name and Designation	Member
1	Dr. Daniel Mize (Head, in-charge), Associate Professor	Chairman
2	Prof. H.N Sarma, Professor	Member
3	Prof. D.N. Das, Professor	Member
4	Prof. J. Chakravorty, Professor	Member
5	Mr. M. S. Singh	Member
6	Dr. Hiren Gogoi, Assistant Professor	Member
7	Dr. Gunjan Kumar Saurav, Assistant Professor	Member
8	Dr. Arnab Ghosh, Assistant Professor	Member
9	Dr. Munendra Kumar, Assistant Professor	Member

3. Board of Studies (BoS)

S.N.	Name and Designation	Member
1	Dr. Daniel Mize, (Head, i/c), Associate Professor, Dept. of Zoology, Rajiv Gandhi University	Chairman
2	Prof. H.N Sarma, Professor, Dept. of Zoology, Rajiv Gandhi University, Arunachal Pradesh	Member
3	Prof. D.N. Das, Professor, Dept. of Zoology, Rajiv Gandhi University, Arunachal Pradesh	Member
4	Prof. J. Chakravorty, Professor, Dept. of Zoology, Rajiv Gandhi University, Arunachal Pradesh	Member
5	Mr. M.S. Singh, Assistant Professor, Dept. of Zoology, Rajiv Gandhi University, Arunachal Pradesh	Member
6	Dr. Hiren Gogoi, Assistant Professor, Dept. of Zoology, Rajiv Gandhi University, Arunachal Pradesh	Member
7	Prof. SumpamTangjang, Professor, Dean Faculty of Life Sciences Dept. of Botany, Rajiv Gandhi University, Arunachal Pradesh	Member
8	Prof. Hui Tag, Professor, Dept. of Botany, Rajiv Gandhi University, Arunachal Pradesh	Cognate Member
9	Prof. S.R. Hajong, Professor, Dept. of Zoology, North Eastern Hill University, Shillong, Meghalaya	External Member
11	Prof. Robin Doley, Professor, Dept. of Molecular Biology and Biotechnology, Tezpur University, Assam	External Member
12	Dr. Prashanta Nanda, Assosiate Professor Dept. of Zoology, Dera Natung Govt. College , Itanagar, Arunachal Pradesh	Member

Course Structure for Three years UG and Four Years UG Degree with Honours in Zoology without or with Research

NCrF Credit Level	Sem	Major		Minor		Multidisciplinary Course		Ability Enhancement Course		Skill Enhancement Course		Value-Added Course		Internship/ Research Project		Total Credit
		Course	Credit	Course	Credit	Course	Credit	Course	Credit	Course	Credit	Course	Credit	Course	Credit	
4.5	1st	Major 1 (ZOO-CC-1110)	4	Minor 1 (ZOO-MC-1110)	4	MDC 1 (ZOO - MD-1110)	3	AE 1 (ENG-AE-1110)	4	SE 1 (ZOO-SE-1110	3	VA 1	2			**20**
	2nd	Major 2 (ZOO CC-1120)	4	Minor 2 (ZOO MC-1210)	4	MDC 2 (ZOO - MD-1120)	3	AEC 2 (HIN-AE-1210)	4	SE 2	3	VA 2	2			**20**
Students exiting the programme after securing 40 credits will be awarded UG Certificate in the relevant Discipline /Subject provided they secure 4 credits in work-based vocational courses offered during the summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during the first and second semester.																
5.0	3rd	Major 3 (ZOO -CC-2310)	4	Minor 3 (ZOO -MC-2310)	4	(ZOO - MD-2310)	3			SEC 3*	3	VAC 3**	2			**20**
		Major 4 (ZOO -CC-2320)	4													
	4th	Major 5 (ZOO -CC-2410)	4	Minor 4 (ZOO -MC-2410)	4											**20**
		Major 6 (ZOO -CC-2420)	4													
		Major 7 (ZOO -CC-2430)	4													
		Major 8 (ZOO -CC-2440)	4													
Students exiting the programme after securing 80 credits will be awarded UG Diploma in the relevant Discipline /Subject provided they secure additional 4 credits in skill-based vocational courses offered during the first year or second year summer term.																
5.5	5th	Major 9 (ZOO CC-3510)	4	Minor 5 (ZOO -MC-3510)	4									Internship (INT- ZOO - 0010)	2	**20**
		Major 10 (ZOO -CC-3520)	4													
		Major 11 (ZOO CC-3530)	4													
		Major 12	2													

		(ZOO -CC-3540)														
	6th	Major 13 (ZOO -CC-3610)	4	Minor 6 (ZOO -MC-3610)	4											**20**
		Major 14 (ZOO -CC-3620)	4													
		Major 15 (ZOO -CC-3630)	4													
		Major 16 (ZOO -CC-3640)	4													
Students who undertake a 3-year UG programme will be awarded UG Degree in the relevant Discipline /Subject upon securing 120 credits.																
	7th	Major 17 (ZOO -CC-4710)	4	Minor 7 (Research Methodology) (ZOO -MC-4710)	4											**20**
		Major 18 (ZOO -CC-4720)	4													
		Major 19 (ZOO -CC-4730)	4													
		Major 20 (ECO-CC-4740)	4													
6.0	**8th**	Major 21 (ZOO -CC-4810)	4	Minor 8 (Research and Publication ethics)	**4**											**20**
		Major 22 – elective (ZOO -DE-4810)	4													
		Major 23 - elective (ZOO -DE-4820)	4													
		Major 24 - elective (ZOO -DE-4830)	4													
			94		**32**		**9**		**8**		**9**		**6**		**2**	**160**
Students who undertake a 4-years UG programme will be awarded UG Degree with Honours in the relevant Discipline /Subject upon undergone the three Department elective without any research dissertation and securing overall 160 credits (Major-94 credits (including Departmental electives), Minor-32 credits, MDC-9 credits, AEC-8 credits, SEC-9 credits, VEC-6 credits & intership-2 credits)																

	8th	Major 21 (ZOO -CC-4810)	4	Minor 8 (Research and Publication ethics)	**4**									**Research Project**	**12**	**20**
			82		**32**		**9**		**8**		**9**		**6**		**14 (2+12)**	**160**
Students who undertake a 4-years UG programme will be awarded UG Degree with Honours with research in the relevant Discipline /Subject upon completion of 12 credits research dissertation instead of three departmental electives and securing overall 160 credits (Major-82, credits, Minor-32 credits, MDC-9 credits, AEC-8 credits, SEC-9 credits, VEC-6 credits, research – 12 credits & intership-2 credits).																

NCrF level	Semester	Course Code, name and categories	Credit	Total Credit
4.5	1st	Major 1: ZOO-CC-1110- Systematics and Diversity of Protists and Non-Chordates	4	20
		Minor-1: ZOO-1110- Animal Diversity	4	
		Multidisciplinary course-1: ZOO-MD-1110- Freshwater Ornamental fishery	3	
		Ability Enhancement Course-1: ENG-AE-0010- Communicative English	4	
		Skilled Enhancement Course 1: ZOO-SE-0010- Apiculture	3	
		Value added Course 1: ZOO-VA-001	2	
	2nd	Major 2: ZOO-CC-1210- Cell biology and Histology	4	20
		Minor 2: ZOO-MC-1210- Human Physiology	4	
		Multidisciplinary course 2: ZOO-MD-1210- Dairy Production and Technology	3	
		Ability Enhancement Course 1: EVS-AE-0020- Environmental studies	4	
		Skilled Enhancement Course 2: ZOO-SE-0020- Sericulture	3	
		Value added Course 2: ZOO-VA-002	2	
Students exiting the programme after securing 40 credits will be awarded UG Certificate in the relevant Discipline /Subject provided they secure 4 credits in work-based vocational courses offered during the summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during the first and second semester.				
5.0	3rd	Major 3: ZOO-CC-2310- Comparative Structure and Function of Chordata	4	20
		Major 4: ZOO-CC-2320- Physiology of Chordates	4	
		Minor 3: ZOO-MC-2310- Natural Resource management	4	
		Multidisciplinary course 3: ZOO-MD-2310- Environmental Biotechnology	3	
		Skilled Enhancement Course 1: ZOO-SE-0030- Public Health and Hygiene	3	
		Value added Course 1: ZOO-VA-003-	2	
	4th	Major 5: ZOO-CC-2410- Evolutionary Biology	4	20
		Major 6: ZOO-CC-2420- Human Reproductive Biology	4	
		Major 7: ZOO-CC-2430- Pest and Management strategies	4	
		Major 8: ZOO-CC-2440- Biodiversity and Conservation Biology	4	
		Minor 4: ZOO-MC-2410- Aquatic Biology	4	
Students exiting the programme after securing 80 credits will be awarded UG Diploma in the relevant Discipline /Subject provided they secure additional 4 credits in skill-based vocational courses offered during the first year or second year summer term.				
5.5	5th	Major 9: ZOO-CC-3510- Animal Behaviour	4	20
		Major 10: ZOO-CC-3520- Fundamentals of Biomolecules	4	
		Major 11: ZOO-CC-3530- Molecular Biology	4	
		Major 12: ZOO-CC-3540- Microbiology and Parasitology	2	
		Minor 5: ZOO-MC-3510- Global Climate Change	4	
		Internship/dissertation/seminar	2	

	6th	Major 13: ZOO-CC-3610- Developmental Biology	4	20
		Major 14: ZOO-CC-3620- Genetics	4	
		Major 15: ZOO-CC-3630- Genetic Engineering and Biotechnology	4	
		Major 16: ZOO-CC-3640- General Endocrinology	4	
		Minor 6: ZOO-MC-3610- Wildlife Conservation and Management	4	
Students who want to undertake a 3-years UG programme will be awarded UG Degree in the relevant Discipline /Subject upon securing 120 credits.				
6.0	7th	Major 17: ZOO-CC-4710- Ecology	4	20
		Major 18: ZOO-CC-4720- Immunology	4	
		Major 19: ZOO-CC-4730- Biostatistics and Bioinformatics	4	
		Major 20: ZOO-CC-4740- Biological Techniques	4	
		Minor 7: ZOO-MC-4710- Research Methodology	4	
	8th (for 4 years UG honour)	Major 21: ZOO-CC-4810- Biochemistry: Basic concepts of metabolism	4	20
		Major 22: ZOO-DE-4810/4811/4812/4813/4814	4	
		Major 23: ZOO-DE-4820/4821/4822/4823/4824	4	
		Major 24: ZOO-DE-4830/4831/4832/4833/4834	4	
		Minor 8: ZOO-MC- 4810- Research and Publication Ethics	4	
Major course=24, Minor course=8, Multidisciplinary course=3, Ability Enhancement course=2, Skill Enhancement Course=3, Value added course=3 & Internship=1				160
Students who want to undertake a 4-years UG programme will be awarded UG Degree with Honours in the relevant Discipline /Subject upon securing 160 credits.				
	8th (For 4 years UG honour with research)	Major 21: ZOO-CC-4810- Biochemistry: Basic concepts of metabolism	4	20
		Minor 8: ZOO-MC- 4810- Research and Publication Ethics	4	
		Research Project	12	
Major course=24, Minor course=8, Multidisciplinary course=3, Ability Enhancement course=2, Skill Enhancement Course=3, Value added course=3 & Internship=1 & dissertation=1				160
Students who undertake a 4-years UG programme will be awarded UG Degree with Honours with research in the relevant Discipline /Subject upon securing 160 credits.				

COURSE CONTENTS

Semester I
Major Course (CC)-1
ZOO-CC-1110- Systematics and Diversity of Protists and Non-Chordates

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	03	Theory:	45
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	04	Total:	75

About the course: The course is a walk through the amazing diversity of living forms. It enlightens origin of organisms and its gradual adaptation in the environment with their special characteristics. It also deals with the differences and similarities between organisms on the basis of their morphology and anatomy which led to their grouping into taxa and clades.

Learning outcomes: The students will be able to develop understanding on the diversity of life with regard to protists and non-chordates, group of animals on the basis of their morphological characteristics, evolution of animal, evolutionary history through phylogenetic tree and morphological change due to change in environment helps drive evolution over a long period of time.

Theory

Unit 1 **15 Hours**

Systematics and taxonomy. Species concept, clades. Concept of type specimen, taxidermy and maintenance of museum specimen. Nomenclature and utility of scientific names. Classification: morphological and evolutionary (molecular). Relationship of taxa: phylogenetics and cladistics with special reference to paraphyly, monophyly, apomorphy, plesiomorphy and phenoplasticity

Unit 2 **15 Hours**

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

Unit 3 **15 Hours**

The Ecdysozoa: characteristics of the representative taxa. Pseudo coelomates; Basic organization and adaptive radiations in roundworms. The coelomates: Basic organization and adaptive radiations in Arthropods- Ancestors/ fossil arthropods. Adaptive radiations in Crustaceans, Myriapods, Chelicerates, Insects, etc. Basic organization and diversity in Annelids. Basic organization and diversity in Molluscs. Disruption of bilateral symmetry and its significance. Basic organization of Echinoderms; their affinity to Chordates. Canal system in Porifera. Locomotion of Protozoa, Annelida and Mollusca and their locomotory organs. Respiratory systems of Arthropod. Circulatory system in Arthropods. Torsion in gastropods. Nervous systems of Mollusca. Larvae in echinoderms and their affinities with chordates. Locomotion system in Echinodermata. Coelom and its modifications in invertebrates. Venoms and venomous insects. Excretory system in invertebrates.

Practical

Unit 4 **30 Hours**

1. Study of permanent slides and museum specimens and their classification and diagnostic features.
2. Collection of five species (preferably invertebrates, insects) belonging to a clade.
3. A project work on their generic identification, description, illustration and construction of cladogram using characters and character states.
4. Microscopic study of structure of certain protists
5. Study of locomotory organs of protozoa and Annelida
6. Study of Respiratory organs in Arthropoda
7. Study of Nervous system in Mollusca

Recommended readings:

1. Barnes, R. S. K. et al. (2002) The Invertebrates: a Synthesis, Blackwell Publishing.
2. Hickman, C. et al (2018) Animal Diversity, McGraw-Hill.
3. Holland, P. (2011) The Animal Kingdom: A Very Short Introduction, Oxford University Press.
   Barrington, E.J.W. (1979) Invertebrate Structure and Functions. II Edition. E.L.B.S. and Nelson.
4. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
5. Bushbaum, R. (1964) Animals without Backbones. University of Chicago Press.

Semester I
Minor Course (MC)-1
ZOO-MC-1110- Animal Diversity

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: The course is a walk through diversity of invertebrate forms. It enlightens origin of organisms and its gradual adaptation in the environment with their special characteristics. It also deals with the differences and similarities between organisms on the basis of their morphology and anatomy which led to their grouping into taxa and clades.

Learning outcomes: The students will be able to develop understanding on the diversity of life with regard to protists and non-chordates, group of animals on the basis of their morphological characteristics, evolution of animal, evolutionary history through phylogenetic tree and morphological change due to change in environment helps drive evolution over a long period of time.

Theory

Unit 1 **15 Hours**

Kingdom Protista: Diversity concept and General characters and classification up to classes; Locomotory organelles and locomotion in Amoeba and Paramecium; Kingdom Animalia and diversity and forms ; Phylum Porifera- General characters and classification up to classes; Canal System in Sycon; Phylum Cnidaria - General characters and classification up to classes; Metagenesis in Obelia; Phylum Platyhelminthes-General characters and classification up to classes; Life history of Taenia solium; Phylum Nemathelminthes-General characters and classification up to classes; Life history of Ascaris lumbricoides and its adaptation

Unit 2 **15 Hours**

Phylum Annelida- General characters and classification up to classes; Metamerism in Annelida; Phylum Arthropoda-General characters and classification up to classes; Eye in Cockroach, Metamorphosis in Lepidoptera; Phylum Mollusca-General characters and classification up to classes; Respiration in Pila

Unit 3 **15 Hours**

Phylum Echinodermata- General characters and classification up to classes; Water vascular system in Asteroidea; Protochordates- General Characters; Pharynx and feeding mechanism in Amphioxus; Agnatha- General features of Agnatha and classification of cyclostomes up to classes; Pisces-General features and Classification up to orders. Amphibia- General features and Classification up to orders, Reptiles-General features and Classification up to orders; Poisonous and non-poisonous snakes, Biting mechanism; Aves-General features and Classification up to orders, Mammals-Classification up to orders.

Practical

Unit 4. **30 hours**

1. Identification with reasons of the following specimens: Amoeba, Euglena, Paramecium, Taenia solium, Ascaris lumbricoides (Male and female), Aphrodite, Nereis, Hirudinaria, Palaemon, Limulus, Apis, Chiton, Unio, Sepia, Octopus, Echinus, Cucumaria and Antedon, Balanoglossus, Branchiostoma, Petromyzon, Labeo rohita, Tor potitora, Cyprinus carpio, Clarias batrachus, Prawn
2. Observation and Key for Identification of poisonous and non-poisonous snakes
3. Study of anatomy of digestive system, salivary gland, mouth parts of Periplaneta
4. Study of reproductive system of female cockroach

Recommended Readings:

1. Barnes, R. S. K *et al* (2002) The Invertebrates: a Synthesis, Blackwell Publishing.
2. Hickman, *et al.* (2018) Animal Diversity, McGraw-Hill.
3. Holland, P. (2011) The Animal Kingdom: A Very Short Introduction, Oxford University Press.
4. Barrington, E.J.W. (1979) Invertebrate Structure and Functions. II Edition. E.L.B.S. and Nelson.
5. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Pub. Home.
6. Bushbaum, R. (1964) Animals without Backbones. University of Chicago Press.
7. Young, J.Z. (2004). The Life of Vertebrates .III Edition. Oxford university press.
8. Jordan, E. L. and Verma, P. S. (2015) Chordate Zoology (14th edition).
9. Ganguly, Sinha and Adhikari. Biology of Chordates.
10. Kotpal, R.L. Vertebrates. Rastogi Publications
11. Jordan, E. L. and Verma, P. S. (2015) Chordate Zoology (14th edition).

Semester I
Multidisciplinary Course (MDC)-1
ZOO-MD-1110- Freshwater Ornamental fishery

Marks	Credits	Contact hours
End semester exam: 80	Theory: 02	Theory: 30
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 03	Total: 60

About the course: The course will provide students with fundamental subject knowledge in the discipline of Freshwater Ornamental Fish. It also aims to make the student understand the economic viability of ornamental fish as well as diversity of Fresh water ornamental fish.

Learning outcomes: The students will be able to understand the values, diversity and scientific management of ornamental fishes, aquarium, brood stock, ornamental fish diseases. Also, will be able to explore unique problems with fresh water ornamental fish management and will acquired knowledge about freshwater water quality and feeds required for culture of fresh water ornamental fish.

Theory

Unit 1. **15 Hours**

Design and construction of aquaria and its accessories. Water quality management in aquarium systems and plants for Aquarium. Identification and biology of Important Fresh water and indigenous ornamental fishes. Sexual dimorphism in ornamental fishes. Breeding and rearing of common ornamental fishes. Conditions for breeding- pH, temperature and sex ratio.

Unit 2. **15 Hours**

Brood stock management- selection of brooders, maintenance and management of brood stocks. Modern breeding techniques. Colour enhancement techniques. Food and feeding habits of ornamental fishes. Preparation and culture of live feed (Artemia, Infusoria, Spirulina). Control of algal growth, snails and other predators. Common disease of ornamental aquarium fishes and its symptoms, treatment and prophylactic measures.

Practical

Unit 3. **30 Hours**

1. Identification of common aquarium fishes
2. Groupings of light-bearers and egg-scatterer ornamental fish
3. Physico-chemical analysis of aquarium water
4. Identification of aquarium plants
5. Culture of live fish food and use of commercial formulated feed
6. Aquarium management using aquarium devices

Recommended readings:

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

Semester I
Ability Enhancement Course (AEC)-1
ENG-AE-1110- Communicative English

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	04	Theory:	60
Assignment/sessional exam:	20	Practical:	00	Practical:	00
Total:	100	Total:	04	Total:	60

About the course: The course will provide students insight into popular work of English literature of world as well as of India. It also aims to make the student proficient in both spoken and as well as in the written English language.

Learning outcomes: The students will become proficient in spoken as well as in written English language, particularly in public speaking. The student will also acquire basic knowledge of the popular literary work and daily use of communicative English.

Theory

Unit 1 **15 Hours**

Poetry: William Shakespeare – All the World is a stage; William Wordsworth – I wondered lonely as a Cloud; Ralph Waldo Emerson – The Mountain and the Squirrel; Emily Dickinson – Success is Counted Sweetest; Robert Frost - Stopping by Woods on a Snowy Evening; Rabindranath Tagore – Where the Mind is without Fear; A. K. Meherotra – Songs of the Ganga.

Unit 2 **15 Hours**

Short Stories: R.K. Narayan – Lawly Road; Mulk Raj Anand – Barbar's Trade Union; Somerset Mangham – The Luncheon; Guy De. Maupassant – The Necklace; Anton Chekhov – The Lament; O' Henry – The Last Leaf; Manoj Das – The Submerged Valley.

One-Act Plays and Short Fiction: (a) Norman Mckinnell - The Bishop's Candle Sticks; Anton Chekov – A Marriage Proposal; Eugene Lonesco – The Lesson; August Strandberg – Miss Jullie; Fritz Karinthy– Refund; (b) Harper Lee – To kill a Mocking Bird, (Or) R. K. Narayan – Vendor of Sweets.

Unit 3 **15 Hours**

Fundamentals of Grammar: Parts of speech, Articles and Intensifiers, use of tense forms, Use of Infinitives, Conditionals, Adjectives and Adverbs, Prepositions, Making Affirmative, Negative and Interrogative, Making Question Tag.

Unit 4 **15 Hours**

Composition Practice: (a) Comprehension, Precis Writing, Paragraph Writing (150 words), Letter writing – Personal, Official, Demi-official, Business, Public speaking, Soft Skills, Interviews, Preparing Curriculum Vitae, Report (Meetings and Academic) writing; (b) Communication Practice – Introducing yourself, Introducing people to others, Meeting People, Exchanging Greetings, Taking Leave, Answering the Telephone, Asking Someone for Some Purpose, Taking and Leaving Messages, Call for help in emergency.

Recommended Readings:

1. For reading the texts available sources of texts and help of the Web source may be taken.
2. Crystal, David (1985) Rediscover Grammar with David Crystal. Longman.
3. Hewings, M. (1999) Advanced English Grammar. Cambridge University Press.
4. Bakshi, R. N. A course in English Grammar, Orient Longman
5. Krishnaswamy, N. A Book of Grammar, Usage and Composition. MacMillan India Ltd.
6. Bailey, Stephen (2003). Academic Writing. London and New York, Routledge.
7. Grellet, F (1981). Developing Reading Skills: A Practical Guide to Reading Skills. New York, CUP
7. Hedge, T. (2005). Writing. London, OUP
8. Kumar, S and Pushp Lata (2015). Communication Skills. New Delhi, OUP
9. Lazar, G. (2010). Literature and Language Teaching. Cambridge, CUP
10. Nuttall, C (1996). Teaching Reading Skills in a Foreign Language. London, Macmillan
11. Raman, Meenakshi and Sangeeta Sharma (2011). Technical Communication: Principles and Practice. New Delhi, OUP

Semester I
Skill Enhancement Course (SEC)-1
ZOO-SE-1110- Apiculture

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	02	Theory:	30
Internal assessment :	20	Practical:	01	Practical:	30
Total:	100	Total:	03	Total:	60

About the course: The course will provide students with fundamental subject knowledge in the discipline of Apiculture. It also aims to make the student understand the economic viability of apiculture as well as diversity of honey bee species.

Learning outcomes: The students will be able to understand the values, diversity and scientific management of honey bees and its diseases. Also, will be able to explore unique problems with Apiculture management and will acquired knowledge about bee keeping equipment, honey bee identification and feeds required for culture of honey bee

Theory

Unit 1 **15 Hours**

Systematics and Beekeeping, Bee species, Bee morphology, Colony organization, Polymorphism, Caste system, Division of labour, Bee flora, Extent of Beekeeping in India, Limitations on the development of beekeeping, Advantages of extensive Beekeeping.

Unit 2 **15 Hours**

Beekeeping equipments: Bee box and tools, how to manage a colony, the manipulation of a colony. Bee products: Honey, Bees wax, Pollens, Royal Jelly, Propolis and Bee venom. taking care of bee diseases and enemies, Routine management, Harvesting and marketing of bee products. Important Institutions pertinent to Apiculture: National Bee Board, Bee research and Training Institute, Apiaries. Economics and extension of Bee keeping.

Practical

Unit 3 **30 Hours**

1. Identification of honey bees: Apis laboriosa, Apis dorsata, Apis cerana, Apis mellifera, Apis florea,.
2. Identification of comb of honey bees.
3. Detailed study of wing venation, legs and antenna of Apis cerana and Apis mellifera.
4. Identification of different parts of movable beehive and beekeeping equipments.
5. Identification of major pollen and nectar plants.
6. Demonstration of swarm capture and honey harvesting.

Recommended readings

1. Abrol , D. P. (1997) Bees and Beekeeping. Kalyani Publisher, New Delhi.
2. Abrol, D. P. (2010) A Comprehensive guide to Bees and Beekeeping. Scientific Publisher, New Delhi.
3. Withhead, S. B. (2010) Honey bees and their management Axis books Publisher,Jodhpur.
4. Nagaraja, N. and Rajagopal , D. (2015) Honey bees: Diseases, Parasites, Pests,Predator and their management. M.J.P Publisher, Chennai.
5. Dharamsing and Singh, D. P. A Handbook of Beekeeping, Agrobios India (Publisher), Jodhpur.

Semester II
Major Course (CC)-2
ZOO-CC-1120- Cell Biology and Histology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

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

Learning outcomes: After this course, the students will be able to understand the functioning of nucleus and extra nuclear organelles and understand the intricate cellular mechanisms involved. Also, the student will acquire the detailed knowledge of different pathways related to cell signalling and apoptosis thus enabling them to understand the anomalies in cancer. Also, the student will understanding how cells work in healthy and diseased states.

Theory

Unit 1 **15 Hours**

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

Unit 2 **15 Hours**

Cell membrane organization: cell membrane: origin, structure, composition, models and function. Fluid mosaic model. Lipid Composition, inner and outer leaflets. Structure and functions of membrane proteins: Integral, peripheral and lipid-anchored membrane proteins. Junctional complexes, membrane receptor modifications: microvilli, desmosomes and plasmodesmata. Transport across membrane: diffusion and osmosis. Active and passive transport, endocytosis and exocytosis Cell cycle, cell division- mitosis and meiosis. Cell division check points and their regulation. Programmed cell death (Apoptosis). Cell regulation and Cell signaling: Signaling molecules and their receptors. Functions of cell surface receptors. Regulation of signaling pathways.

Unit 3 **15 Hours**

Introduction to tissues. Epithelial tissue: types, structure and characteristics. surface modifications. Connective tissue cells. Structure and function of loose, dense and adipose tissue. Cartilage and bone: classification, and fine structure. Blood: plasma, blood cells, lymph– their structural and functional. Muscular tissue: ultrastructure of smooth, skeletal and cardiac muscles. Structure and classification of neurons. Types of supporting (glial) cells and their function. Myelin sheath and its formation.

Practical

Unit 4 **30 Hours**

1. Study of prokaryotic and eukaryotic cell types with the help of chart, slide and video.
2. Disruption of cells, isolation and identification of subcellular components, isolation of nuclei
3. Chromosome segregation in mitosis and meiosis.
4. Preparation of polytene chromosome from Drosophila/Chironomous larvae
5. Preparation of mitotic chromosome from Onion root tips
6. Preparation of chromosome squashes from grasshopper/cockroach testes for the observation of stages of meiosis.
7. Study the permanent slides: epithelial, connective, muscular and nervous tissue
8. Study of histology of tissues by preparing permanent stained slides through microtomy.

Recommended readings

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

Semester II
Minor Course (MC)-2
ZOO-MC-1120- Human Physiology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: The course will provide insight into functions and structure of human's excretory system, respiratory system, endocrine, circulatory system, digestive system, etc system It also gives an account of the complex regulatory mechanisms of excretion, reproduction, digestion etc. in human

Learning outcomes: After this course, the students will be able to understand the functioning of human's excretory system, respiratory system, endocrine, circulatory system, digestive system, etc system . Also, the student will acquire basic idea of of different physiological functions thus enabling them to understand the heathy and sick health . Also, the student will understanding how human organs like kidney, lung heart etc work in healthy and diseased states.

Theory

Unit 1 **15 Hours**

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

Unit 2 **15 Hours**

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

Unit 3 **15 Hours**

Structure of heart. Coordination of heartbeat; control of heart beat (neural and hormonal) Blood cells and blood vessels. Cardiac cycle. ECG. Lymph and lymph vessels. Endocrine and reproductive physiology. Structure and function of endocrine glands viz., pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries and testes. Processes of spermatogenesis and oogenesis. Fertilization and implantation. Menstrual cycle. Pregnancy and Parturition.

Practical

Unit 4 **30 Hours**

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

Recommended readings:

1. Tortora, G.J. and Derrickson, B.H. (2009) Principles of Anatomy and Physiology (15th edition) John Wiley and Sons, Inc.
2. Widmaier, E.P., Raff, H. and Strang, K.T. (2008) Vander's Human Physiology McGraw Hill.
3. Guyton, A.C. and Hall, J.E. (2011) Textbook of Medical Physiology (15th edition) Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
4. Marieb, E. (1998) Human Anatomy and Physiology (4th edition) Addison-Wesley.
5. Kesar, S. and Vashisht, N. (2007) Experimental Physiology, Heritage Publishers.

Semester II
Multidisciplinary Course (MDC)-2
ZOO-MD-1120- Dairy Production and Technology

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	02	Theory:	30
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	03	Total:	60

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

Learning outcomes: After successfully completing the course, the students will be able to learn about protein metabolism and nutritional recommendations for various stages of the lactating mother and diet preparation techniques. acquire the skills to manage a dairy farm or to start one with adequate inputs.

Theory

Unit 1 **15 Hours**

Breed selection: Breeds of cattle and buffalo, Native cow varieties, Indian exotic breeds their popularity and performance. Source of Feed and its composition– nutrients for milk production, Water Energy, Protein, Fibre, Vitamins, Energy and digestibility. Distribution map of dairy farming areas/ major milk producing regions in India. Dairy Products (Milk, cheese, yoghurt, gluten etc) and their nutritive value.; Dairy farm planning Management.Managing Dairy Cattle and its Housing and health. Cooling strategies, Cow comfort Management; Cleaning Management. Animal signs Management. Dairy herd Management and growth; Cow health and reproductive performance.

Unit 2 **15 Hours**

Breeding Dairy Cattle. Artificial insemination and conception; Maternity management, The Lactation Cycle. Calf management, Calf diseases; Common management procedures. Vaccination, dehorning, weaning etc. Milking Management. Gathering cow for milking; Milking machines for smallholders; cleaning and sanitizing dairy equipment; Milking procedure. Dry cow therapy; Milk filtration Management. Milking Hygiene; Post-harvest milk quality. Dairy business profit strategies. Common disorders in Dairy Cattle. Mastitis, metabolic disorders, hypermagnesemia, ketosis and fatty liver, Ruminal acidosis, metritis; Hoof management. Manure-handling. Cow Longevity; Dairy buffalo Production Management, Biosecurity; Farm level economics affecting productivity and profitability.

Practical

Unit 3 **30 Hours**

1. Studying various breeds of cattle
2. Process of Setting up of a Dairy farm
3. Study preparation of various milk products Cheese, yogurt, gluten etc

Recommended readings:

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

Semester II
Ability Enhancement Course (AEC)-2
ENV-AE-002- Environmental studies

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	04	Theory:	60
Assignment/sessional exam:	20	Practical:	00	Practical:	00
Total:	100	Total:	04	Total:	60

About the course: The course is designed to give an account environment, causes of pollution of environment, biodiversity and its importance. Also, the course will provide insight into various Acts enacted for the protection of the environment and biodiversity

Learning outcomes: After successfully completing the course, the students will be able to understand environment science and its importance, causes of various types of pollution and hazards, and ways to monitor environment and the various green technologies. Also, the student about biodiversity and its importance and know the various Acts enacted for the protection of the environment and biodiversity

Theory

Unit I **15 Hours**

Environment: Definition, scope and importance; Multidisciplinary nature of environmental studies. Concept of sustainability and sustainable development. Ecosystem – Concept, Structure and function; Energy flow in an ecosystem: food chains, food webs, ecological pyramid. Ecological succession. Ecosystem services.

Unit 2 **15 Hours**

Environmental pollution: types, causes, effects and controls of Air, water, soil, noise, solid waste and nuclear pollution. Global environmental issues: Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture. Land: Land use patterns, degradation, soil erosion and desertification. Forest: Use of forest resources, over- exploitation; deforestation - causes and impacts on environment Water: Use and over-exploitation of surface and ground water; floods, droughts, Case studies on conflicts over water (international & inter-state)..

Unit 3 **15 Hours**

Biodiversity: Definition, levels (genetic, species and ecosystem diversity) and values; Biogeographic zones of India; Biodiversity hot spots. Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions. Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Unit 4 **15 Hours**

Salient features of Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD). Paris agreement, Nagoya Protocol. Human Communities and the Environment: Human population growth: Impacts on environment, human health and welfare. Disaster management: floods, earthquake, cyclones and landslides. Environmental movements: Chipko, Silent valley, Bishnois of Rajasthan.

Recommended readings

1. E. Bharucha. (2020). Textbook for Environmental Science for undergraduate students. UGC, New Delhi
2. Gupta, A., & Gupta, S. (2021). Environmental Studies: Principles and Practices.
3. V.K. Ahluwalia. Environmental Studies. 2nd Ed. TERI Press.
4. Kaushik, A. & Kaushik, C.P. (2020). Perspectives in Environ. Studies. New Age International Pvt. Ltd.
5. Krishnamurthy, K. V. (2020) Advanced textbook on Biodiversity: Principles and Practice, CBS Publisher and Distributors
6. Ambasht, R. S. & Ambasht P.K. (2017). Environment and Pollution an Ecological Approach 5th Ed. CBS Publisher and Distributors.
7. R. S. Ambasht and N.K. Ambasht. 2017. A textbook of Plant Ecology. 15th Ed. 2017.
8. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.

Semester II
Skill Enhancement Course (SEC)-2
ZOO-SE-1120- Sericulture

Marks	Credits	Contact hours
End semester exam: 80	Theory: 02	Theory: 30
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 03	Total: 60

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

Learning outcomes: Upon successful completion of this course, the student will be a skilled manpower for the in the field of sericulture. Also, the student will be able to impart training in extension management and transfer of technology, Post Cocoon Technology. Also, the student will have basic idea of diseases and its management in sericulture.

Theory

Unit 1 **15 Hours**

Mulberry and non-mulberry Sericulture. Silkworm rearing technology. Types of mountages, Spinning, harvesting and storage of cocoons. Sericulture Types- natural and synthetic fibres- types of silk produced in India; Importance of mulberry silk. Silk industry in different states, potential in mulberry and non- mulberry sericulture.

Unit 2 **15 Hours**

Introduction and classification of silkworm diseases, Protozoan disease, Bacterial, Viral and Fungal diseases: causative agents, symptoms, transmission prevention and control. Employment generation in sericulture: Role of women in sericulture

Practical

Unit 3 **30 Hours**

1. Identification of moths of mulberry and non-mulberry silkworms.
2. Identification of host plants of silkworms.
3. Identification of cocoons of silkworms
4. Identification of different larval stages of silkworms
5. Diagnosis of diseases of silkworm.
6. Demonstration of rearing technique of silkworms. 7. Demonstration of silk-reeling and spinning

Recommended readings:

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

Semester III
Major Course (CC)-3
ZOO-CC-2310- Comparative Structure and Function of Chordata

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	03	Theory:	45
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	04	Total:	75

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

Learning outcomes: After successfully completing this course, the students will be able to understand the characters used to classify besides being able to differentiate the organisms belonging to different taxa, relative position of individual organs and associated structures and various organ systems in vertebrates.

Theory

Unit 1 **15 Hours**

General characteristics and outline of classification. Salient features and classifications of Protochordates: Hemichordates, Cephalochordates, Urochordates. Larval forms in protochordates, Retrogressive metaphorphosis in urochordates. Affinities of Hemichordata. Origin of Chordates: Dipleurula concept and the Echinoderm theory of origin of chordates

Unit 2 **15 Hours**

General characteristics and classification of cyclostomes up to class, Salient feature and classification of Pisces up to order. Origin of tetrapods. Salient features and classification of Amphibia up to order. Amphibian metamorphosis and Neoteny. Parental care in fishes and amphibians. Fish migration, Osmoregulation, Lateral line and balancing organs

Unit 3 **15 Hours**

Salient features and classification of Reptilia, Aves and Mammals up to order. Affinities of sphenodon, Poisonous and non-poisonous snakes, Poison apparatus and biting mechanism in snakes. Archaeopteryx-a connecting link. Affinities of Prototheria and Marsupials. Dentition in mammals and adaptive radiation in mammals. Comparative anatomy of Integuments, circulatory system (heart and aortic arches) and urinogenital system in vertebrates.

Practical

Unit 4 **30 Hours**

1. Identification, classification and study of morphological characteristics of Hemichordates and Protochordates, Fishes, amphibians, reptiles, birds and mammals.
2. Collection and preservation of specimens (permissible as per wildlife act) from Arunachal Pradesh and submission to the laboratory
3. Study of scales of fishes (cycloid, placoid, ganoid, ctenoid), mouth parts specially of hill stream and cold water -fishes from Arunachal Pradesh; Beak and Feathers of birds
4. Fish: study of weberian ossicles, gills, digestive system and reproductive system
5. Study of poison apparatus of snakes and morphological study of carapace of turtles
6. Comparison of two species of birds belonging to same genus (Interspecific difference).
7. Comparison of characters of two birds belonging to same family but dissimilar genera.
8. Identification of vertebrate bones
9. Comparative study of brain with the help of models and charts.
10. Comparative study of urinogenital system with the help of models and charts.
11. Comparative study of heart with the help of models and charts.

Recommended readings

1. Young, J.Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.
2. Pough H. Vertebrate life, VIII Edition, Pearson International.
3. Darlington, P.J. The Geographical Distribution of Animals, R.E.Krieger Pub Co.
4. Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution, Jones and Bartlett Publishers Inc.
5. Weichert, C.K. (1970) Anatomy of Chordates (4th edition).
6. Jordan, E. L. and Verma, P. S. (2015) Chordate Zoology (14th edition).
7. Saxena, R. K. and Saxena, S. (2015) Comparative Anatomy of Vertebrates (2nd edition).
8. Ganguly, Sinha and Adhikari. Biology of Chordates.
9. Kotpal, R.L. Vertebrates. Rastogi Publications
10. Jordan P. Nigam. Chordates. S. Chand

Semester III
Major Course (CC)-4
ZOO-CC-2320- Physiology of Chordates

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

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

Learning outcomes: After successfully completing this course, the students will be able to understand working mechanism of major organ systems, and cells, tissues and organ function at different levels. Also, the student have basic understanding the abnormal function in animal and human diseases and new methods for treating those diseases.

Theory

Unit 1 **15 Hours**

Physiology of digestion and absorption of carbohydrate protein and fat in mammal. Physiology of Respiration in vertebrate, diffusion and transport of gases, respiratory quotients. Single and Double circulation. Structure of mammalian heart. Blood: composition and function; blood groups and mechanism of blood coagulation. Acid-base balance, thermoregulation.

Unit 2 **15 Hours**

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 and, Neuromuscular junction. Types and structure of muscles; physiology of muscle contraction, Structure of Eye, physiology of vision, defects of vision and their correction. Olfactory System and Mechanism of olfaction.

Unit 3 **15 Hours**

Ammonotelism, uricotelism and ureotelism. Physiology of excretion: structure of nephron and mechanism of urine formation. Role of ADH and aldosterone. Osmoregulation in vertebrates. Structure and types of bones and cartilages; Bone formation and resorption**.** Lateral line system in fishes. Structure of Ear, Mechanism of hearing and balancing.

Practical

Unit 4 **30 Hours**

1. Qualitative analysis of nutrients: Carbohydrate, Proteins, Lipids.
2. Estimation of haemoglobin.
3. Counting of different types of blood cells using haemocytometer.
4. Study of action of salivary amylase.
5. Rate of oxygen uptake in fish.
6. Effect of temperature on opercular movement of fish.
7. Physiology of Reflex action in animals with diagrams
8. Preparation of Temporary mounts: Squamous epithelium, Striated muscle fibres, Nerve cells
9. Studies on ammonotelism, uricotelism and ureotelism in animals
10. Efferent branchial and afferent branchial system in fish.

Recommended readings

1. Vander, A.; Sherman, J. and Luciano, D. (2003) Human Physiology (9th edition).
2. Randall, D. et al. (2002) Eckert Animal Physiology (5th edition) Freeman.
3. Hill, R.W. et al. (2008) Animal Physiology (3rd edition) Sinaur Associates.
4. Guyton, A.C. et al. (2008) Textbook of Medical Physiology (15th edition) W.B. SaundersCo.
5. Withers, P.C. et al. (1992) Comparative Animal Physiology (1st edition) Brooks Cole.
6. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
7. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology.John Wiley &sons
8. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. &Wilkins.

Semester III
Minor Course (MC)-3
ZOO-MC-2310- Natural Resource Management

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: The course provides insight into natural resources, depletion of resources, the loss of biodiversity and the remedial efforts undertaken by various agencies. The course is also focused to creating environmental awareness among learners.

Learning outcomes: After successfully completing this course, the students will be able to develop understanding for the environment which is largely degraded in the current scenario, the importance of biodiversity and the consequences of biodiversity loss, green technology and the eco-friendly practises and other prospects of environment protection, the judicious utilisation of natural resources and appropriate legal/regulatory and ethical issues in the context of the natural resources.

Theory

Unit 1 **15 Hours**

Natural resources: Land resources. Air and water resources. Bioresources. Conventional Fuel, wood, fossil fuels. Non-conventional or alternate sources of energy: sun, wind, bio-energy, geothermal, ocean, nuclear etc. Carrying capacity, exploitation of resources due to urbanization, industrialization and agricultural practices. Eutrophication. Deforestation; Threats to biodiversity, Extinction of species. Threats to biodiversity.

Unit 2 **15 Hours**

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

Unit 3 **15 Hours**

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

Practical

Unit 4 **30 Hours**

1. Visit to an area to document environmental assets including natural resources/flora/fauna, etc.
2. Identification and study of common insects, fish, birds, mammals of a particular area.
3. To determine the physical conditions of water: Depth, Viscosity, Density, Buoyancy.
4. To determine Cl, SO_4, NO_3 in soil and water samples from different locations.
5. To study acidity and alkalinity of sample water by methyl orange and phenolphthalein
6. Visit to a local polluted site (Urban/Rural/Industrial/Agricultural).

Recommended readings

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

Semester III
Multidisciplinary Course (MDC)-3
ZOO-MD-2310- Environmental Biotechnology

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	02	Theory:	30
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	03	Total:	60

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

Learning outcomes: Upon the completion of the course, the students shall understand the causes of environmental pollution and their remedies. Also, the student will be proficient to analyse microbiology of waste water and its implications, examine the role of immobilized cells/enzymes in treatment of toxic compounds and evaluate the implications of international legislations, policies for environmental protection**.**

Theory

Unit 1 **15 Hours**

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

Unit 2 **15 Hours**

Xenobiotic compounds: Organic compounds (Chlorinated hydrocarbons, Polyaromatic hydrocarbons, Pesticides, Surfactants etc.) and inorganic compounds (metals, radionuclides, phosphates, nitrates etc.). Xenobiotic bioremediation: decay behaviour and degradative plasmids, molecular techniques used in bioremediation. Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. WTO and Environment, Environmental Education and awareness programmes; Environmental Ethics. Regulation of the safety of biotechnology procedure and products: Deliberate release and fate of genetically modified microorganisms.

Practical

Unit 3 **30 Hours**

1. Soil/ analysis - pH, DO, salinity, chloride, hardness, alkalinity, acidity,
2. Soil/ Water analysis- dissolved substances viz., nitrate, calcium, magnesium and phosphorus.
3. Gravimetric estimation-Total solid, dissolved solid, suspended solid in an effluent
4. Microbial study of air (open plate and air sample) and water.

Recommended readings

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

Semester III
Skill Enhancement Course (SEC)-1
ZOO-SE-0030- Public Health Hygiene

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	02	Theory:	30
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	03	Total:	60

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

Learning outcomes: After successfully completing the course, the students will be able to identify current, national and global public health problems, aware about the issues of food safety, water safety, vaccination, exercise and obesity, exposure to toxins, frame a public health plan during any epidemic or spread of infectious disease etc., analyse case studies of infant mortality and obesity, assess the health inequalities with regard to gender, race, ethnicity, income etc.

Theory

Unit 1 **15 Hours**

Introduction to public health and hygiene. Pollution and health hazards; water and air borne diseases. Radiation hazards. Role of health education in environment improvement and prevention of diseases. Balanced diet, dietary plan and its importance for an infant, normal adult, pregnant woman and old person. Significance of breast feeding. Malnutrition anomalies – Anaemia (Iron and B15deficiency), Kwashiorkar, Marasmus, Rickets, Goiter (cause, symptoms, precaution and cure). Substitution of diet with required nutrients to prevent malnutrition disorders.

Unit 2 **15 Hours**

Communicable (fungal, bacterial, viral, sex-related) and non-communicable (hypertension, stroke, coronary heart disease, myocardial infarction) diseases. Health education and preventive measures for communicable and non-communicable diseases. . Osteoporosis, osteoarthritis and rheumatoid arthritis-cause, symptom, precautions. Diabetes- types and their effect on human health. Obesity (Definition and consequences). Mental illness (depression and anxiety). Oral and lung cancer and their preventive measures.

Practical

Unit 3 **30 Hours**

1. Blood glucose measurement using glucometer.
2. Study of malnutrition diseases in nearby areas.
3. Measurement of blood oxygen level
4. Measurement of body temperature
5. Survey of diseases from nearby health centre
6. Study of dental diseases from a nearby population
7. Measurement of blood pressure
8. Interpretation of BMI

Recommended readings:

1. Mary Jane Schneider (2011) Introduction to Public Health.
2. Muthu, V.K. (2014) A Short Book of Public Health.
3. Detels, R. (2017) Oxford Textbook of Public Health (6th edition).
4. Gibney, M.J. (2015) Public Health Nutrition.
5. Wong, K.V. (2017) Nutrition, Health and Disease.

Semester IV
Major Course (CC)-5
ZOO-CC-2410- Evolutionary Biology

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	03	Theory:	45
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	04	Total:	75

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

Learning Outcomes: After successfully completing this course, the students will be able to understand develop a the phylogeny and adaptations in animals, the evolution of universe and life, the diversity and relationships in animal world, the process and theories in evolutionary biology.

Theory

Unit 1 **15 Hours**

Origin of life: Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes; Historical review of evolutionary concept: Lamarckism, Darwinism, Neo- Darwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, Geological time scale, evolution of man and horse, Molecular (universality of genetic code and protein synthesising machinery, three domains of life, neutral theory of molecular evolution, molecular clock, Sources of variations: Heritable variations and their role in evolution.

Unit 2 **15 Hours**

Hardy-Weinberg Law; Evolutionary forces upsetting H-W equilibrium; Natural selection; concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection. Genetic Drift; mechanism, founder's effect, bottleneck phenomenon, role of migration and mutation in changing allele frequencies.

Unit 3 **15 Hours**

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches; Extinctions, mass extinctions (causes and effects). Phylogenetic trees, Multiple sequence alignment, construction of phylogenetic trees, interpretation of trees.

Practical

Unit 4 **30 Hours**

1. Study of fossils from models/pictures.
2. Study of homology and analogy from suitable specimens
3. Study and verification of Hardy-Weinberg Law by chi square analysis.
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies.
5. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.

Recommended readings

1. Campbell, N. and Reece, J. (2014) Biology (10th edition). Benjamin Cummings
2. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing.
3. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.
4. Hall, B.K. and Hallgrimson, B (2008) Evolution (4^{th} edition) Jones and BarlettPublishers
5. Campbell, N.A. and Reece J.B (2011) Biology (9^{th} edition) Pearson, Benjamin, Cummings
6. Douglas, J.F. (1997) Evolutionary Biology. Sinauer Associates.
7. Pevsner, J. (2009) Bioinformatics and Functional Genomics (2^{nd} edition) Wiley- Blackwell.

Semester IV
Major Course (CC)-6
ZOO-CC-2420- Human Reproductive Biology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

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

Learning outcomes: Upon successful completion of this course, students should be able to understand the processes of spermatogenesis, oogenesis, hormonal control of reproduction in males and how this is regulated, stages of embryonic, foetal and neonatal development and causes of foetal disorders, origin and characteristics of common congenital malformations, sexually transmitted diseases

Theory

Unit 1 **15 Hours**

Structure and function of male reproduction; Formation of sperm and fertility of individual; Structure and function of female reproduction; Sexual differentiation, Puberty; Formation of the gametes; Formation of ova. Physiology of ovulation, menstrual cycle; Nutrition and stress influences on the ovulatory cycle. Process of fertilization; Implantation and formation of the foetus and placenta; Pregnancy, foetal development; Labour, birth and lactation, Reproductive ageing; Menopause.

Unit 2 **15 Hours**

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

Unit 3 **15 Hours**

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

Practical

Unit 4 **30 Hours**

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

Recommended readings:

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

Semester IV
Major Course (CC)-7
ZOO-CC-2430- Pest and Management Strategies

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

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

Learning outcomes: After successfully completing this course, the students will be able to understand the concept of pests and pest bioecology, pesticides and their modes of action and their fates in the agro-ecosystem, laws and regulations governing the proper use of pesticides, factors involved in calibrating equipment for pesticide application. Also, student will **h**ave basic knowledge of pesticide families and be able to differentiate among families based on their specific modes of activity.

Theory

Unit 1 **15 Hours**

Introduction to different categories of pests and their status, Factors responsible for emergence of pest, Pest population dynamics. Bionomics and Control of Crop pests: *Leptocorisa acuta*, *Sesamia inferens*, *Helicoverpa armigera*, *Pyrilla perpusilla*, *Earias vitella*, *Raphidopalpa faveicollis*, *Papilio demoleus*. Bionomics and strategies for the management of stored grain pests: *Sitophilus oryzae*, *Callosobruchus chinensis*, *Trogoderma granarium* and *Corcyra cephalonica*.

Unit 2 **15 Hours**

Principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Mass production of quality biocontrol agents- techniques.

Unit 3 **15 Hours**

Different groups of pesticides and their mode of action; Pyrethroids, Organochlorides, Carbamates, organophosphates, Nicotinoids and neonicotinoids. Pesticides of plant origin.Pest Control: Mechanical, Cultural, Biological, Genetical, Pheromonal, Insect growth regulators; *Bacillus thuringiensis* toxins in pest control - Mechanism and use.Integrated Pest Management: Principle and strategies

Practical

Unit 4 **30 Hours**

1. Identification of insect pests of rice, tea, citrus, vegetables.
2. Identification of common natural enemies of crop pests (parasitoids, predators, microbes).
3. Study the damage caused by the commonly occurring insect pests – Infected plant/plant parts.
4. Field trips to bio-control laboratories – IARI, CWC, FCI.
5. Preparation of botanical extract (from citronella, neem etc.) and study of insecticidal property.

Recommended readings

1. Hill, D.S. (1983) Agricultural insect pests of the tropics and their control- CambridgeUniv. Press.
2. Dent, D. (2000) Insect pest management (2nd edition) CAB International.
3. Roberts, D.A. (1978) Fundamentals of Plant Pest Control.
4. De Bach, P. (1964) Biological Control of Insect Pests and Weeds, Chapman & Hall, NewYork.
5. Koul, O. and Dhaliwal, G.S. (2003) Phytochemical Biopesticides, Harwood AcademicPublishers.
6. Pedigo, L.P. (1996) Entomology and pest management, Prentice Hall, N. Delhi.
7. Atwal, A.S. and Dhaliwal G.S. (2015) Agricultural Pests of South Asia and their Management. Kalyani
8. Hajek A.E. Natural Enemies: An Introduction to Biological Control. Cambridge University Press, UK
9. Shepard BM, Banion AT, Litsinger JA (1995) Rice-feeding insects of tropical Asia. International Rice Research Institute, Philippines.
10. George E. Heimpel, Nicholas J. Mills (2017). Biological Control: Ecology and Applications. Cambridge University Press

Semester IV
Major Course (CC)-8
ZOO-CC-2440- Biodiversity and Conservation Biology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: The course gives insight into the biodiversity and its values, distribution pattern and ethno-biodiversity, threats to biodiversity, biodiversity conservation and protection acts.

Learning outcomes: After successfully completing this course, the students will gain knowledge and expertise on biodiversity and its use, distribution, threats and conservation. The student will aware of the laws and regulations related to biodiversity protection, acquire knowledge on protected area network, know factors involved in biodiversity distribution and be able to estimate the abundance of species, population size and biodiversity richness

Theory

Unit 1 **15 Hours**

Concept of biodiversity, Scope of biodiversity, Composition and Scales of biodiversity: Genetic Diversity, Species diversity, Ecosystem diversity, Direct use value: Food, medicine, product values; Indirect use value: Social, Cultural, Religious, Ethical values of Biodiversity. Aesthetic and option values of Biodiversity. Ecological Services provided by biodiversity.

Unit 2 **15 Hours**

Hotspots of biodiversity of the world. India as a Mega diversity Nation, Indigenous Knowledge System. Biodiversity conservation by ethnic societies. Wildlife as food resources used by the ethnic community in Arunachal Pradesh. Traditional medicine knowledge system and its importance. Biopiracy of medicinal plants & animals. Threats and Loss of Biodiversity and its causes: Habitat Destruction, Fragmentation, Transformation, Degradation, alien invasive species, climate change and over-exploitation. Impact of big river dams on biodiversity.

Unit 3 **15 Hours**

Endemic species, IUCN Threatened Categories, Concept of Conservation, Ex-situ and In-situ conservation strategies, Protected areas in Arunachal Pradesh: Wildlife Ecological restoration, Environment protection Act, 1986, The wildlife protection Act, 1972, The forest (conservation) Act, 1980, The Biodiversity Act., 2002. Environmental Impact Assessment, National Biodiversity Authority, State biodiversity board, Village biodiversity committee, Biodiversity register.

Practical

Unit 4 **30 Hours**

1. Estimation of abundance of animal community using quadrat and transect method.
2. Comparison of species richness and evenness using biodiversity indices (Shannon and Simpson index)
3. Identification of economically important animal species (honey bees, silkworm, wild bees, pollinators, edible insect, fishes etc.)
4. Identification of invasive alien species.
5. Identification of ethno-zoological collection.
6. Identification of endangered and threatened animal species using photographs/video.

Recommended readings:

1. Krishnamurthy, K. V. (2003). Textbook of Biodiversity. CRC Press, Taylor & Francis Group.
2. Hambler, C. 2004. Conservation. Cambridge University Press, UK
3. Groom, M. J., *et al.* (2006). Principles of Conservation Biology. Sinauer Associates, Inc., USA.
4. Primack, R. 2006. Essentials of Conservation Biology. Sinauer Associates, Inc., USA.
5. Van Dyke, F.2008. Conservation Biology Foundations, Concepts, Applications 2nd Edition, Springer.
6. Sinha S.K. and Sinha S. 2001 Ethnobiology (Role of Indigenous and Ethnic Societies in Biodiversity Conservation, Human Health Protection and Sustainable Development)/ Surabhi Publication.

Semester IV
Minor Course (MC)-4
ZOO-MC-2410- Aquatic Biology

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	03	Theory:	45
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	04	Total:	75

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

Learning outcomes: After successfully completing this course, the students will be able to understand and apply relevant scientific principles & methodologies in the area of aquatic biology. The student will be able to analyse, interpret and evaluate information relevant to aquatic biology. Also, will acquire employable skills in aquatic biology.

Theory

Unit 1 **15 Hours**

Physical and chemical properties of water; Introduction with aquatic biomes: Freshwater ecosystem; flood plain lakes and Lakes in higher altitude, wetlands, streams and rivers, estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs. Physico-chemical characteristics of lakes and rivers: Light, Temperature, Thermal stratification, Origin and classification of lakes; Rivers, streams, and different stages of stream development.

Unit 2 **15 Hours**

Lake as an Ecosystem, Nutrient Cycles in Lakes-Nitrogen, Sulphur and Phosphorous; Respiration and Feeding in aquatic organisms; osmoregulation in freshwater and marine organisms; sensory system and Locomotion of aquatic organism, adaptation of hill-stream and cold-water fishes; Adaptation of deep sea organisms, coral reefs continental shelf

Unit 3 **15 Hours**

Aquatic pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation of aquatic organisms and ecosystem; legislations; Sewage treatment; Water quality assessment - BOD and COD.

Practical

Unit 4 **30 Hours**

1. Determine the area of a lentic water body using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lakustrine /riverine ecosystems
3. Determine the amount of dissolved oxygen (BOD and COD), and free Carbon dioxide, in water collected from a nearby lake / stream /water body.
4. Visit to any mountain lake/ freshwater wetlands/ fish raising pond ecosystem and preparation and submission of report.

Recommended readings

1. Goldman, C. (1994) Limnology (2nd edition).
2. Ananthakrishnan, T.N. (1989) Bioresources Ecology (3rd edition).
3. Odum, E.P. and Barrett, G.W. (2004) Fundamentals of Ecology (5th edition).
4. Pawlowski, L. (1980) Physicochemical Methods for water and Wastewater Treatment.
5. Wetzel, R. (2001) Limnology (3rd edition) Elsevier.
6. Trivedy, R.K. and Goyal, P.K. (1986) Chemical and biological methods for water pollution studies.
7. Welch, P.S. (2014) Limnology Vol. I-II.
8. Saikia, S. and Das, D.N. Laboratory Hand Book on Basic Ecology by Saikia, S.K. & Das, D.N.1st Edition, 2013, Science Publishing Group, UK.
9. Sarma, D., Baruah, D and Das, D.N.Coldwater Lakes and Rivers in Arunachal Pradesh, India (Monograph-19) , ICAR Publication, New Delhi.

Semester V
Major Course (CC)-9
ZOO-CC-3510- Animal Behaviour

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	03	Theory:	45
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	04	Total:	75

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

Learning outcomes: After successfully completing this course, the students will know about wide range of theoretical and practical aspects and develop skills and experience to understand all aspects of animal behaviour,. Also, the students will understand and evaluate information about animal behaviour and ecology encountered in our daily lives, to objectively evaluate the role of behaviour in the protection and conservation of animals in the wild.

Theory

Unit 1 **15 Hours**

Animal behaviour. Scope and importance of study. Proximate and ultimate causes of behavior. Types of stimuli invoking response: internal and external cues. Patterns of behaviour: Kinds of behaviour: foraging behaviour, Territorial behaviour. Mate selection and courtship behaviour. Parental care, defensive behaviour. Stereotyped Behaviours (Orientation, Reflexes).

Unit 2 **15 Hours**

Innate behaviour: communication (primates, bees and ants). Decision making. territorial behaviour, schooling behaviour. Mimicry and colouration. Evolution of reproductive behavior, mating systems and parental care. Asymmetry in sex, sexual dimorphism. Role of hormones in drive; role of pheromones in alarm spreading; social hierarchies in primates. Crypsis, predator detection, predator tactics. Social organization (e.g., Honey bee, Termites etc.). Communication in living in groups. Evolution of sociality. Genetic basis of behaviour. Regulation of behaviour: Neural control: kineses, taxes, simple reflexes. Sensory processing: echolocation (bats).

Unit 3 **15 Hours**

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

Practical

Unit 4 **15 Hours**

1. Orientation of an animal to light.
2. Constructing an ethogram.
3. Chemical communication in ants.
4. Selective predation of coloured prey items.
5. Predatory behaviour of a carnivorous animal.
6. Nests and nesting habits of the birds and social insects
7. To study the behavioural responses of wood lice to dry and humid conditions.
8. To study geotaxis behaviour in earthworm.
9. To study the phototaxis behaviour in insect larvae.
10. Study of circadian functions in humans (daily eating, sleep and temperature patterns).

Recommended readings:

1. McFarland, D. (1999) Animal Behaviour (3rd edition) Pitman Publishing Limited, London, UK.
2. Manning, A. and Dawkins, M. S. (2015) An Introduction to Animal Behaviour (6th edition) Cambridge, University Press, UK
3. Alcock, J. (2005) Animal Behaviour (8th edition) Sinauer Associate Inc., USA.
4. Sherman, P. W. and Alcock, J. (2015) Exploring Animal Behaviour (6th edition) Sinauer Associate Inc., Massachusetts, USA.
5. Dunlap, J. C.; Loros, J.J. and DeCoursey, P. J. (2009) Chronobiology Biological Timekeeping (1st edition) Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
6. Kumar, V. (2002). Biological Rhythms: Narosa Publishing House, Delhi/ Springer - Verlag, Germany.

Semester V
Major Course (CC)-10
ZOO-CC-3520- Fundamentals of Biomolecules

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

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

Learning Outcomes: After successfully completing this course, the students will be able to interpret the structure-functional relationships of carbohydrates, proteins, lipids and nucleic acids, understand the qualitative analysis of functional groups**,** understand the properties of various biomolecules and appreciate the action of the enzyme and the various factors that affect their action detail.

Theory

Unit 1 **15 Hours**

Structure and biological importance: with emphasis on aldose, ketose, chiral centre, polarised Light, Fischer nomenclature, Haworth projection formula, mutarotation of glucose, anomers, pyranose, furanose, glycosidic linkage; reducing and non-reducing sugars: monosaccharides, disaccharides, polysaccharides and glycoconjugates.

Unit 2 **15 Hours**

Structure and Significance: Physiologically important saturated and unsaturated fatty acids, tri-acylglycerols, phospholipids, glycolipids, steroids. Amino acids: Structure, classification and general properties of α-amino acids; physiological importance of essential and non-essential amino acids; proteins: bonds stabilizing protein structure; Levels of organization in protein motifs, folds and domains; Denaturation. Structure: purines and pyrimidines, nucleosides, nucleotides, nucleic acids; Cot Curves: Base pairing, Denaturation and Renaturation of DNA; Types of DNA and RNA.

Unit 3 **15 Hours**

Nomenclature and classification, cofactors; specificity of enzyme action, Isozymes, Mechanism of enzyme action; Enzyme kinetics; factors affecting rate of enzyme-catalysed reactions; derivation of Michaelis-Menten equation, concept of K_m and V_{max}, Lineweaver-Burk plot, multi-substrate reactions, enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme reaction.

Practical

Unit 4 **30 Hours**

1. Preparation of models of amino acids and dipeptides.
2. Ninhydrin test for α-amino acids.
3. Thin layer chromatography (TLC)
4. Benedict's test for reducing sugars.
5. Iodine test for starch.
6. Preparation of models of nitrogenous bases, nucleosides and nucleotides.
7. Qualitative test for DNA & RNA.
8. Determination of the activity of enzyme (amylase)- (i) Effect of [S] and determination of Km and Vmax. (ii) Effect of temperature. (iii) Effect of time.

Recommended readings

1. Nelson, D.L. & Cox, M.M. (2017) Lehninger Principles of Biochemistry (7th edition) Worth.
2. 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.
3. Voet, D., Voet. J. G. (2013). Biochemistry (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd.
4. Stryer, L., Berg, J., Tymoczko, J., Gatto, G. (2019). Biochemistry (9th ed.). New York, WH: Freeman.
5. Berg, J.M.; Tymoczko, J.L. and Stryer, L. (2015) Biochemistry (7th edition) Freeman.
6. Zubay, G. (2017) Biochemistry (4^{th} edition) McGraw-Hill.
7. Conn, E.E.; Stumpf, P.K.; Bruening, G. and Doi, R.H. (2006) Principles of Biochemistry (5th edition) Wiley.

Semester V
Major Course (CC)-11
ZOO-CC-3530- Molecular Biology

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	03	Theory:	45
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	04	Total:	75

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

Learning outcomes: After successfully completing this course, the students will be able to develop an understanding of concepts, mechanisms and relevance of molecular biology in the current scenario, get well versed in recombinant DNA technology which holds application in biomedical & genomic science, agriculture, environment management, etc. Therefore, a fundamental understanding of Molecular Biology will help in career building in all these fields and apply their knowledge in problem solving and future course of their career development in higher education and research.

Theory

Unit 1 **15 Hours**

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

Unit 2 **15 Hours**

Chromosomes, Chromatin, Histones, Histone-modifications. DNA Replication, plasmid DNA replication, telomeric DNA replication, DNA polymerases and other regulatory proteins during DNA replication. Mutation, types of gene mutation, mutagenic agents, molecular basis of mutation, DNA recombination. DNA repair; direct DNA repair, base excision repair, nucleotide excision repair, mismatch repair,

Unit 3 **15 Hours**

Transcription, RNA polymerase I, II, III, transcription factors. Regulation of gene expression in prokaryotes and eukaryotes. Operon Concept and Lac Operon, RNA processing: RNA splicing and alternative splicing, RNA editing, 5'-capping and 3'-polyadenylation of mRNA, rRNA and tRNA modifications and processing. Ribosomes, Genetic Code, and Wobble hypothesis. Translation, protein synthesis in *E. coli* and eukaryotic cells. Aminoacylation of tRNA, initiation, elongation, peptide bond formation, translocation, termination. Post-translational modifications and processing of proteins

Practical

Unit 4 **15 Hours**

1. Preparation of ball and stick model for B-DNA molecule (A=T and G=C base pairs).
2. Demonstration of Electrophoretic apparatus
3. Isolation of genomic DNA by ethanol precipitation method.
4. Agarose gel electrophoresis of the plasmid DNA and the genomic DNA.
5. Separation of protein by SDS-PAGE
6. Study and interpretation of electron micrographs/photograph showing DNA replication, transcription and split genes.
7. Estimation of the growth kinetics of *E. coli* by turbidity method

Recommended readings

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

Semester V
Major Course (CC)-12
ZOO-CC-3540- Microbiology and Parasitology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 02	Theory: 30
Assignment/sessional exam: 20	Practical: 00	Practical: 00
Total: 100	Total: 02	Total: 30

About the course: This is a composite course with remarkable utility and importance. Microbiology being the study of microorganisms such as viruses, bacteria etc., covers theoretical studies and practical proficiency training which may help in their placement at a clinical microbiological laboratory. Parasitology component takes care of the parasites and parasitism, emphasizing the influence of parasites on the ecology and evolution of free-living species, and the role of parasites in global, public, health.

Learning outcomes : After successfully completing this course, the students will be able to describe the mechanisms for transmission, virulence and pathogenicity in pathogenic micro-organisms; diagnose the causative agents, describe pathogenesis and treatment for important diseases like malaria, leishmaniasis, trypanosomiasis, toxoplasmosis, schistosomiasis, cysticercosis, filariasis etc.; assess the importance of incidence, prevalence and epidemiology in microbiological diagnostic activities.

Theory

Unit 1 **15 Hours**

General classification of virus, (structure, nucleic acid, cultivation of bacteriophage, coliphage). Viral diseases: hepatitis, influenza/coronavirus, AIDS, chikungunya with emphasis on their causative agents. Basic introduction to bacteria (Slime layer, capsule, cell wall, flagella, pili, fimbriae, nucleoid, plasmid and episome). Growth media for bacterial culturing (natural, synthetic, complex, enriched, selective- definition with example). Bacterial diseases caused by *Salmonella typhi*, and *Mycobacterium tuberculosis*. Basic introduction to fungi. Fungal diseases: Ringworm infection, and aspergillosis.

Unit 2 **15 Hours**

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

Recommended readings

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

Semester V
Minor Course (MC)-5
ZOO-MC-3510- Global Climate Change

Marks	Credits	Contact hours
End semester exam: 80	Theory: 04	Theory: 60
Assignment/sessional exam: 20	Practical: 00	Practical: 00
Total: 100	Total: 04	Total: 60

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

Learning outcomes: After completing this course, the student will be able to develop understanding on the concept and issues of global environmental change, analyse the causes and effects of depletion of stratospheric ozone layer, examine the climate change and its effect on living beings, understand the physical basis of natural green gashouse effect on man and materials, and evaluate human influenced driver of our climate system and its applications.

Theory

Unit 1 **15 Hours**

Global Environmental change issues. Paleoclimate – what can we learn from the past? Concept of earth system, climate forcing, responses, feedback loops, equilibrium states, Daisy world model, Solar Flux at Earth's Orbit, Stratospheric ozone layer.

Unit 2 **15 Hours**

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

Unit 3 **15 Hours**

Atmospheric deposition: Past and present scenario; Causes and consequences of excessive atmospheric deposition of nutrients and trace elements; Acid rain and its effects on plants, animals, microbes, and ecosystems. Eutrophication, Consequences on climate, oceans, agriculture, natural vegetation and humans.

Unit 4 **15 Hours**

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

Recommended readings:

1. Adger, N.; Brown, K. and Conway, D. (2012). Global Environmental Change: Understanding the Human Dimensions. The National Academic Press.
2. Turekian, K.K. (1996). Global Environmental Change-Past, Present, and Future. Page 71 of 93 Prentice-Hall.
3. Matthew, R.A.; Barnett, J. and McDonald, B. (2009). Global Environmental Change and Human Security. MIT Press., USA.
4. Hester, R.E. and Harrison, R.M. (2002). Global Environmental Change. Royal Society of Chemistry.

Semester VI
Major Course (CC)-13
ZOO-CC-3610- Developmental Biology

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	03	Theory:	45
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	04	Total:	75

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

Learning outcomes: After successfully completing the course, the students will be able to develop critical understanding how a single-celled fertilized egg becomes an embryo and then a fully formed adult by going through three important processes of cell division, cell differentiation and morphogenesis; understand how developmental processes and gene functions within particular tissue or organism can provide insight into functions of other tissues and organisms; realize that similar mechanisms are used in diverse organisms; understand that development is controlled through molecular changes resulting in variation in the expression and function of gene networks and understand the relevance of developmental biology in medicine or its role in development of diseases.

Theory

Unit 1 **15 Hours**

Reproduction: a basis of species sustenance. Asexual and sexual reproduction and their relevance in corresponding environments. Germ cells, Gamete formation, types, external and internal fertilization; Structural and biochemical changes in gametes during and after fertilization, block to polyspermy. Fate maps, their relevance.

Unit 2 **15 Hours**

Developmental commitment. Mosaic and regulative development. Direct and indirect development. Cleavage: types and patterns. Body plan and symmetries. Gastrulation. Tubulation. Morphogenesis: Epiboly, emboly/ invagination, involution and ingression in vertebrate.

Unit 3 **15 Hours**

Organogenesis: formation of gut, heart, kidney and muscles. Role of extra embryonic membranes in development. Placenta: types, structure and functions. Hormonal regulation of metamorphosis in insects and amphibian. Regeneration: epimorphosis, morphollaxis and compensatory regeneration. Development, ageing and apoptosis. Teratogenesis

Practical

Unit 4 **30 Hours**

1. Types of eggs based on quantity and distribution of yolk: sea urchin, insect, frog, Chick.
2. Comparative study of cleavage patterns in Frog and Amphioxus models.
3. Study of cells movement and change in shape and size during morphogenetic movement of Blastulation, Gastrulation in fishes/amphibian/birds.
4. Preparation of permanent slides and study of development of chick embryo through incubated chick eggs up to 96 h.
5. Extra embryonic membranes of chick through permanent slides.
6. Demonstration to develop understanding on the process of development through videos
7. Study of developmental stages of arthropods

Recommended readings

1. Gerhart, J. et al. (1997) Cells, Embryos and Evolution. Blackwell Science
2. Gilbert, S.F. (2010) Developmental Biology (9th edition). Sinauer
3. Wolpert, L. (2007) Principles of Developmental Biology (3rd edition). Oxford University Press
4. Campbell, N. and Reece, J. (2014) Biology (10th edition). Benjamin Cummings

Semester VI
Major Course (CC)-14
ZOO-CC-3620- Genetics

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

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

Learning outcomes: After successfully completing this course, the students will be able to understand how DNA encodes genetic information and the function of mRNA and tRNA, apply the principles of Mendelian inheritance, understand the cause and effect of alterations in chromosome number and structure, relate the conventional and molecular methods for gene manipulation in other biological systems, analyse the epigenetic modifications and imprinting and its role in diseases.

Theory

Unit 1 **15 Hours**

Genetics: scope and importance. Elements of heredity and variation: Classical and Modern concept of Gene (Cistron, muton, recon), Alleles etc. Mendel's laws of inheritance, Chromosomal basis of inheritance and its applications. Exceptions to Mendelian Inheritance: Incomplete dominance, Codominance, Multiple allelism, Pleiotropy, Epistasis, Polygenic inheritance.

Unit 2 **15 Hours**

Linkage and crossing over, cytological basis of crossing over. Organelle inheritance (Mitochondrial) Extra-nuclear inheritance, Maternal Inheritance, Sex Chromosomes and sex-linked inheritance: XX/XO, XX/XY, ZZ/ZW and haploidy/diploidy types, Dosages compensation, Epigenetics. Structural and numerical alterations of chromosomes, meiotic consequences in structural heterozygotes. Autosomal dominant and autosomal recessive , X-linked dominant, and X-linked recessive disorders. Haplodiploidy. Sex determination insect and reptiles.

Unit 3 **15 Hours**

Human Genetics: banding and nomenclature of chromosome subdivisions. Genetic disorders: chromosomal aneuploidy (Down, Turner and Klinefelter syndromes), chromosome translocation (Chronic Myeloid Leukemia) and deletion ("cry of cat" syndrome), gene mutation (sickle cell anemia), thalassemia, Genetic counselling, Pedigree analysis; Karyotype, Human genome project.

Practical

Unit 4 **30 Hours**

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

Recommended readings:

1. Gardner, E.J. et al. (2006) Principles of Genetics (John Wiley).
2. Russell, P.J. (2010) Genetics (Benjamin Cummings).
3. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. (VIIIedition) Wiley India.
4. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics. (V edition) John Wiley and Sons Inc.
5. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2015). Concepts of Genetics. Benjamin Cummings.
6. Carroll S.B.; Doebley J.; Griffiths, A.J.F. and Wessler, S.R. (2018) An Introduction to Genetic Analysis. W. H. Freeman and Co. Ltd.

Semester VI
Major Course (CC)-15
ZOO-CC-3630- Genetic Engineering and Biotechnology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

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

Learning outcomes: After successfully completing this course, the students will be able to develop an understanding of the fundamental molecular tools and their applications of DNA modification and cloning, appreciate shifting their orientation of learning from a descriptive explanation of biology to a unique style of learning through graphic designs and quantitative parameters to realize how such research and innovations have made science interdisciplinary and applied and apply their knowledge with problem solving approach to recommend strategies of genetic engineering for possible applications in Biotechnology and allied industry.

Theory

Unit 1 **15 Hours**

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

Unit 2 **15 Hours**

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

Unit 3 **15 Hours**

Polymerase Chain Reaction (PCR), Restriction fragment length polymorphism (RFLP) and Site-directed mutagenesis, Transgenic animals, Cloning, Transformation. Gene Targeting: Knock-ins and Knock-outs. DNA Sequencing and Genome Analysis, Model Genomes (*E. coli*). Applications of Genetic Engineering and Biotechnology in agriculture, medicine, and its economic and social implications, Ethical precautions.

Practical

Unit 4 **30 Hours**

1. Culture of bacteria and study of antibiotic resistance
2. DNA isolation from bacterial culture/other sample
3. Restriction enzyme digestion.
4. Separation of molecules using electrophoresis and cloning.
5. Transformation, Calculation of transformation efficiency.
6. Models and Presentations by students on the topics: Microbial degradation of waste materials, Antibiotics from microorganisms, Transgenic Tomato and Rice, Recombinant Interferon, Growth Hormone, Insulin, Colony Stimulating Factor, Streptokinase, Industrial Enzymes.
7. Video-graphic demonstrations on the above-mentioned topics.

Recommended readings

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

Semester VI
Major Course (CC)-16
ZOO-CC-3640- Endocrinology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: The course envisages information on endocrine system of animals with their evolutionary significance, structure and function. The associated hormones and the related disorders will be explained.
Learning outcomes: After successfully completing this course, the students will be able to understand neurohormones and neurosecretions, about hypothalamo and hypapophysial axis, about different endocrine glands and anatomy and function, and the mechanism of hormone action.

Theory

Unit 1 **15 Hours**

Endocrine organs in vertebrate; fishes, amphibians, reptiles, birds and mammals. Endocrine system and neuro secretory organs in invertebrates; arthropods, and mollusc. Hormones; definition, classification. Endocrine, paracrine, and autocrine modes of hormone delivery, Hormone of neurosecretory organs of insect and function in metabolism, Types of hormone in vertebrates.

Unit 2 **15 Hours**

Structure of hypothalamus in mammals: Hypothalamic nuclei, and their functions, Structure of pituitary gland, its hormones and their functions; Hypothalamo-hypophysial portal system. Feedback concept of hormone action

Unit 3 **15 Hours**

Structure, Hormones and functions of Thyroid gland; Parathyroid; Adrenal glands; & Pancreas. Structure of ovary and testis and their endocrine function. Structure of pineal gland, secretions, and their functions in biological rhythms. Hormones in homeostasis.

Practical

Unit 4 **30 Hours**

1. Study of neurosecretory organs of insects
2. Histological preparation of endocrine organs of vertebrate (fishes, amphibians, reptiles and birds).
3. Detection of pro-thoracic gland in insect.
4. Dissection and demonstration of endocrine glands in laboratory bred mice/rat*.
5. Study of the permanent slides of all the endocrine glands.
6. Demonstration of Castration/ ovariectomy in laboratory bred mice/rat*.
7. Estimation of plasma level of any hormone using ELISA.

Recommended readings

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

Semester VI
Minor Course (MC)-6
ZOO-MC-3610- Wildlife Conservation and Management

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

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

Learning outcomes: After successfully completing this course, the students will be able to develop an understanding of how animals interact with each other and natural environment, develop the ability to use the fundamental principles of wildlife ecology to solve local, regional and national conservation and management issues, develop the ability to work collaboratively on team-based projects, gain an appreciation for the modern scope of scientific inquiry in the field of wildlife conservation management and develop an ability to analyse, present and interpret wildlife conservation management information.

Theory

Unit 1 **15 Hours**

Definition, and importance of wildlife. Causes of depletion of wildlife; Factors responsible for the extinction of animals; Types of protected areas and the concept of zoning within the protected areas; Wildlife Sanctuaries and National Parks in India

Unit 2 **15 Hours**

Wildlife conservation, ethics and importance of conservation; Impact of topography, geology, soil and water on wildlife; Impact of habitat destruction and fragmentation on wildlife; Biological parameters such as food, cover, forage and their impact on wildlife; Population attributes; concepts of exponential and logistic growth rates of wildlife; Density dependent and independent population regulation; Impact of introduced species on preexisting flora and fauna of wildlife. Predator-prey models and impact of predation.

Unit 3 **15 Hours**

Wildlife conservation objectives- strategies and issues; Captive breeding, translocation and reintroduction; Inviolate area and critical habitats and their impact on wildlife; Bio-geographical zones on India; Restoration of degraded habitat; Damage caused by wildlife in India and its mitigation, Man wildlife conflict resolution and mitigation.

Practical

Unit 4 **30 Hours**

1. Identification of flora, mammalian fauna, avian fauna, herpeto-fauna.
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).
3. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers etc.
4. Demonstration of different field techniques for flora and fauna.
5. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).

Recommended readings

1. Caughley, G., and Sinclair, A.R.E. (1994) Wildlife Ecology and Management. Blackwell Science.
2. Woodroffe, R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict or Co-existence? Cambridge University.
3. Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats (5^{th} edition) The Wildlife Society, Allen Press.
4. Sutherland, W.J. (2000) The Conservation Handbook: Research, Management and Policy. Blackwell Sciences
5. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008) Problem solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.
6. Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI Learning Pvt. Ltd., New Delhi

Semester VII
Major Course (CC)-17
ZOO-CC-4710- Ecology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provides the student insight into the life sustaining processes of nature, the interactions between species and their environments. The course highlights on some of the important aspects about populations and communities in different habitats, energy flow in the ecosystems, interactions between the communities and consequences of changing environment on the biodiversity.

Learning outcomes : After successfully completing this course, the students will be able to understand the ecological function and process, flow of energy and nutrient to sustain life, the influence of physical factors on organism, population and community regulation, and gradual evolution of ecosystem.

Theory

Unit 1 **15 Hours**

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

Unit 2 **15 Hours**

Ecology of populations: Unitary and Modular populations. Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal. Factors regulating population dispersal and growth: Exponential and logistic growth. Population regulation: density-dependent and independent factors; r and K strategies. Metapopulation.

Unit 3 **15 Hours**

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

Practical

Unit 4 **30 Hours**

1. To measure microclimatic variables viz., temperature, humidity and light conditions in a microhabitat.
2. Calculation of species richness, evenness and abundance.
3. Preparation of growth curve
4. Enumeration of population and construction of age structure model.
5. Calculation of photosynthetic extinction coefficient
6. Constructing a food web by observing and collecting organisms from a given area.
7. Preparing and clearly present an essay based on the evaluation of 4-7 publications
8. Studying the impact of herbivore on plant species (planted in pots under specific conditions)
9. Estimation of the ratio of the producers and consumers.
10. Studying insect diversity in a habitat.

Recommended readings

1. Colinvaux, P. A. (1993). Ecology (2^{nd} edition) Wiley, John and Sons, Inc.
2. Krebs, C. J. (2001). Ecology (6^{th} edition) Benjamin Cummings.
3. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole.
4. Ricklefs, R.E. (2000). Ecology (5^{th} edition) Chiron Press.
5. Southwood, T.R.E. and Henderson, P.A. (2000). Ecologial Methods (3rd edition) Blackwell Sci.
6. Kendeigh, F C. (1984). Ecology with Special Reference to Animal and Man. Prentice Hall Inc.
7. Stiling, P. D. (2015). Ecology Companion Site: Global Insights and Investigations. McGraw Hill Education.

Semester VII
Major Course (CC)-18
ZOO-CC-4720- Immunology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: Immunology part provides the students with the fundamental knowledge of the immune system and its protective roles against diseases.

Learning outcomes: After successful completion of this course the student will able to know how resistance development and resistance transfer occur, identify the major cellular and tissue components which comprise the innate and adaptive immune system, understand how are immune responses by CD4 and CD8 T cells, and B cells, Initiated and regulated, understand how does the immune system distinguish self from non-self. Also, the student will gain experience at reading and evaluating the scientific literature in the area.

Theory

Unit 1 **15 Hours**

Introduction to immunology, Innate immunity: components and importance, Properties of adaptive immunity, Humoral and cell mediated immunity, Clonal selection and clonal proliferation, Active and passive immunity, Primary and secondary immune response, Organs of the Immune System: Primary lymphoid organs, Lymphatic System, Secondary Lymphoid Organs, Cells of immune system: Mononuclear Phagocytes, Granulocytic Cells and Natural Killer Cells

Unit 2 **15 Hours**

Antigens and immunogens: Chemical nature and characteristics, Adjuvant- properties and mechanism of action, Epitopes, Haptens, Pattern-Recognition Receptors, Antibodies: structure and function, Immunoglobulin heterogeneity: Isotypes, Allotype and idiotype, Antigen-antibody interactions: cross reactivity, precipitation reactions and agglutination reactions, Complement system: classical, alternate and lectin pathways, Cytokines

Unit 3 **15 Hours**

Origin and maturation of T & B lymphocytes and their functions, T-cell activation-molecular mechanism, Major histocompatibility complex (MHC): structure of gene and protein of MHC, biological significance, HLA antigen**,** Allograft reaction, prevention of graft rejection, Antigen processing and presentation to T lymphocytes, Hybridoma and monoclonal antibodies-applications and therapeutic uses, Hypersensitivity and autoimmunity-factors responsible for autoimmunity

Practical

Unit 4 **30 Hours**

1. Blood: Erythrocyte Sedimentation Rate (ESR), Haematocrit.
2. Demonstration of antigen-antibody interaction in gel
3. Separation of γ-globulin by salt precipitation
4. Determination of total count of RBC
5. Determination of total count WBC in Mammalian blood
6. Differential count of WBC in Mammalian blood
7. Estimation of blood glucose in mammalian blood
8. Study of B-lymphocytes in Bone marrow
9. Blood Grouping and testing method for Rh factor

Recommended readings

1. Punt J., Stranford S. A., Jones P. P., Owen J. A., 2019. Kuby Immunology , W. H. Freeman,
2. Abbas, AK, Lichtman AH, Pillai A, Baker, DL, Baker A, 2016. Basic immunology: functions and disorders of the immune system. 5th Edition, Elsevier, St. Louis, Mo. USA
3. Abbas, A. K., Lichtman, A. H. and Pillai, S. (2018). Cellular and molecular Immunology. 9th ed. Elsevier.
4. Abbas, A. K. and Lichtman, A. H. (2019). Basic Immunology. 6thed. Elsevier.
5. Goldsby, R. A., Kindt, T. J., Kuby, J. and Osborne, B. A. (2019). Immunology, W. H. Freeman and Co.

Semester VII
Major Course (CC)-19
ZOO-CC-4730- Biostatistics and Bioinformatics

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

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

Learning outcomes: After successfully completing this course, the students will be able to know the theory behind fundamental bioinformatics analysis methods, be familiar with widely used bioinformatics databases. know basic concepts of probability and statistics, describe statistical methods and probability distributions relevant for molecular biology data, know the applications and limitations of different bioinformatics and statistical methods, perform and interpret bioinformatics and statistical analyses with real molecular biology data. acquire knowledge of various databases of proteins, nucleic acids. Primary, secondary and composite databases-BLAST & FASTA, develop understanding in Primer designing and understand data mining tool.

Theory

Unit 1 **15 Hours**

Concept of biostatistics-types of data, methods of data collection. Sampling techniques; classification and representation of data- tabular, diagrammatic and graphical representation of data. Measures of central tendency-mean, median and mode Measures of dispersion: Standard deviation, Coefficient of variation (CV), Standard error of mean (SEM), Skewness and Kurtosis, Hypothesis testing: Parametric and Non-parametric tests, (t- test, Chi square and Goodness of fit, F-test- Analysis of Variance (ANOVA).

Unit 2 **15 Hours**

The Analysis of Variance, Single factor analysis of variance, confidence limits for population mean; Power and sample size, Homogeneity of variances. Correlation analysis (Karl Pearson's and Spearman's Rank), Regression analysis, Tukey's HSD test, Principal Component Analysis, Receiver Operator Characteristic (ROC) Curve and Area Under Curve (AUC). Probability distribution and its application in biological studies.

Unit 3 **15 Hours**

Introduction & scope of bioinformatics, Biological databases (Protein & nucleotide sequence databases), Access to molecular biology databases, Sequence alignment and phylogenetic trees, Knowledge discovery in Databases and data mining, important servers in bio-informatics, Application of available software (BLAST, CLUSTAL W), Open reading frame, Protein 3D structure determination using bioinformatic tools. Application in Artificial intelligence (AI) in bioinformatics.

Practical

Unit 4 **30 Hours**

1. Calculation of mean, standard deviation and standard error.
2. Calculation of correlation coefficient values and finding out the probability.
3. Calculation of 'F' value and finding out the probability value for the F value.
4. Chi-square test of given data
5. Student's t-test: Independent and dependent. Hand calculation and calculation using statistical software
6. Pair-wise alignment of sequences (BLAST) and interpretation of the output
7. Finding of ORF using bioinformatic tools
8. Demonstration of 3D structure of protein using bioinformatics tools

Recommended readings:

1. Attwood T. (2007). Introduction to Bioinformatics. 1st ed. Pearson Education.
2. Mallick B. and Ghosh Z. (2008). Bioinformatics: Principles and Applications. OUP Publications, India
3. Bailey, N. T. J. (1995). Statistical Methods in Biology. 3rd ELBS ed.
4. Das S. (2006). Unix – Concepts and Applications. 4thed.Tata McGraw-Hill.
5. Forthofer, N. and Lee, E. S. (2006). Introduction to Biostatistics: A Guide to Design, Analysis and Discovery. Academic Press.
6. Gun A. M., Gupta, N. K. and Dasgupta, B. Fundamentals of Statistics. Volume 1. World Press.
7. Kanetkar Y. P. (2008). Let Us C. 8th ed. Infinity Science Press.
8. Lipschutz, S. (2011). Data structure with C. 1st ed. McGraw Hill Education (India) Private
9. Zar J. H. (1999). Biostatistical Analysis. 5th ed. Pearson Education (India) Ltd

Semester VII
Major Course (CC)-20
ZOO-CC-4740- Biological Techniques

Marks		Credits		Contact hours	
End semester exam:	80	Theory:	03	Theory:	45
Assignment/sessional exam:	20	Practical:	01	Practical:	30
Total:	100	Total:	04	Total:	75

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

Learning outcomes: After successfully completing this course, the students will learn the theoretical basis of technique, its principle of working and its correct application, the construction repair and adjustment of any equipment required for a technique, the accuracy of technique, the maintenance laboratory equipment/tools, safety hazards/precautions, and the techniques of separation of amino acids, proteins and nucleic acids.. Also, the student will acquire basic knowledge on the technique of cell and tissue culture and the process of preparation of buffer.

Theory

Unit 1 **15 Hours**

Light microscopy: Brightfield, Darkfield, fluorescence, phase contrast and confocal – Principles and applications; Electron microscopy: TEM and SEM: Principles, sample preparation and application in biological science. Spectroscopy: UV-VIS, IR, Atomic absorption spectroscopy and its application, Centrifugation: Principles, types and applications, Electrophoretic technique: Agarose gel electrophoresis, SDS-PAGE, isoelectric focusing.

Unit 2 **15 Hours**

Principles and applications of gel filtration, Chromatography: Thin Layer Chromatography (TLC), Ion exchange and affinity chromatography; HPLC & Gas Chromatography (GC): Principles and applications. Methods, Principles and application of Radioimmunoassay (RIA) and ELISA, Fixation of tissue and histological technique (Paraffin Embedded Sections, Cryo-sectioning), Staining methods (Heamatoxylin and Eosin Method).

Unit 3 **15 Hours**

Basic Principles, method and applications of Immunohistochemistry, Principle and methods of animal cell culture, Transgenic animals, PCR (Principles and methods of nucleic acid extraction, amplification, RT-PCR and Q-PCR), RAPD, RFLP, DNA fingerprinting and techniques of In-situ hybridization of nucleic acids, Principles, methods and application of blotting techniques, Sequencing of nucleic acids (Maxam – Gilbert and Sanger's method)

Practical

Unit 4 **30 Hours**

1. Preparation of buffer and determination of pH.
2. Identification of amino acids in the mixture using paper chromatography.
3. Verification of laws of spectrophotometry.
4. Separation of proteins using SDS-PAGE.
5. Tissue fixation, paraffin block preparation, sectioning.
6. Preparation of permanent slides of microscopic organisms/ small insects.
7. Demonstration of centrifuges
8. Demonstration of bright field, phase contrast, fluorescence, confocal and electron microscopes.

Recommend Readings

1. Bajpai, P.K. (2006). Biological Instrumentation and Methodology. 1st Ed. S. Chand & Company Ltd.
2. Cantor, C.R. & Schimmel, P.R. (2003). Biophysical chemistry (3 vol. set). W. H. Freeman & Co. Das, D. (2009). Biophysics & Biophysical Chemistry. Academic Publishers.
3. Sharma, B. K. (1991). Techniques in Microscopy and Cell Biology. Tata-McGraw Hill.
4. Switzer, R. L. and Garrity, L. F. (1999). Experimental Biochemistry. W. H. Freeman and
5. Company.
6. Wilson, K., & Walker, J. (eds.) (2001). Principles & Techniques of Practical Biochemistry. 5th Ed. Cambridge University Press.
7. Sharma, B. K. (1991). Techniques in Microscopy and Cell Biology. Tata-McGraw Hill.
8. Stoward, P. J. and Everson Pearse, A. G. (1991). Histochemistry: Theory and Practical. 4th ed. Churchill Living Stone.24
9. Weesner, F. M. (1965). General Zoological Techniques. The William and Wilkins Company.

Semester VII
Minor Course (MC)-7
ZOO-MC-4710- Research Methodology

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: The course will provides knowledge on various research approaches and methods. Also, the course will provide student insight into various statistical tools for interpretation of data, research design and hypothesis testing.

Learning outcomes: After successful completion of this course, the student will understand the scientific & philosophical approach of research, research design, selection of appropriate methods for any research, hypothesis testing, appropriate statistical tools for analysis of data.

Theory

Unit 1 **15 Hours**

Meaning, objectives and nature of scientific research; Approaches to pursue research, Review and identifying researchable issues; Significance of building information and data, Defining the research questions, formulation of research hypothesis; Adoption of methodologies to answer the problem, layout and design for research, examining technical feasibility, Communicating research results in peer-reviewed journals.

Unit 2 **15 Hours**

Basic research and applied research, Philosophy of Rene Descartes Measurement; sensitivity, accuracy, precision and specificity, The limits and range of measurement in different systems, Positive and negative controls, biological and technical replicates, Sampling – theory, types, steps and sample size, Advantage and limitation of sampling methods and standardization, Computer application: tabulation, graphs & figures, MS word, MS Power Point; Relevant Bio-informatics tool.

Unit 3 **15 Hours**

Mean, Standard deviation, Standard error of mean, Co-efficient of variation, parametric and non-parametric tests, Correlation and Regression, Testing of hypothesis –Chi square test, t test, analysis of variance (ANOVA) and F test; Software application : MS Excel, SPSS, Sigma plot and relevant other packages of for statistical analysis.

Practical

Unit 4 **30 Hours**

1. Demonstration of sampling technique in field
2. Determine the Mean of the given sample
3. Determine the standard deviation of the given sample
4. Determine the standard error of mean of the given sample
5. Testing the Chi square test for the given sample
6. Demonstration of MS excel with suitable data
7. Demonstration of SPSS with suitable date set

Recommended Reading:

1. Gun A. M., Gupta, N. K. and Dasgupta, B. Fundamentals of Statistics. Volume 1. World Press.
2. Zar J. H. (1999). Biostatistical Analysis. 5th ed. Pearson Education (India) Ltd
3. Kothari, C.R. (2013). Research Methodology: Methods & techniques (4th Edition), New Age International Publishers

Semester VIII
Major Course (CC)-20
ZOO-CC-4810- Concept and Regulation of Metabolism

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course is designed to learn and develop an understanding of the various metabolic pathways in humans, like carbohydrate metabolism, lipid metabolism and protein meta

Learning outcomes: After undergone this course, students will be able to understand the properties of carbohydrates, proteins, lipids, and their importance in biological systems, explain the biological mechanisms, such as the processes and control of bioenergetics and metabolism, as chemical reactions; comprehend the concept of enzyme, its mechanism of action and regulation, appreciate the importance of high energy compounds, electron transport chain, synthesis of ATP under aerobic and anaerobic conditions and understand the role of TCA cycle in central carbon metabolism.

Theory

UNIT 1 **15 Hours**

Glycolysis: Preparatory and Payoff phases, regulation, fates of pyruvate, Pentose phosphate pathway: oxidative and non-oxidative Phases; Gluconeogenesis: Bypass reactions, regulation and reciprocal coordination of glycolysis and gluconeogenesis; Glycogen Metabolism: Glycogenolysis, Glycogenesis and its coordinated regulation, Kreb's Cycle (formation of Acetyl CoA, reactions of cycle, regulation)

UNIT 2 **15 Hours**

Fatty Acid synthesis and regulation; β oxidation of palmitic acid: activation of fatty acids and oxidation with bioenergetics, regulation. Protein metabolism; Transamination, Deamination, Glutamine formation, and Urea Cycle, Synthesis of purine and pyrimidine, Nucleotide biosynthesis and metabolism, salvage pathways.

UNIT 3 **15 Hours**

Oxidative phosphorylation: basics of electron transfer chain structure and reactions, chemiosmotic theory, ATP synthesisa and energetics of ATP synthess, Mitochondria in thermogenesis; uncoupled mitochondria in brown adipose tissue to produce heat, Mitochondria role in initiating apoptosis

Practical

Unit 4 **30 Hours**

1. Qualitative tests to identify functional groups of carbohydrates.
2. Qualitative tests to identify functional groups of amino acids.
3. Qualitative tests to identify functional groups of lipids.
4. Estimation of total protein in given solutions by Lowry's method.
5. Estimation of Carbohydrate by Spectrophotometric method and reactions of carbohydrate
6. Estimation of DNA by Spectrophotometric method and Reactions of DNA
7. Estimation of RNA by Spectrophotometric method and Reactions of RNA
8. Separation of serum proteins by Polyacraylamide Gel Electrophoresis
9. Determination of Km Value of an Enzyme
10. Study effect of temperature enzymatic activity of salivary amylase.
11. Study effect of pH on enzymatic activity of salivary amylase
12. To study the enzymatic activity of Lipase.

Recommended readings

1. Nelson, D.L., Cox, M.M. (2017). Lehninger: Principles of Biochemistry (7th ed.). New York, WH: Freeman Company.
2. 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.
3. Stryer, L., Berg, J., Tymoczko, J., Gatto, G. (2019). Biochemistry (9 th ed.). New York, WH: Freeman.
4. Voet, D., Voet. J. G. (2013). Biochemistry (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd.

Semester VIII
Elective Course (DE)
ZOO-DE-4810- Aquaculture and Fish Biology–I

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provides various aspects on pisciculture, its management and economic importance. Further, the course will provides detail knowledge on various cultivable species of fish, anatomy, reproductive physiology and foods of the fish.

Learning outcomes: After successfully completing this course, the students will be able to understand the management and economic importance of pisciculture. Further, the student will know about cultivable species of fish, anatomy, reproductive physiology and foods of the fish.

Theory

Unit 1 **15 Hours**

Aquaculture: Concept; History, Status & Scope in India; Aquaculture System; Freshwater, Brackish water & Marine; Biology of aquaculturally important fin fishes, shell fishes, algae, crustaceans; Principles and methods in taxonomy for aquatic Zoology; Identification of eggs, Juveniles of cultivable major carps.

Unit 2 **15 Hours**

Food habits and feeding mechanisms in fishes; Digestive systems of Cultivable fishes; digestion and absorption; Concept of fish Nutrition and bioenergetics; Determination of age and growth of fishes; Length-weight relationship and condition Factor. Respiration: aquatic mechanism and aerial adaptation; Swim Bladder in fish: Structure and function;

Unit 3 **15 Hours**

Comparative anatomy of Reproductive Systems in fish & Crustacea ; Modes of reproduction, Role of hormones in reproduction of fishes and Crustacea; Fecundity, breeding and parental care in fishes; Developmental stages of carps and prawn: Embryo, hatching and metamorphosis Comparative anatomy of hearts in fish, Fish blood; Excretion: Kidney, Osmoregulation; Fish migration .

Practical

Unit 4 **30 Hours**

1. Taxonomy of edible & ornamental fishes (with special reference to Arunachal Pradesh): Cat fishes, carps, prawns, glassfishes, mahaseers, Minnows & barbs, loaches, perches, eel; Taxonomy and identification of disease causing organisms in fishes.
2. Morphometrics, meristics and sexual dimorphism: Cat fishes, Carps, Tilapia, crabs and Prawns.
3. Dissection & morpho-anatomy: Digestive and reproductive system – Carp, cat fishes & prawns; Excessory respiratory system of fish ; morpho-anatomical localization of Endocrine glands: Pituitary, pineal , adrenal, thyroid.

Recommended readings

1. Ayyappan, S., J.K. Jena., A Gopalakrishan., A.K.Pandey (eds.,)Hand Book of Fisheries and Aquaculture, ICAR, New Delhi , 2006:
2. Desilva, Sena. S., T.A. Anderson (eds.) Feed nutrition in aquaculture, Chapman & Hall, 2-6 Boundary Row, London,
3. Jyoti, M.K & A. Sharma (2006) Fishes (Aid to collection preservation and identification), Daya Publishing House, Delhi-35,
4. Turner, W.B. Algae Aquae Dulcis Indiae Oriantalis (The Freshwater algae (Principally Desmidieae), Bishen Singh Mahendra Pal Singh, 23-A, New connout place, Dehra Dun-01,
5. Pentecost, A. Introduction to Freshwater algae, Richmond Publishing Co. Ltd, Surrey, London
6. Ponniah, A.G & U.K. Sarkar (eds., 2000) Fish Biodiversity of North East India, Director, NBFGR, Canal Ring Road, Lucknow-02, U.P,
7. Raghuramulu N, K.M Nair, S. Kalyanasundaram (eds., 1983) A manual of Laboratory Techniques, National Institute of Nutrition, Indian council of medical research, jamai Osmania, Hyderabad
8. Mahanta P.C. & D. Sarma (eds., 2010) Coldwater Fisheries Management. ICAR-Directorate of Coldwaer Fisheries Research, Bhimtal-36, Nainital, Uttarakhand,
9. McMillan D.B. Fish Histology: Female Reproductive Systems, Springer-Verlag New York Inc,

Semester VIII
Elective Course (DE)
ZOO-DE-4811- Cell and Molecular Biology–I

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course is designed to learn and develop an understanding of the cellular dynamics and molecular mechanisms of the different cells. Also, the course will provides advanced techniques in DNA isolation, purification, and sequencing, along with methodologies like DNA barcoding and fluorescence microscopy, to investigate genetic variations and signal transduction mechanisms.

Learning outcomes: Upon completion of the course, the student will be able to understand the intricacies of cell cycle regulation; cell division,; evaluate the molecular underpinnings of cancer, including proto-oncogenes, tumor suppressor genes, and the influence of carcinogens on cellular homeostasis; understand the functions of DNA modifying enzymes like exonucleases, endonucleases, and DNA ligases, crucial for DNA manipulation and molecular cloning and apply advanced techniques in DNA isolation, purification, and sequencing, along with methodologies like DNA barcoding and fluorescence microscopy, to investigate genetic variations and signal transduction mechanisms.

Theory

Unit 1 **15 Hours**

Cell cycle, Cell cycle regulation-role of cyclin and CDK, Cell fusion experiment, cell cycle and checkpoints. Retinoblastoma protein and cell-cycle regulation. p53 in cell-cycle regulation. Mechanism of cell division-Mitosis and Meiosis. Cell death- Apoptosis and Necrosis, Mechanism of Apoptosis, Apoptotic pathways- extrinsic and Intrinsic. Molecular basis of cancer, Proto-oncogenes, Tumour suppressor genes, carcinogens

Unit 2 **15 Hours**

Signal transduction: Intracellular receptor and cell surface receptors, Signalling via G-protein. linked receptors (PKA, PKC, CaM kinase) Enzyme-linked receptor signaling pathways, Network and cross-talk between different signal mechanisms. Pharmacogenomics/drug metabolism in relation to individual genetic makeup (personalized medicine). Pulse-chase experiments; tracking protein movement within cell. Fluorescence resonance energy transfer (FRET) microscopy. DNA fingerprinting and chromosome walking.

Unit 3 **15 Hours**

DNA Barcoding of different organisms: method and applications.Next-generation DNA sequencing; principle of Illumina sequencing and its application. Transcriptome; introduction, its study by RNA sequencing and application. Identifying protein binding sites on a DNA molecule; Gel retardation of DNA–protein complexes, Foot-printing with DNase I, Chromatin immunoprecipitation sequencing (ChIP-seq)

Practical

Unit 4 **30 Hours**

1. Introduction to the Good Lab Practices (GLP)
2. Introduction and handling of instruments available in the lab
3. Handling and imaging in microscopes. (Light, Inverted, Phase contrast and Fluorescent microscope)
4. Micrometry and its application
5. Performing BLAST searches using NCBI server
6. Multiple alignment using clustal X
7. Analysis of barcoding using bioinformatics tools.
8. Polytene chromosome: preparation and detection of RNA activity at the puffs.
9. Study of mitotic chromosome from bone marrow of rats.
10. Study of different types of cells
11. Histochemical detection of cellular organelle

Recommended Readings

1. Watson, J. D., *et al*. (2007). Molecular Biology of the Gene. 6th ed. Benjamin Cummings.
2. Brown, T. A. (2016). Gene Cloning and DNA Analysis: An Introduction. 7th Ed. Wiley Blackwell.
3. Cooper, G. M. (2004). The Cell. 3rd edn. ASM Press.
4. W.H.Freeman.Karp, G. (2008). Cell and Molecular Biology: Concepts and experiments. John Wiley.
5. Lewin, B. (2008). Genes IX. Jones and Bartlett Publishers.
6. Benjamin Cummings. Malacinski, G. M. (2003). Essentials of Molecular Biology. Jones and Bartlett.
7. Primrose, S. B. and Twyman, R.M., (7th Ed. 2006). Principles of Gene Manipulation and Genomics, Blackwell Publishing, West Sussex, UK
8. Bernard R. and Jack. Molecular Biotechnology: Principles and application of recombinant DNA, ASM Press, Herndon, USA

Semester VIII
Elective Course (DE)
ZOO-DE-4812- Entomology–I

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: In this course, students will delve into the fascinating world of insects, exploring their origins, evolution, and intricate relationships with their environments. From the ancestral roots to the co-evolution with plants and predators, the course covers the gamut of insect biology, including sensory perception, ecological roles, and behavioral adaptations.

Learning outcomes: After successfully completing this course, the students will be able to understand of the origin and evolutionary timeline of insects, explore the evolutionary adaptations and ecological roles of specific insect species Also, the student have profound knowledge on sensory receptors in insects and their role and on insect ecology and its role in evolution

Theory

Unit-1 **15 Hours**

Origin and evolution of insects- Ancestors, geological timescale of insect evolution, Evolution of autapomorphic characters of insect orders; Evolution of silkworms, bees and rove beetles, Co-evolution of plants, pollinators and pests, Structure and evolution of insect legs, mouthparts, eyes.

Unit 2 **15 Hours**

Sensory receptors-types and structure, Host plant selection, Tri-trophic interactions, Mimicry and camouflage in insects, Insect population growth, Niche partitioning in insects, Habitat based techniques for collection of insects, Prey-capture structures and mechanism in insects, Virus transmitting Insects, Insect-Microbe interaction.

Unit-3 **15 Hours**

Ecology of honeybees, silkworms and mosquitoes. Phenotypic plasticity in insects and endocrine control of insect polyphenism; Predators and parasites in agroecosystems, Communication in insects, Pheromones and stridulatory organs, Insect-host plant interactions, Pesticide resistance in insects.

Practical

Unit 4 **30 Hours**

1. Identification of silkworms and their host plants.
2. Identification of mosquitoes and study of larval habitat.
3. Predatory insects and prey capture apparatus.
4. Identification and collection of pest, parasites of insects and parasitoids.
5. Study of insect legs and mouthparts.
6. Study of stridulatory organs in insects.
7. Estimation of population density and size of insect community
8. Compare insect species richness and evenness using diversity indices

Recommended Readings:

1. David Grimaldi and Michael S. Engel. (2005). The Evolution of Insects. Cambridge University Press.
2. Timothy D. Schowalter. (2022). Insect Evolutionary Ecology. Academic Press.
3. P.J. Gullan and P.S. Cranston (2014). The Insects: An Outline of Entomology. Wiley Blackwell.
4. Martin Stevens (2013). Sensory Ecology, Behaviour, and Evolution. Oxford University Press
5. Peter W. *et al* (2011). Insect Ecology: Behavior, Populations and Communities. CUP
6. David M. *et al* (2014). The Evolution of Insect Mating Systems. Oxford Academic
7. Michael P. Hassell. (1992). Insect Population Ecology: An Analytical Approach. Uni. of California Press
8. A. Rami Horowitz and Isaac Ishaaya 2004. Insect Pest Management and Ecological Research. Springer
9. David W. Onstad (2022). Insect Resistance Management: Biology, Economics, and Prediction. Academic Press
10. R.F. Chapman 2012. The Insects - Structure and Function. Cambridge University Press
11. Larry P. Pedigo, *et al* (2021). Entomology and Pest Management. Waveland Press.
12. Lawrence I. Gilbert. (2009). Insect Development - Morphogenesis, Molting & Metamorphosis. Academic.Press
13. Lawrence I. Gilbert 2011. Insect Molecular Biology and Biochemistry. Academic Press
14. Berthold Hedwig 2014. Insect Hearing and Acoustic Communication. Springer
15. Simon R. Leather 2004. Insect Sampling in Forest Ecosystems by Blackwell Science Ltd
16. Sakis Drosopoulos 2006. Insect Sounds and Communication - Physiology, Behaviour, Ecology and Evolution. CRC Press
17. Charles D.Michener 2007. The Bees of the World. Johns Hopkins University Press

Semester VIII
Elective Course (DE)
ZOO-DE-4813- Integrative Physiology–I

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provide various aspects on structural anatomy of endocrine organs and reproductive systems as well as integrative approach of its physiological functions among the vertebrates. Further, the course will provide detail knowledge on various hormones and its physiological role in organs' signalling system and physiology. Students will also get an understanding of Reproduction as endocrine regulatory functions of the system in vertebrates.

Learning outcomes: After successfully completing this course, the students will be able to understand the basic endocrine physiological and regulatory mechanism of integrative metabolic processes of cells and organs. Students will get hands on training on the method of study of reproductive aspects of organism and various instrument and methods of investigation.

Theory

Unit 1 **15 Hours**

Origin and development of pituitary in mammal. Comparative anatomy of hypophyseal gland , thyroid and adrenal in vertebrates- hormones in different vertebrate group. Hypothalamus and neuroendocrine cells in vertebrates, hypothalo-hypophyseal portal system. Evolutionary sequences of Oxytocin and vasopressin in vertebrates

Unit 2 **15 Hours**

Structure and functions of releasing hormones and tropic hormones. Mode of hormone release- episodic and pulsatile. Glycoprotein hormones: genetic variation and FSH heterogeinity. Structure and biosynthetic pathway of steroid hormones in mammals. Mechanism of hormone action- ligand receptor binding and signal transduction in target organs; Structure of G-Protein

Unit 3 **15 Hours**

Development of Gonad in mammals: hormonal and nonhormonal factors. Attainment of puberty and feedback regulation of hormones in mammals Female reproductive cycles (estrous/ menstrual)- hormonal regulation, ovulation. Growth of preimplantation embryo, mechanism of implantation, endometrial receptivity and decidual cell reaction. Epididymal protein and sperm maturation, Biochemical aspects of sperm capacitation and acrosome reaction

Practical

Unit 4 **30 Hours**

1. Dissection and demonstration of Endocrine glands in laboratory bred mice/rat.
2. Study of the permanent slides of all the endocrine glands.
3. Study of estrous cycle in laboratory bred mice/rat
4. Demonstration of Castration/ ovariectomy in laboratory bred mice/rat.
5. Estimation of plasma level of any hormone using ELISA.
6. Study of effects of steroid hormones on uterus and epididymis

Recommended readings

1. Turner, C. D. (1971) General Endocrinology, Pub- Saunders Toppan.
2. Nussey, S.S.; and Whitehead, S.A. (2001) Endocrinology: An Integrated Approach, Oxford: BIOS Scientific Publishers.
3. Hadley, M.E. and Levine J.E. (2007) Endocrinology (6th edition) Pearson Prentice-Hall, New Jersey.
4. David, O.N. (2013) Vertebrate Endocrinology.
5. Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press.
6. Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
7. Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd.
8. Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme.

SEMESTER-VIII
Department Elective (DE)
ZOO-MC-4814- Wildlife Biology and Ornithology-I

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provides various aspects on wildlife and its management. The course will also provide insight into ornithology Further, the course will provides detail knowledge on wildlife resources in India. Further, the course will impart knowledge on anatomy, physiology, biogeography, habitat, diseases, speciation of bird.

Learning outcomes: After successfully completing this course, the students will be able to understand the management and importance of wildlife. Further, the student will know about anatomy, physiology, habitat and identification of birds.

Theory

Unit 1 **15 Hours**

Wildlife-concept and definition, wildlife resources of Arunachal Pradesh and India, consumptive & non consumptive value of wildlife, threats to wildlife, concept of keystone, umbrella, cryptic, rare, endemic and exotic species. Geological era & their fauna; Wildlife diseases– Viral, bacterial, protozoans, Helmith, Mycotic diseases and their control, Tick borne, mite borne

Unit2 **15 Hours**

Biome concept & types (India & world), Biogeography- concept & types (India & world), Animal communication and signaling-Modes & significance, home range and territory; strategies of territory defend & advertisement; Influence of water on wildlife, Influence of soil on wildlife, Adaptation- camouflage & mimicry

Unit 3 **15 Hours**

Ornithology- concepts & scope; origin & evolution of birds; Speciation in bird; diversity & classification of bird; Natural selection & adaptive radiation in birds; Morphology of birds- body topography, feathers & plumages, leg types & beak types; toe arrangement & webbing in birds; extinct birds; threatened birds of India, Phylogenetics- the evolutionary tree of birds.

Practical

Unit 4 **30 Hours**

1. Taxonomic study of the mammal of Arunachal Pradesh
2. Taxonomical study of vultures of Arunachal Pradesh
3. Study of the various types of feathers in the birds
4. Study the body topography (Body parts) of any birds
5. Study the various parts of Wings of any birds.
6. Sexual dimorphism in birds

Recommended Readings:

1. Goutam Kumar Saha & Subhendu Mazumdar (2022) : Wildlife Biology: An Indian Perspective (1st edition), PHI Learning Pvt Ltd, Delhi India.
2. H.R. Singh & Neeraj Kumar (2014): Ecology and environmental Science (8th (Reprint) edition, Vishal Publishing Delhi
3. Anthony R.E. Sinclair, John M Fryxell and Graeme Caughley (2014): Wildlife ecology, Conservation and management 3rd edition, Blackwell Publishing, USA.
4. Timothy E. Fulbright, David G. Hewitt (2007): Wildlife Science: Linking Ecological Theory and Management Applications (1st edition), CRC publishers, USA
5. S.E. Jorgensen (2011) Fundamentals of Ecological Modelling: Applications in Environmental Management and Research (4th edition), Elsevier Science Ltd, Netherland.
6. Irby,J., and John, W.F. (2016) Handbook of bird biology (3rd ed), Cornell Lab of Ornithology, USA
7. Noble, S.P and Patrick, J.L.(1993). Mannual of ornithology: Avian structure and function. Yale University

Semester VIII
Elective Course (DE)
ZOO-DE-4820- Aquaculture and Fish Biology–II

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provides various aspects on pisciculture, its management and economic importance. Further, the course will provides detail knowledge on various cultivable species of fish, anatomy, reproductive physiology and foods of the fish.

Learning outcomes: After successfully completing this course, the students will be able to understand the management and economic importance of pisciculture. Further, the student will know about cultivable species of fish, anatomy, reproductive physiology and foods of the fish.

Theory

Unit 1 **15 Hours**

Fish farm's site selection & **c**onstruction- Types of ponds, dyke and channel design; Water qualities, soil quality, and other biotic and abiotic factors; Pre and Post stocking pond management - Nursery , rearing , brooder's ponds. Pond fertilization, manuring and liming- Process, needs and significance; Supplementary feed- feed ingredients, feed formulation; Fish diseases - Occurrences, symptoms, prophylaxis & treatments

Unit 2 **15 Hours**

Cold water aquaculture; Species, principles and methods; Composite culture- Ponds; Periphyton based aquaculture; Brackish water aquaculture- Methods & cultivable fish; Integrated fish farming: Rice – fish, Pig cum & Bird cum fish. Harvesting- Fish catching methods and fishing gears; Post harvesting technology- fish and prawn processing and preservation; Fish bye products

Unit 3 **15 Hours**

Fish seed production : Brood stock raising & management ; Induced breeding: Hypophysation and other inducing systems , Striping, LINPE method and multiple breeding of IMC ; Aquarium management & Techniques of ornamental fish (OF) breeding; Market potentials OF; Fish seed industry vs. natural collection; fish seed transportation.

Practical

Unit 4 **30 Hours**

1. Identification of major fish food organisms, analysis of gut contents of fishes & formulation of supplementary feeds; Characteristic of brooders- Oocyte and sperm structure, Fecundity & GSI calculation; Hands on training on induced breeding of carps, recording of development stages carp embryo.
2. Analysis of water – Qualitative and quantitative assessment of plankton, periphyton, physical properties of water B.O.D, phosphate, organic matter; Analysis of soil parameters - pH, conductivity, water holding capacity, moisture content, nitrogen, phosphate & potassium.
3. Techniques of aquarium framing and fitting of various aquarium accessories. Identification of Aquarium plants, collection from wild.

Recommended Readings

1. Das, D.N., S.K, Abujam & A.D. Singh (eds., 2019), Research Trends on Fish & Fisheries in mountain waters of Eastern Himalayan Region, Notion Press, McNichols Road, Chetpet, Chennai-31, 326p.
2. Sadhu, J.S (2020) Text book of fish and fisheries, Wisdom press, 116-A, South Anarkali, Delhi-51,
3. Rath, R.K. (2011) Freshwater Aquaculture, Scientific Publishers, 5-A, New Pali Road, P.O. Box 91, Jodhpur-01, 597p.
4. Sharma D, D.N. Das, R. Dutta, D. Baruah, P. Kumar, P.C. Mahanta (2012) Coldwater Lakes and Rivers in Arunachal Pradesh, India, Bulletin no. 19, ICAR, DCFR, Bhimtal-36, Nainital, Uttarakhand,
5. Gupta S.K & P.C. Gupta (1st eds., 2006) General and Applied Ichthyology (Fish and Fisheries), S. Chand & Company Ltd, Ram Nagar, New Delhi-55, 1131p.
6. Nath, S (2013) Food, Feeding Habits, Alimentary Canal and Digestion in Fishes: A bibliography, Today & Tomorrow's Printers and Publishers, Daryaganj, New Delhi-02, 201p.
7. Pal R (1982) Recent Advances in studies on acute diseases of fishes- A Review, Central Inland Fisheries Research Institute, Barrackpore-01, West Bengal, 52p.
8. Chattopadhyay, N.R (2017) Induced fish breeding: A Prractical Guide for Hatcheries, Elsevier, Amsterdam

Semester VIII
Elective Course (DE)
ZOO-DE-4821- Cell and Molecular Biology–II

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will develop the understanding of molecular intricacies of gene regulation mechanisms, the spectrum of diseases & diagnostic techniques, and the structural biology of bacteria, viruses, and fungi, alongside the pressing issues of antibiotic resistance.

Learning outcomes: After successful completion, the student will be proficient in molecular chaperones assist in protein folding, the operon concept, regulation of gene expression, PCR, ELISA, and molecular techniques like True NAT and CBNAAT. Further, the student have basic understanding of diagnosis and detection, including sensitivity, specificity, and predictive values of tests such as rapid tests, antigen tests, antibody tests, and nucleic acid tests, are essential for accurate disease diagnosis and management.

Theory

Unit 1 **15 Hours**

Structure of bacterial cells, mode of actions of antibiotics, MDR, Antibiotic resistant genes, causing factors of resistance. Structure of Viruses, Different Types, HIV- Pathogenesis, Possible drug targets, currently used antiviral drugs. Structure of fungal cells, Yeast and Mold, Aspergillosis and Candidiasis, Mycotoxins, Mycotoxins and Human Health, Antifungal drugs and their targets. Side effects of different drugs. India's role in pharmaceutical sectors.

Unit 2 **15 Hours**

Diabetes; types, causes, and therapy. Alpha and Beta Thalassemia and Cystic fibrosis. Pathophysiology of neurological diseases (Alzheimer, Parkinson and Dementia). Principles of Diagnosis and detection, Sensitivity, specificity, PPV and NPV of the test, rapid test, antigen test, antibody test, nucleic acid test, Detection of malarial infection by PCR and LDH based ELISA, TrueNAT, CBNAAT method for TB

Unit 3 **15 Hours**

Translational modification of proteins; Amino-Terminal and Carboxyl-Terminal Modifications, Loss of Signal Sequences, Modification of Individual Amino Acids, Proteolytic Processing, Addition of Isoprenyl groups, Formation of Disulfide Cross-Links, Attachment of Carbohydrate Side Chains, Ubiquitination of protein.Molecular Chaperone and its role in protein folding.Regulation of gene expression in prokaryotes; Operon concept (*Lac* Operon).Regulation of gene expression in Eukaryotes; histone modification and chromatin remodelling.

Practical

Unit 4 **30 Hours**

1. Different bacterial media preparation
2. Isolation of bacteria from water sample through serial dilution method
3. Culturing, streaking of bacteria
4. Measuring molecular weight and pI of protein using bioinformatic tools
5. Identification of protein coding DNA segment by using ORF finder
6. In-silico detection of site for Signal Peptidase in gene.
7. Potato dextrose agar (PDA) preparation for fungal culture
8. Glycerol stock preparation of bacterial and fungal culture
9. Protein: isolation, quantitative estimation and separation by SDS-PAGE (Western Blot)
10. Demonstration of mammalian cell culture techniques and mammalian cell storage.
11. Handling, restraining and care of laboratory animal. (Mice/Rats/Zebrafish)
12. Methods of injection and blood collection form laboratory animals. (Mice/Rats/Zebrafish)
13. Survival surgery in mice including different stitching techniques.(laparotomy, thoracotomy, etc.)

Recommended Readings:

1. Watson, J. D., *et al*. (2007). Molecular Biology of the Gene. 6th ed. Benjamin Cummings.
2. Brown, T. A. (2016). Gene Cloning and DNA Analysis: An Introduction. 7th Ed. Wiley Blackwell.
3. Lodish et al. Molecular Cell Biology, 6th ed. Freeman Pub.
4. Cooper, G. M. (2004). The Cell. 3rd edn. ASM Press.
5. Lewin, B. (2008). Genes IX. Jones and Bartlett Publishers.
6. Watson et al., Recombinant DNA: Genes and Genomics – a short course, W. H. Freeman and Company, New York, USA
7. Malacinski, G. M. (2003). Essentials of Molecular Biology. 4th ed.

Semester VIII
Elective Course (DE)
ZOO-DE-4822- Entomology–II

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: In this course, students will explore the fascinating world of insect physiology and molecular entomology. Beginning with an exploration of insect integument, chitin metabolism, digestive anatomy, immunity, and luminescence in fireflies. The subsequent section delves into neuroendocrine systems, covering hormone structures, functions, and regulation. Following that, attention shifts to insect reproduction, encompassing anatomy, hormonal controls, and development. The final part offers practical applications such as chitin detection, dissections, haemocyte identification, larval classification, and slide preparation.

Learning outcomes: By the end of this course, students will be able to demonstrate a comprehensive understanding of insect physiology and molecular entomology, analyze the intricate mechanisms of neuroendocrine systems in insects, evaluate the processes involved in insect reproduction, from the anatomy of reproductive systems to the hormonal controls and developmental stages, apply practical skills acquired throughout the course, including chitin detection, anatomical dissections, haemocyte identification, larval classification, and slide preparation, to address real-world entomological challenges.

Theory

Unit I: **15 Hours**

Biochemical composition of insect integument; Chitin metabolism in insects; Anatomy of digestive system; digestion of carbohydrates and proteins; Excretory, circulatory and respiratory system; Insect immunity- Physical barriers, role of haemolymph, fat bodies and anti-microbioal peptides. Luminescence in fireflies.

Unit 2: **15 Hours**

Structure and function of neuroendocrine system in insects Neurosecretory hormones-Allatotropin, allatostatin, prothoracicotropic hormone, Bursicon, proctolin, Diapause hormones-chemical structure and function, JH structure and function, JH as gonadotropin. Ecdysone-synthesis and metabolism. Insect growth regulators.

Unit 3: **15 Hours**

Reproductive system-Male and female reproductive system; Structure of ovarian follicle and oogenesis, Structure of testicular follicles and spermatogenesis; Metamorphosis, Egg, larva and Pupa; Cleavage; Hormonal control of reproduction, Regulation of development by TGF-β signaling. Axes and pattern formation in Drosophila. Giant chromosomes in insects.

Practical

Unit 4: **30 Hours**

1. Detection and extraction of chitin.
2. Anatomy of digestive system
3. Identification of haemocytes
4. Reproductive system in Male and female insects,
5. Types of larvae.
6. Preparation of slides of polytene chromosomes from Chironomus larvae.
7. Neoroendocrine system in insects

Recommended Readings:

1. L.I. Gilbert 2004. Comprehensive Molecular Insect Science. Pergamon Press Inc
2. Lawrence I. Gilbert 2011. Insect Molecular Biology and Biochemistry. Academic Press
3. James L. Nation 2015. Insect Physiology and Biochemistry. CRC Press.
4. Nancy E. Beckage 2007. Insect Immunology. Academic Press
5. Stanley S. Hillman and Peter W. Price 2017. Insect Reproduction. CRC Press
6. Lawrence I. Gilbert 2011. Insect Endocrinology. Academic Press
7. Marjorie A. Hoy 2013. Insect Molecular Genetics: An Introduction to Principles and Applications. Academic Press
8. Alfred, M. H and Anthony A. J. 2000. Insect Transgenesis: Methods and Applications. CRC Press.
9. Frederick A. Lehmeyer 2009. Insect Hemocytes: Development, Forms, Functions and Techniques. Cambridge University Press
10. David Grimaldi 2023 The Complete Insect: Anatomy, Physiology, Evolution, and Ecology. Princeton University Press

Semester VIII
Elective Course (DE)
ZOO-DE-4823- Integrative Physiology–II

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provide various aspects on integrative physiology of Biological systems of organism, Further, the course will provides detail knowledge on basic mechanism organism specific physiology and its study method. Moreover, it will provide physiological and biochemical integration of organ systems' functional physiology like respiratory, muscle, nervous system as well as various methods of investigation.
Learning outcomes: After successfully completing this course, the students will be able to understand the basic physiology of organism. At the same time, students will be able to analyse the effects of environmental changes on the on the organisms' physiology and subsequent measures to be taken for its regulation.

Theory

Unit 1 **15 Hours**

Physiology and biochemistry of Biolouminiscence and chemoluminiscence in animals, BRET and FRET technique. Osmoregulation in terrestrial and aquatic animals: its regulatory mechanism and hormonal control. Aestivation and hibernation, echolocation, adaptations to temperatures in extremes, Environmental stress and acclimatization

Unit 2 **15 Hours**

Respiratory pigments in vertebrates and invertebrates; regulatory mechanism of respiration in higher vertebrates, alkali reserve, respiratory acidosis and alkalosis, hypoxia and oxygen therapy, high altitude acclimatization, mountain sickness.Neuronal and non-neural components of Central nervous system; blood brain barrier and transportation of nutrient to brain; Sensory organs- holoreception, mechanoreception, chemoreception; Biological rhythm and biological clock

Unit-3: **15 Hours**

Gastrointestinal secretions and functions in higher vertebrates, Single cell gland and neural innervations of GI tract, Secretion of bile and bile salts. Excretion in vertebrates: excretory organs, mechanism of acid –base homeostasis, chloride shift in mammal. Sources of energy for muscle contraction, sliding filament theory of muscle contraction, role of calcium, cardiac muscle- Purkinjee fiber

Practical

Unit 4 **30 Hours**

1. Preparation of buffer and determination of pH.
2. Test of urea, salivary amylase and pepsin using spectroscopic method.
3. Separation of proteins using SDS-PAGE.
4. Tissue fixation, paraffin block preparation, sectioning, staining of parts of alimentary canal, liver
5. Preparation of permanent slides of microscopic organisms/ small insects.
6. Identification of lymphocytes and monocytes, tissue macrophages using differential staining method

Recommended readings:

1. Barret, K.; Brooks, H.; Boitano, S. and Barman, S. (2010) Ganong's Review of Medical Physiology (23rd edition) Lange Medical.
2. Guyton, A.C. and Hall, J.E. (2006) A text book of Medical Physiology (11th edition) Saunders.
3. Keele, C.A. & Neil, E. (1989) Samson Wright's Applied Physiology (13th edition) Oxford.
4. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company.
5. David, M., Jonathan, B., David, R. B. and Ivan R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication.
6. Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology. V Edition. Saunders Publication.

SEMESTER-VIII
Department Elective (DE)
ZOO-MC-4824- Wildlife Biology and Ornithology-II

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provides various aspects on wildlife and its management. The course will also provide insight into ornithology Further, the course will provides detail knowledge on wildlife resources in India. Further, the course will impart knowledge on anatomy, physiology, biogeography, habitat, diseases, and speciation of bird.

Learning outcomes: After successfully completing this course, the students will be able to understand the management and importance of wildlife. Further, the student will know about anatomy, physiology, habitat and identification of birds.

Theory

Unit 1 **15 Hours**

Census techniques in wildlife -Transect methods, point count methods, waterhole census method, Territory Mapping, Track count, dung count & Pugmark census; Tools for wildlife's study: Telemetry, camera trap, Geographical position System (GPS), Geographical Information System (GIS), and Remote Sensing (RS)-concept & application in wildlife;

Unit 2 **15 Hours**

Bird's anatomy- skeletal, respiratory, muscular, digestive, urinogenital, circulatory & nervous system; sense organs of birds; Avian flight-aerodynamics, power, maneuvering and stability; Bird's Physiology-thermoregulation, salt & water balance, counter current exchange, torpor, hyperthermia

Unit 3 **15 Hours**

Bird's vocal behaviours- Syrinx; development, production & significance of sound; Bird's foraging behaviour-diversity, stages of foraging, foraging guild, Bird's social & sexual behaviours- Pair bond & courtship, sexual selection and mating system, cost & benefits of social behaviour; Bird's migration- types, causes, flyways & navigation

Practical

Unit 4 **30 Hours**

1. Study of genital system of bird (Chicken or Japanese Quail)
2. Study of skeletal system of bird (Chicken or Japanese Quail)
3. Study area map generation using open source software QGIS
4. Importing of satellite imagery to QGIS from satellite imagery database
5. Exercise of tracking route record with GPS.
6. Pugmark study of various wildlife using cast
7. Exercise to install & data retrieval using camara
8. Exercise to locate an animal using Radio telemetry

Recommended Readings:

1. Goutam Kumar Saha & Subhendu Mazumdar (2022) : Wildlife Biology: An Indian Perspective (1st edition), PHI Learning Pvt Ltd, Delhi India.
2. H.R. Singh & Neeraj Kumar (2014): Ecology and environmental Science (8th (Reprint) edition, Vishal Publishing Delhi
3. Anthony R.E. Sinclair, John M Fryxell and Graeme Caughley (2014): Wildlife ecology, Conservation and management 3rd edition, Blackwell Publishing, USA.
4. Timothy E. Fulbright, David G. Hewitt (2007): Wildlife Science: Linking Ecological Theory and Management Applications (1st edition), CRC publishers, USA
5. S.E. Jorgensen (2011) Fundamentals of Ecological Modelling: Applications in Environmental Management and Research (4th edition), Elsevier Science Ltd, Netherland.
6. Irby,J., and John, W.F. (2016) Handbook of bird biology (3rd ed), Cornell Lab of Ornithology, USA
7. Noble, S.P and Patrick, J.L.(1993). Mannual of ornithology: Avian structure and function. Yale University

Semester VIII
Elective Course (DE)
ZOO-DE-4830- Aquaculture and Fish Biology–III

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provides various aspects on aquculture, its management and economic importance. Further, the course will provides detail knowledge on various cultivable species of fish, anatomy, reproductive physiology and foods of the fish.

Learning outcomes: After successfully completing this course, the students will be able to understand the management and economic importance of pisciculture. Further, the student will know about cultivable species of fish. Also, the student will be proficient in taxonomy and reproductive biology of fish.

Theory

Unit 1 **15 Hours**

Principle and procedure in molecular taxonomy of fish; Fish genomics and fish chromosome & karyotyping techniques ; Genetic markers in fish; Genetics techniques for brood stock management; Techniques of Hybridization in carps- Intergeneric , intraspecfic hybrid, Natural hybrids & Natural hybrids .

Unit 2 **15 Hours**

Fish population- Changes in gene and genotype frequencies; Inbreeding stress and genetic drift; Assessment of heritability & repeatability; Evaluation of ploidy status; Gynogenesis, androgenesis and induced polyploidy. Isolation of genomics DNA: Quantification and quality checking. Cloning and transgenesis in fish.

Unit 3 **15 Hours**

Phenomenon of sex reversal in fish; Carp milt cryo-preservation and significance; Fish immunology- basic concept, fish vaccine and immunization method; Disease diagnosis- Serological techniques, agglutination test . Genotoxicity assays-Micronucleus test & single cell gel electrophoresis; Probiotics for Aquaculture; Microbial Biofertilizer; Micro- algae; Use of sewage: Treatment, sewage fed aquaculture

Practical

Unit 4 **30 Hours**

1. Proximate biochemical analysis of fish protein, fat and carbohydrate and moisture contents
2. Experiment for commet assay and micronucleus test after pesticide exposure
3. Karyotyping of fish chromosome from carps and cat fishes
4. Haematological study using blood samples from carps-RBC, WBC counts, blood parasites
5. Barcoding and phylogeny study.

Recommended Readings

1. Anand, N. (1998) Indian Freshwater microalgae, Bishen Singh Mahendra Pal Singh, 23-A, New Connaught Place, Dehra Dun.
2. Darshan, A, S.K. Abujam & D.N. Das (2018) Biodiversity of Fishes in Arunachal Himalayan: Systematics, Classification, and Taxonomic identification, Elsevier, Academic Press, London, 270p.
3. Hoelzel, A.R. (1998) Molecular Genetic Analysis of Populations-A Practical Approach, IRL Press, Oxford University Press, Oxford,
4. Jadhav, U (2009) Aquaculture technology and Environment, PHI Learning Pvt Limited, New Delhi
5. NIIR Board of Consultants & Engineers (eds.,) Fisheries and Aquaculture Technology, Asia Pacific Business Press Inc, 106-E, Kamla Nagar, Delhi-07, 750p
6. Lee, C-S & E.M. Donaldson (1st eds., 2001) Reproductive Biotechnology in Finfish Aquaculture, Elsevier Science B.V, Amsterdam, The Netherlands, 320p.
7. Lutz C.C (2001) Practical Genetic for Aquaculture, Fishing News Books, Osney Mead, Oxford OX20EL, 25 John Street, London.
8. Redd P.V.G.K, S. Ayyappan, D.M. Thampy & G. Krishna (eds., 2005) Textbook of Fish Genetics and Biotechnology, ICAR, Krishi Anusandhan Bhawan-I, Pusa, New Delhi-12, 218p.
9. Purdom, C.E (1st Ed., 1993) Genetics and Fish Breeding, Chapman & Hall, London, UK, 277p
10. Dunham R.A (2004) Aquaculture and Fisheries Biotechnology: Genetics approaches, CABI Publishing CAB International, Wallingford, UK.

Semester VIII
Elective Course (DE)
ZOO-DE-4831- Cell and Molecular Biology–III

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: The course will develop an understanding of Microbiome studies, Stem cell research, Techniques in cellular processes, Molecular biology techniques, Genome sequencing, and Cloning.

Learning outcomes: The student will be able to understand about microbiome on the diverse communities of bacteria and viruses inhabiting various environments, stem cell & its uses, techniques in cellular processes involve a range of methodologies (confocal microscopy and flow cytometry etc), gene knockout procedures, CRISPR-Cas systems, and primer design for PCR, genome sequencing and PCR-based approaches, SDS-PAGE and protein structure.

Theory

Unit 1 **15 Hours**

Primer designing, Applications of genome sequencing, Role of PCR in cloning. Preparation of gene of interest for cloning, Vector preparation for cloning. Screening of transformants. SDS-PAGE and Protein screening, Protein structure, and Ramachandran plotting. Protein structure prediction and validation, Drug development; *in-silico*, *in-vitro* and *in-vivo* studies. Vaccine development

Unit 2 **15 Hours**

Stem cells: types, properties, application in modern biological research and medicine. Techniques in cellular process: Primary culture and cell lines, organoid culture, MTT assay, cancer lines, Cell freezing. National and global Cell repositories – ATCC, NCCS. Confocal and Atomic force microscopy, Flow cytometry, Microarray. Western blotting, Nucleic Acid Hybridization Assays. Gene knockout procedure, Cre-Lox P, CRISPR-Cas system, and generation of transgenic animal.

Unit 3 **15 Hours**

Introduction to microbiome: bacteria, viruses and fungi. Human microbiome: gut microbiome and their role in digestion and nutrition. Application of microbiome in treatment of diseases. Metagenomics; definition and principle of metagenomics, bacterial metagenomics of insect and role of bacterial metagenome in its biology.

Practical

Unit 4 **30 Hours**

1. Primer designing for gene amplification and gene cloning.
2. Sanger sequence analysis and screening through databases
3. Construction of phylogenetic trees for DNA and proteins.
4. Software to study protein structure.
5. DNA: isolation, quantitative estimation, digestion by restriction endonuclease, and separation by GEL electrophoresis.
6. Vector and insert ligation and PCR amplified product.
7. Metagenomic DNA isolation/data analysis.
8. Histochemical staining techniques (PAS, Feulgen, Sudan Black, Toluidine Blue, Gomori, Mucicarmine, Bielschowsky, DAPI, Alexa fluor, Rhodamine, DAB)
9. Popular Types of Fixatives used in Histopathology (Formalin,Zenker's, Bouin's, Carnoy's, Acetic acid, etc.)
10. Histological preparation of liver, kidney of Albino Mice
11. Immunohistochemistry: demonstration.

Recommended Readings:

1. Brown, T. A. (2016). Gene Cloning and DNA Analysis: An Introduction. 7th Ed. Wiley Blackwell.
2. Malacinski, G. M. (2003). Essentials of Molecular Biology. 4th ed. Jones and Bartlett.
3. W.H.Freeman.Karp, G. (2008). Cell and Molecular Biology: Concepts and experiments. John Wiley.
4. Lewin, B. (2008). Genes IX. Jones and Bartlett Publishers.
5. Twyman, R.M. (2003). Advanced Molecular Biology. Viva Books..
6. Watson et al., Recombinant DNA: Genes and Genomics – a short course, W. H. Freeman and Company, New York, USA
7. Papers published in "Nature, Science, Cell, Microbiome, Gut" and other journals

Semester VIII
Elective Course (DE)
ZOO-DE-4832- Entomology–III

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This applied entomology course delves into various aspects, including beekeeping, emerging areas in sericulture, the field of edible insects, insect transgenesis and pollination services Additionally, the course covers honey extraction, wax production, and the chemical composition of bee products.

Learning outcomes: By the end of this course, students will gain a deep understanding of beekeeping practices, including honey bee colony genetics and methods for effective hive management, fostering an appreciation for the vital role of bees in pollination services and ecosystem health, acquire practical knowledge and skills in honey extraction, wax production, and analysis of the chemical composition of bee products, enabling students to engage in the production and quality control of honey and related products.

Theory

Unit 1 **15 Hours**

Honey bee colony genetics and caste differentiation, Pollination services of bees and other insects. Beekeeping: Hive types and components, Hive placement and apiary setup, Beekeeping calendar and seasonal management, Supplementary diet for bee rearing; Honey bee diseases, parasites and predators and control measures, Mating and swarming of honey bees, Hypopharyngeal, mandibular and labial gland.

Unit 2 **15 Hours**

Honey Extraction and Processing, Wax gland cells and production of wax scales, honeycomb cell properties and comb construction, Chemical composition of honey, beeswax and propolis; honey and beeswax authenticity and quality control, Quality criteria standard of propolis; Sampling and processing of beeswax, resin and propolis, Biological activity and Health benefits of honey and propolis. Chemical profile of Royal jelly, Queen raising techniques.

Unit 3 **15 Hours**

Edible insects and their importance. Neutraceutical components in insects. Culture of edible insects. Lac insects. Silkworms and their cocoons. Diseases of silkworms. Chemical composition of silk proteins, Silk gland structure and regulation of silk protein gene; Uses of silk proteins, methods for extraction and purification of protein, DNA and RNA from insects. Insect transposable elements; Insect transgenesis-Methods and applications, Insect cell culture and insect cell lines.

Practical

Unit 4 **30 Hours**

1. Extraction of DNA/proteins from insects
2. Study of the structure of silk gland
3. Identification of bees and pollinators.
4. Identification of sugars in honey using TLC.
5. Study of hypopharyngeal gland of honey bees.
6. Identification and culture of edible insects.
7. Estimation of nutrients in edible insects

Recommended readings:

1. Diana, S. and Alphonse A. (2011). The Beekeeper's Handbook. Comstock Publishing Associates
2. Kim, F. (2005). The Backyard Beekeeper: An Absolute Beginner's Guide to Keeping Bees in Your Yard and Garden. Quarry Books.
3. Howland B (2009). Beekeeping For Dummies. John Wiley & Sons
4. Dadant & Sons (1976). The Hive and the Honey Bee: A New Book on Beekeeping to Succeed the Book Langstroth on the Hive and the Honey-Bee. Macmillan Pub Co.
5. Harry H. Laidlaw Jr. and Robert E. Page Jr. 1977. Queen Rearing and Bee Breeding. Wicwas Press" by
6. David, W. and Roger, C-K. (2010). Queen Bee: Biology, Rearing, and Breeding. Northern Bee Books
7. Mark L. Winston 1991. The Biology of the Honey Bee. Harvard University Press
8. Petra Ahnert (2015). Beeswax Alchemy: How to Make Your Own Soap, Candles, Balms, Creams, and Salves from the Hive. Quarry Books
9. Jürgen Tautz (2009). The Buzz about Bees: Biology of a Superorganism. Springer.
10. Paul H. Williams, Robbin W. Thorp, Leif L. Richardson, and Sheila R. Colla (2014). Bumble Bees of North America: An Identification Guide. Princeton University Press
11. Joseph S. W. and Olivia J. M. C. (2015). Bees in Your Backyard: A Guide to North America's Bees. Princeton University Press

Semester VIII
Elective Course (DE)
ZOO-DE-4833- Integrative Physiology–III

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provide various aspects on structural anatomy of endocrine organs and reproductive systems as well as integrative approach of its physiological functions among the vertebrates. Further, the course will provide detail knowledge on various hormones and its physiological role in organs' signalling system and physiology. Students will also get an understanding of Reproduction as endocrine regulatory functions of the system in vertebrates.

Learning outcomes: After successfully completing this course, the students will be able to understand the basic endocrine physiological and regulatory mechanism of integrative metabolic processes of cells and organs. Students will get hands on training on the method of study of reproductive aspects of organism and various instrument and methods of investigation.

Theory

Unit 1 **15 Hours**

Origin and development of pituitary in mammal. Comparative anatomy of hypophyseal gland , thyroid and adrenal in vertebrates- hormones in different vertebrate group. Hypothalamus and neuroendocrine cells in vertebrates, hypothalo-hypophyseal portal system. Evolutionary sequences of Oxytocin and vasopressin in vertebrates

Unit 2 **15 Hours**

Structure and functions of releasing hormones and tropic hormones. Mode of hormone release- episodic and pulsatile. Glycoprotein hormones: genetic variation and FSH heterogeinity. Structure and biosynthetic pathway of steroid hormones in mammals. Mechanism of hormone action- ligand receptor binding and signal transduction in target organs; Structure of G-Protein

Unit 3 **15 Hours**

Development of Gonad in mammals: hormonal and nonhormonal factors. Attainment of puberty and feedback regulation of hormones in mammals Female reproductive cycles (estrous/ menstrual)- hormonal regulation, ovulation. Growth of preimplantation embryo, mechanism of implantation, endometrial receptivity and decidual cell reaction. Epididymal protein and sperm maturation, Biochemical aspects of sperm capacitation and acrosome reaction

Practical

Unit 4 **30 Hours**

1. Dissection and demonstration of Endocrine glands in laboratory bred mice/rat.
2. Study of the permanent slides of all the endocrine glands.
3. Study of estrous cycle in laboratory bred mice/rat
4. Demonstration of Castration/ ovariectomy in laboratory bred mice/rat.
5. Estimation of plasma level of any hormone using ELISA.
6. Study of effects of steroid hormones on uterus and epididymis

Recommended readings

1. Turner, C. D. (1971) General Endocrinology, Pub- Saunders Toppan.
2. Nussey, S.S.; and Whitehead, S.A. (2001) Endocrinology: An Integrated Approach, Oxford: BIOS Scientific Publishers.
3. Hadley, M.E. and Levine J.E. (2007) Endocrinology (6th edition) Pearson Prentice-Hall, New Jersey.
4. David, O.N. (2013) Vertebrate Endocrinology.
5. Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press.
6. Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
7. Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd.
8. Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme.

SEMESTER-VIII
Department Elective (DE)
ZOO-MC-4834- Wildlife Biology and Ornithology-III

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the course: This course will provides various aspects on wildlife and its management. The course will also provide insight into ornithology Further, the course will provides detail knowledge on wildlife resources in India. The course will impart knowledge on anatomy, physiology, biogeography, diseases, speciation of bird.

Learning outcomes: After successfully completing this course, the students will be able to understand the management and importance of wildlife. Further, the student will know about anatomy, physiology, habitat and identification of birds.

Theory

Unit 1 **15 Hours**

Conservation-strategies & significanc; Wildlife sanctuaries, National Parks & Biosphere reserves in India; Captive breeding-importance, challenges & re introduction; Wildlife corridor- types & significance. Man-wildlife conflict – causes, consequences & mitigation; Project Tiger; Snow Leopard Project; Lion conservation project; Wildlife Protection Act, 1972; Biodiversity Act 2002; IUCN conservation categories; red data book.

Unit 2 **15 Hours**

Bird identification techniques, Bird's Breeding biology- nest (functions & types), egg (structure, size, colour & shape), clutch size, Incubation (concept, brood patch, Brooding, incubation period, Brood reduction), hatching (Altricial, precocial, nidicolous, nidifugous young); Parental care; Avian diseases & its control; threatened birds of Arunachal Pradesh

Unit 3 **15 Hours**

Bird's population-limiting factors & regulations of bird population, impact of climate change on bird population, metapopulation; Bird communities-diversity (alpha, beta gamma diversity), niche (concept, fundamental niche, realized niche & overlap), competitive exclusion principle, competition, brood parasitism, Mixed species flock; ecological services of birds, mist netting, species distribution modelling

Practical

Unit 4 **30 Hours**

1. Estimate the species richness and evenness of avian community in a habitat
2. Estimate the relative abundance of an avian community in a habitat
3. Study the types egg of the bird
4. Study the avian community composition using Mist netting
5. Enumerate and prepare age structure model of the population
6. Study the hair texture of wild animal
7. Visit a nearby National Park/Wildlife Sanctuary and study the bird diversity.
8. Estimate the birds using point count and line transect methods
9. Demonstration of basic of wildlife photography techniques.

Recommended Reading:

1. Goutam Kumar Saha & Subhendu Mazumdar (2022) : Wildlife Biology: An Indian Perspective (1st edition), PHI Learning Pvt Ltd, Delhi India.
2. H.R. Singh & Neeraj Kumar (2014): Ecology and environmental Science (8th (Reprint) edition, Vishal Publishing Delhi
3. Anthony R.E. Sinclair, John M Fryxell and Graeme Caughley (2014): Wildlife ecology, Conservation and management 3rd edition, Blackwell Publishing, USA.
4. Timothy E. Fulbright, David G. Hewitt (2007): Wildlife Science: Linking Ecological Theory and Management Applications (1st edition), CRC publishers, USA
5. S.E. Jorgensen (2011) Fundamentals of Ecological Modelling: Applications in Environmental Management and Research (4th edition), Elsevier Science Ltd, Netherland.
6. Irby,J., and John, W.F. (2016) Handbook of bird biology (3rd ed), Cornell Lab of Ornithology, USA
7. Noble, S.P and Patrick, J.L.(1993). Mannual of ornithology: Avian structure and function. Yale University

Semester VII
Minor Course (MC)-7
ZOO-MC-4710- Research and Publication Ethics

Marks	Credits	Contact hours
End semester exam: 80	Theory: 03	Theory: 45
Assignment/sessional exam: 20	Practical: 01	Practical: 30
Total: 100	Total: 04	Total: 75

About the Course: The course will enlighten the student on research and publication ethics, The course will provides information on various categories of journal, plagiarism and copyright.

Learning outcomes: Upon completion of this course, the student will be able to understand the ethics to publish and conduct research. Also, the student will have basic understanding of copyright, intellectual Property Right (IPR) etc.. Further, the student will know about plagiarism, software to check plagiarism and appropriate journal for publication.

Theory

Unit 1 **15 Hours**

Philosophy and ethics: Introduction to philosophy, definition, nature and scope; ethics: definition, moral philosophy, nature of moral judgements and reactions. Scientific conduct: ethics with respect to science and research, Intellectual honesty and research integrity, scientific misconduct, falsification, fabrication and plagiarism.

Unit 2 **15 Hours**

Publication ethics: definition, introduction and importance, best practices/standards setting initiatives and guideline: COPE, WAME etc. conflicts of interests, publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types. Innovation and creativity; concept and ethics

Unit 3 **15 Hours**

Open access publishing: Open access publications and initiatives, journal finder/journal suggestion tools viz. Elsevier journal finder, Databases and research metrics: Indexing databases, citation databases, UGC CARE, Web of science, Scopus, digital object identifier (DOI), impact factor, h-index and i10 index. Concept and types of Intellectual property rights (IPR). ISSN/ISBN, Copy right.

Practical

Unit 4 **30 Hours**

1. Detection of plagiarism using softwares like iThenticate or DrillBit of given document
2. Demonstration of software tools to identify predatory publications developed by SPUU
3. Demonstration of journal finder/journal suggestion tools viz. JANE, Elsevier Finder etc.
4. Calculation of h-index
5. Calculation of i10-index
6. Demonstration of process of applying for copy right, patents and GI tags.
7. Searching the research article, if listed in UGC CARE, Web of science and Scopus
8. Demonstration of referencing software

Recommended Readings:

1. Bora, Pranjal, Saikia, Jibon and Hazarika, Anil (2023). Research methodology, research and publication ethics, Notion press
2. Sing, Upendra Pratap, Ahlawal, Sakshi and Sharma, Shusma (2023). Research publications ethics. S. Chand & Sons
3. Hussain, Noushad (2024). Research and publication ethics: principles & practices. Shipra Publications

जंतु विज्ञान विभाग, राजीव गाँधी विश्वविद्यालय , रोनो हिल्स, दोइमुख,
DEPARTMENT OF ZOOLOGY, RAJIV GANDHI UNIVERSITY
RONO HILLS, DOIMUKH, ARUNACHAL PRADESH

No. RGU/ZOO/BOS/ 2023 **Dated 22nd April, 2024**

Acknowledgements

This course structure and credit framework for three years UG degree/ four years UG degree (honours without research)/ four year UG degree (honours with research) in zoology as per National Education Policy, 2020, has been prepared with the help of Dept. Draft Committee (DDC), Departmental Research Board (DRC) and Board of Studies (BoS), Department of Zoology.

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(Dr. Daniel Mize)
Head (i/c)