COURSE STRUCTURE AND CREDIT FRAMEWORK FOR ONE YEARS PG DEGREE/ TWO YEARS PG DEGREE IN ZOOLOGY

(As per National Education Policy, 2020)

Effective from the Academic Session 2024-25

DEPARMENT OF ZOOLOGY,
FACULTY OF LIFE SCIENCES, RAJIV GANDHI UNIVERSITY
RONO HILLS, DOIMUKH – 791112 , ARUNACHAL PRADES

Introduction

National Education Policy, 2020

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

Background of the department

Since the establishment in 1997, the department of Zoology is immensely contributing in imparting and generation of knowledge in the field of zoology. The department of Zoology was started in the year 1997 under the Faculty of Life Sciences (FLS) at Jawaharlal Nehru College Campus and it was shifted to old Academic building, Rajiv Gandhi University Campus in June,1999, then to, Life Sciences building in October, 2006 and finally will soon shift to Zoology building.

The department is offering course in Master of Science (M.Sc.) in Zoology as per National Education policy, 2020 (NEP-2020) course curricula pattern from the academic session 2024-2025. Besides, the department is offering Doctor of Philosophy (Ph.D.) in

Zoology from 2009 onwards. Currently, the intake capacity of the department is 32 (27+3+1+1) for M.Sc. and as per availability of seat for Ph.D. The admission to M.Sc. is through Rajiv Gandhi University Common Entrance Test (RGUCET) and Common University Entrance Test (CUET), and Ph.D. student is admitted through Rajiv Gandhi University Ph.D. Entrance Test (RGUPET) for Ph.D. Initially, for M.Sc., the department had implemented traditional course (Annual system of evaluation) from 1997 to 2000, Semester system from 2000-2015, Choice Based Credit (CBCS) from 2015- 2024 and NEP 2020 programme is being introduced in 2024-2025 session. Under NEP, the department is offering coursework in 1st & 2nd Semester and research in 3rd & 4th semester which is consist of 8 major courses, two minor courses, three departmental electives and one research (dissertation) for the PG programme. The doctoral programme is normally minimum of two years and maximum of six years with a mandatory Ph.D. course of one semester. To look after the programmes, at present, the department has strength of ten teachers/ faculty members which included three Professors, two Associate Professors and five Assistant Professors.

Apart from teaching, the department is also actively involved in the frontier areas of research via several extramural & intramural funded research projects. The faculty members is being funded with numerous major and minor research projects by extramural funding agencies like DST, DBT, MOEF & CC, NBFGR, RGNIYD and intramural funding by Rajiv Gandhi University as seed money research grant. The bee biology biochemistry of edible insects, fisheries and fish biology, molecular endocrinology, Neuroendocrinology, nutraceuticals and biomarker discovery, plant-pathogen interaction, molecular drug development and ornithology & Avian ecology are the thrust area of research in the department. Numerous articles are published in scopus, web of science etc indexed and UGC-CARE listed journals, and awarded Ph.D. in the aforementioned areas. The University Grants Commission UGC), New Delhi also recognized the department as Center with Potential for Excellence in Biodiversity (CPEB) since 2003, due to potential and prowess in the research activities.

Features of the New Curriculum Framework

The new curriculum framework will have the following features:

- Flexibility to move from one discipline of study to another.
- Flexibility for students who qualify UG with a double major to opt for any of the two subjects they have majored.

- Flexibility for students who qualify UG with a major and minor (s) to opt for either major or minor(s) subject in Master's programme.
- Opportunity for learners to choose the courses of their interest.
- Flexibility to switch to alternative modes of learning (offline, ODL, Online learning, and hybrid modes of learning).
- Mobility and flexibility as per the UGC (Establishment and Operation of Academic Bank of Credits in Higher Education) Regulations, 2021, and UGC Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions.

Assessment Strategy

There will be formative and continuous assessment. The scheme of assessment shall have components of these two types of assessments. Assessment have to have correlations with the learning outcomes that are to be achieved by a student after completion of the course. Therefore, the mode and system of assessments have to be guided by the learning outcomes.

Credit requirement and Eligibility for the Master's Programme:

A 4-year Bachelor's degree with Honours/ Honours with Research with a minimum of 160 credits for a 1-year/2-semester master's programme at level 6.5 on the NHEQF.

A 3-year/6-semester bachelor's degree with a minimum of 120 credits for a 2-year/4-semester Master's programme at level 6.5 on the NHEQF.

A student is eligible for a master's programme in a discipline corresponding to either major or minor(s) discipline in UG programme. In this case, the University can admit the students in the Master's programme based on the student's performance in the UG programme or through an entrance examination. However, irrespective of the major or minor disciplines chosen by a student in a UG programme, a student is eligible for admission in any discipline of Master's programmes if the student qualifies the National level or University level entrance examination in the discipline of the Master's programme.

Exit Point:

There shall be one exit point for those who join the M.Sc. programme, the student will be allow to exit only after completion of 40 credits course of the 1st Year . Student who exit at the end of 1st year shall be awarded a Postgraduate Diploma of the two year PG programme. The student who exited make re entry within three years period.

Award of PG Diploma PG Degree

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:

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

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 PG 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

NCrF Credit Level	Semester	Course Name	Course level	Credit	Total Credit
6.0	1st	Major 17: ZOO-CC-4710- Ecology	400	4	20
		Major 18: ZOO-CC-4720- Immunology	400	4	
		Major 19: ZOO-CC-4730- Biostatistics and Bioinformatics	400	4	
		Major 20: ZOO-CC-4740- Biological Techniques	400	4	
		Minor 7: ZOO-MC-4710- Research Methodology	500	4	
	2nd	Major 21: ZOO-CC-4810- Biochemistry: Basic concepts of metabolism	400	4	20
		Major 22: ZOO-DE-4810/4811/4812/4813/4814	500	4	
		Major 23: ZOO-DE-4820/4821/4822/4823/4824	500	4	
		Major 24: ZOO-DE-4830/4831/4832/4833/4834	500	4	
		Minor 8: ZOO-MC- 4810- Research and Publication Ethics	400	4	
Student exiting the programme after securing 40 credit will be awarded PG Diploma in the relevant discipline subject					
6.5	4th	Research project	500	40	40
	5th				

Course Structure for 2 years PG in Zoology

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	
6.0	1st	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													
	2nd	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													
Student exiting the programme after securing 40 credit will be awarded PG Diploma in the relevant discipline subject																
6.5	3rd 4th													**Research Project**	**40**	**40**
			32		**8**		**0**		**0**		**0**		**0**		**40**	**80**

Course Contents

Semester I
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 I
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 I
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.

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 I

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 I
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 II
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

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

Semester II
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,
10.

Semester II
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 II
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 II
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 integrative physiology of organism range from invertebrate to higher order mammal. It will provide detail knowledge on metabolism of carbohydrates, protein and lipid in cells and organs of animals in integrative manner, metabolic diseases, metabolic pathways and various instrument and methods of investigation.

Learning outcomes: After successfully completing this course, the students will be able to understand the metabolism of nutrients (carbohydrates, protein and fat). Further, the student will know about metabolic diseases, metabolic pathways and various instrument and methods of investigation.

Theory

Unit 1 **15 Hours**

Role of Biomelecules in physiology: Amino acids: Conversion of amino acids to specialized products and amphibolic intermediate: formation of urea, α-ketoglutarate, pyruvate and acetyle coenzyme A. Lactic acid cycle and glucose-alanine cycle. Amino acid metabolic disorder: Phenyle ketonuria. Intermediate metabolism of carbohydrate: energetic of carbohydrate oxidation, generation of high energy bonds in catabolism of glucose. Pentose phosphate pathway of carbohydrate metabolism, TCA cycle in transamination and gluconeogenesis; Amino sugars, glycoproteins and proteoglycans

Unit 2 **15 Hours**

Lipid molecules in plasma membrane: its structure and organization; mecelles, liposomes and emulsions. Plasma lipids and lipoproteins, LDL, HDL and VLDL. Methods for separation and identification of lipid in biological material, techniques of amino acid sequencing Saturated and unsaturated fatty acids, essential fatty acids, Cholesterol and Triglycerids, Liver function test (bilirubin, SGOT, SGPT, Alkaline Phosphatase).

Unit 3 **15 Hours**

Metabolism of purine and myrimidine nucleotide: Salvage reaction and formation of mononucleotide.Metabolic disorder: HMG-CoA and ketogenesis, acidosis. Metabolic disorder of purine metabolism. Concet of porphyrins and bile pigments, structure of heme; hemoproteins –its functions

Practical

Unit 4 **30 Hours**

1. Qualitative analysis of Carbohydrate, lipid and protein by spectroscopic method.
2. Separation of carbohydrate lipid and amino acids by paper/ thin layer chromatography
3. Estimation of haemoglobin.
4. Test of enzymes (SGOT, SGPT, alkaline phosphatise)
5. Qualitative/ quantitative study of Creatine, Cholesterol, LDL, HDL in serum using spectrophotometric method

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. Saunders Co.
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. XI Edition John Wiley &sons
8. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. &Wilkins.
9. Park, K. (2020). Preventive and social medicine, Bhanot Pub

SEMESTER-II
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 II
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 II
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 II
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 II
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-II
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, maneuverring 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. Georeferencing of Map using GIS
7. Pugmark study of various wildlife using cast
8. Exercise to install & data retrieval using camara trap
9. 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 II
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 II
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 II
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 II
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-II
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 & significance; 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. Estimate the birds using point count and line transect methods
8. Demonstration of basic of wildlife photography techniques.
9. Visit a nearby National Park/Wildlife Sanctuary and study the bird diversity.

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 II
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

SEMESTER-III & IV

Research Project related to one of the Department Electives of 40 credits.

Marks	**Internal Assessment**	**Marks: 20**	**End semester examination**	**Mark: 80**
	1st Presentation	20	Presentation on work	30
	2nd Presention		Dissertation submission	50
	3rd Presentation			

जंतु विज्ञान विभाग, राजीव गाँधी विश्वविद्यालय , रोनो हिल्स, दोइमुख,
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Sd/-
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