SIKKIM UNIVERSITY

(A Central University Established by an Act of Parliament of India, 2007)

LEARNING OUTCOME - BASED CURRICULUM

M.Sc. (ZOOLOGY) PROGRAMME

(With effect from Academic Session 2023-24)

DEPARTMENT OF ZOOLOGY

SIKKIM UNIVERISTY

6TH MILE, TADONG - 737102

GANGTOK, SIKKIM, INDIA

VICE-CHANCELLOR'S MESSAGE

Sikkim University stands at the forefront of embracing the transformative National Education Policy (NEP) 2020. In alignment with NEP 2020's vision and the guidelines of the Learning Outcomes-based Curriculum Framework (LOCF) mandated by the UGC, we have undertaken a comprehensive revision of our curriculum across all departments. This initiative ensures a holistic educational experience that transcends traditional knowledge delivery, emphasizing the practical application of knowledge in real-world scenarios.The shift towards LOCF marks a pivotal change from teacher-centric to learner-centric education, fostering a more active and participatory approach to learning. Our updated curriculum clearly defines Graduate Attributes, Programme Learning Outcomes (PLOs), and Course Learning Outcomes (CLOs), setting clear objectives for our students to achieve. This revision is designed to enable a teaching-learning environment that supports the attainment of these outcomes, with integrated assessment methods to monitor and encourage student progress comprehensively.

A key innovation in our curriculum is the mandatory integration of Massive Open Online Courses (MOOCs) through the SWAYAM platform, enhancing accessibility and the breadth of learning opportunities for students. Our approach encourages multidisciplinary studies through the curriculum while allowing for specialization. The curriculum embodies the policy's core principle of flexibility by enabling mobility for students, thereby allowing the exit and entry of students in the program.

I extend my heartfelt gratitude to our faculty, the Head of the Department, the Curriculum Development Committee members, the NEP coordinators, and the dedicated NEP Committee of Sikkim University for their relentless dedication to updating our curriculum. I appreciate Prof. Yodida Bhutia, the Chairperson, and all dedicated NEP Committee members for their thorough review and integration of LOCF and NEP components into our curriculum.

To our students, I convey my best wishes as we embark on this journey with our updated and inclusive curriculum, aiming not only to enrich their academic knowledge but also to nurture their personal growth, critical thinking, and ability to adapt and innovate in an ever-changing world.

Best wishes,

Prof. Avinash Khare
Vice Chancellor
Sikkim University

DEPARTMENT OF ZOOLOGY
Learning Outcomes Based Curriculum
M.Sc. ZOOLOGY PROGRAMME

PREAMBLE

The M.Sc. in Zoology programme at Sikkim University is a two-year programme designed for students who want to continue their higher studies. Candidates for the course must have completed a Bachelor's degree (B.Sc. or equivalent) from a recognized University with Zoology honours with Botany, Physiology, Chemistry, and related subjects as the general papers. The students will receive a Master of Science in Zoology from Sikkim University upon successful completion of the programme. The University's academic policies regarding the demands of the specific curriculum must be followed in order to award the degree in M.Sc. in Zoology. Both basic and advanced topics in Zoology is covered in the M.Sc. in Zoology program. It seeks to prepare the students for effective careers in academia, research, and other areas at the cutting edge of science and technology. The curriculum consists of both theoretical and practical components, and in addition, a dissertation is required to be completed to meet the requirements for the degree to be awarded. In order to help the students, a solid foundation in the fields of their study interest, a number of elective specialized courses are made available to them. The total number of credits needed to complete this programme is 84.

POST GRADUATE ATTRIBUTES

After completion of this programme the students will:

PGA 1: Have a strong sense of intellectual integrity and the ethics of scholarship.

PGA 2: Have the ability to demonstrate advanced independent critical enquiry and analysis, with an aptitude for continued self-directed learning.

PGA 3: Have in-depth knowledge in the subject of Zoology.

PGA 4: Achieve competency in scholarly writing, research or project activities, problem-solving and communication.

PGA 5: Be able to examine critically, synthesise and evaluate knowledge across a broad range of disciplines.

PGA 6: Have a set of flexible and transferable skills for different types of employment.

PGA 7: Be able to initiate and implement constructive change in the society and workplaces.

Programme Learning Outcomes:

At the end of the programme students will be able to:

PLO 1: Demonstrate a good command of fundamental and applied Zoology and its relationship to other disciplines.

PLO 2: Illustrate, design the various laboratory techniques and its applications in biology.

PLO 3: Develop the concepts of bio-systems, organization and evaluation.

PLO 4: Utilize the knowledge of policy and legislation related to animal science and ethics for practical application.

PLO 5: Demonstrate research aptitude, analyze data, interpret results, and prepare scientific documents.

PLO 6: Communicate effectively through written exams, reports, presentations, and participation in discussions.

PLO 7: Develop learning skills and research approach to solve problems of Zoology and related fields.

PLO 8: Distinguish and examine the various characteristics of faunal specimens for taxonomy and systematics.

PLO 9: Demonstrate skills in the usage of advanced methodology including computer-based software packages for learning and research.

COURSE STRUCTURE SHOWING COURSE TITLE AND CODE

COURSE CODE	COURSE TITLE
ZOO-C-501	Functional biology of Non-chordates, Chordates, Neurobiology, Animal Physiology, Endocrinology
ZOO-C-502	Biosystematics, Biodiversity, Restoration and Population Ecology
ZOO-V-503	Indian contribution to Animal Science
ZOO-P-504	Field based Zoological study
ZOO-P-505	Non-Chordates, Chordates, Ecology, Physiology
ZOO-S-506	Adolescent health and well-being/ Yoga and positive psychology/ Introduction to proteomics
ZOO-O-551	Cell Biology, Molecular Biology
ZOO-C-552	Genetics, Evolutionary Biology
ZOO-C-553	Developmental Biology, Fundamentals of Immunology, General Parasitology
ZOO-V-554	Cyber Security and Privacy
ZOO-P-555	Immunology, Genetics, Developmental Biology, Parasitology
ZOO-S-556	Basic course in ornithology/Remote sensing essentials/Basic course in ecotourism
ZOO-O-601	Biochemistry, Biotechnology
ZOO-C-602	Instrumentation biology, Biostatistics, Bioinformatics
ZOO-E-603	Applied Ecology, Climate Change Biology
ZOO-E-604	Immunology and Parasite & Vector Biology
ZOO-P-605	Techniques in Biology, Bioinformatics, Histology, Biochemistry
ZOO-P-606	Synopsis Preparation
ZOO-S-607	Research Methodology
ZOO-E-651	Biodiversity, Conservation Biology
ZOO-E-652	Cellular and Molecular Immunology
ZOO-E-653	Wildlife Biology, Animal Behaviour
ZOO-E-654	Advances in Parasitology
ZOO-P-655	Techniques in Biodiversity, Wildlife Biology, Animal Behaviour
ZOO-P-656	Techniques in Immunology and Parasitology
ZOO-R-657	Dissertation
ZOO-S-658	Statistical technique in biology.

COURSE STRUCTURE SHOWING L+T+P, CREDITS, CREDIT HOURS AND MARKS

SEMESTER I								
Course Code	**Title of the course**	**L**	**T**	**P**	**Total Credits**	**Total Marks**	**IA**	**EA**
ZOO-C-501	Functional biology of Non-chordates, Chordates, Neurobiology, Animal Physiology, Endocrinology	3	1	0	4	100	50	50
ZOO-C-502	Biosystematics, Biodiversity, Restoration and Population Ecology	3	1	0	4	100	50	50
ZOO-V-503	Indian contribution to Animal Science	3	1	0	4	100	50	50
ZOO-P-504	Field based Zoological study	0	0	2	2	50	0	50
ZOO-P-505	Non-Chordates, Chordates, Ecology, Physiology	0	0	4	4	100	50	50
ZOO-S-506	Adolescent health and well-being/ Yoga and positive psychology/ Introduction to proteomics	2	0	0	2	50	0	50
FIRST SEMESTER TOTAL					**20**	**500**	**200**	**300**
SEMESTER II								
ZOO-O-551	Cell Biology, Molecular Biology	3	1	0	4	100	50	50
ZOO-C-552	Genetics, Evolutionary Biology	3	1	0	4	100	50	50
ZOO-C-553	Developmental Biology, Fundamentals of Immunology, General Parasitology	3	1	0	4	100	50	50
ZOO-V-554	Cyber Security and Privacy	3	1	0	4	100	0	100
ZOO-P-555	Immunology, Genetics, Developmental Biology, Parasitology	0	0	4	4	100	50	50
ZOO-S-556	Basic course in ornithology/Remote sensing essentials/Basic course in ecotourism	2	0	0	2	50	0	50
SECOND SEMESTER TOTAL					**22**	**550**	**200**	**350**
SEMESTER III								
ZOO-O-601	Biochemistry, Biotechnology	3	1	0	4	100	50	50
ZOO-C-602	Instrumentation biology, Biostatistics, Bioinformatics	3	1	0	4	100	50	50

ZOO-E-603	Applied Ecology, Climate Change Biology	3	1	0	4	100	50	50
ZOO-E-604	Immunology and Parasite & Vector Biology							
ZOO-P-605	Techniques in Biology, Bioinformatics, Histology, Biochemistry	0	0	4	4	100	50	50
ZOO-P-606	Synopsis Preparation	0	0	2	2	50	0	50
ZOO-S-607	Research Methodology	2	0	0	2	50	0	50
THIRD SEMESTER TOTAL					**20**	**500**	**200**	**300**
SEMESTER IV								
ZOO-E-651	Biodiversity, Conservation Biology	3	1	0	4	100	50	50
ZOO-E-652	Cellular and Molecular Immunology							
ZOO-E-653	Wildlife Biology, Animal Behaviour	3	1	0	4	100	50	50
ZOO-E-654	Advances in Parasitology							
ZOO-P-655	Techniques in Biodiversity, Wildlife Biology, Animal Behaviour	0	0	4	4	100	50	50
ZOO-P-656	Techniques in Immunology and Parasitology							
ZOO-R-657	Dissertation	0	0	8	8	200	0	200
ZOO-S-658	Statistical Techniques in Biology	2	0	0	2	50	0	50
FOURTH SEMESTER TOTAL					**22**	**550**	**150**	**400**

DETAILED CURRICULUM
SEMESTER I
ZOO-C-501
Functional biology of Non-chordates and Chordates, Neurobiology, Animal Physiology and Endocrinology

Semester: First Semester	Course Level: 500	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 50 Hrs + Tutorial: 10 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: describe anatomical features of select non-chordate animals and their functions.
CLO 2: outline biosynthesis of insect hormones and their mode of action.
CLO 3: illustrate various anatomical and physiological adaptation of mammals to aquatic, cave and high-altitude environment.
CLO 4: explain the features of nervous system and its control on body functions.
CLO 5: discuss the mechanism of thermoregulation and interpret adaptation to heat and cold stress.
CLO 6: demonstrate the physiology of digestion, circulation, respiration and excretion in mammals.
CLO 7: give an overview about the endocrine glands and their functions.

UNIT I – FUNCTIONAL BIOLOGY OF NON-CHORDATES AND CHORDATES

Reproductive organs and life history of major crustaceans, decapods and echinoderms.

Defense mechanism in Mollusca.

Cephalization, Trend of neural evolution in non-chordates.

Thermoregulation – Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization,
high altitude adaptation in mammals, adaptation to heat and cold stress.

Echo location in bats, Circadian rhythm.

UNIT II –NEUROBIOLOGY

Nervous system in vertebrates: Central and peripheral nervous system, neurons, action potential, gross neuroanatomy of the brain and spinal cord, neural control of muscle function.

Sense organs in vertebrates: Vision, hearing and tactile response.

Types of neurotransmitters; Neurotransmission and its regulation in mammals.

UNIT III- PHYSIOLOGY

Physiology of digestion in humans: Digestion, absorption, energy balance, BMR.

Circulatory system in humans: cardiac cycle and its regulation, functions of blood and its components, haemopoiesis, blood pressure and its regulation.

Respiration: Neural and chemical regulation of respiration, physiological response to hypoxia and body exercise.

Excretory system: Urine formation in human, electrolyte balance, acid-base balance.

Osmoregulation: control of osmoregulation via ADH; Osmoregulation in aquatic and terrestrial animals.

UNIT IV –ENDOCRINOLOGY

Vertebrate endocrine system: concept of neurosecretion, neurosecretory centers; Hypothalamus, pineal and thymus and their hormones.

Synthesis and mode of action of steroid hormones, thyroid hormones and melatonin.

Hormone receptors: characteristics and types of receptors, membrane-bound and intra-cellular receptors, receptor recycling, signal transduction mechanism.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Viva-Voce, Group Discussion, Fish Bowl Technique, Quiz, Seminar.	Presentation, Seminars, Field Assignments, Poster Presentations.
Summative Marks: 50%	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings:

1. Gullan, P. J. & Crasnston, P. S. (2010) The Insects: An Outline of Entomology. Wiley Blackwell Publisher
2. Jordan, E. L. & Verma, P. S. (2022) Invertebrate Zoology. S Chand and Company Ltd.
3. Kardong, K. (2011) Vertebrates: Comparative Anatomy, Functions, Evolution, 6th edn. McGraw-Hill Science.
4. Price, P. W. (1997) Insect Ecology. Wiley Blackwell Publisher.
5. Pugh, Heifer & McFarland (1999) Vertebrate life. 4th End. Prentice-Hall of India, New Delhi.
6. Ruppert, E. E., Fox, R. S. & Barnes, R. D. (2004) Invertebrate zoology: a functional evolutionary approach, 7th edn. Belmont, CA: Thomas-Brooks.
7. Schmidt, R. F. & Thaws (1989) Human Physiology, (Eds.), 2nd edn. Springer-Vela, Berlin.

ZOO-C-502
Biosystematics, Biodiversity, Restoration and Population Ecology

Semester: First Semester	Course Level: 500	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 50 Hrs + Tutorial: 10 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: classify the organisms based on different taxonomic approaches.
CLO 2: comprehend the rules of International Code of Zoological nomenclature and able to name species and higher taxonomic categories.
CLO 3: identify the types of biodiversity, major threats to biodiversity and methods of conservation.
CLO 4: classify and compare the different ecological restoration techniques.
CLO 5: identify various invasive species and plan the methods of prevention and mitigation of invasion.

UNIT I - BIOSYSTEMATICS

Concept of alpha, beta and gamma taxonomy.
Species: supra and infra species categories, cryptic, polytypic and sibling species, apomictic and panmictic populations.
International Code of Zoological nomenclature: nomenclature at species and higher categories, type methods in taxonomy.
Phenetics, cladistics and evolutionary systematics.
Introduction to recent trends in biosystematics- chemo, sono and molecular taxonomy (DNA barcoding, use of genetic markers, determination of genetic distance).

UNIT II – BIODIVERSITY
Types of biodiversity: species, genetic and ecosystem.
Geographical level of biodiversity: local and regional diversity, β-diversity.
Commonly used biodiversity indices.
Introduction to global Hotspots of biodiversity; Biodiversity hotspots with reference to India.
IUCN threat categories, Major threats to biodiversity of the world.
In-situ and *Ex-situ* conservation: prospects and limitations.

UNIT III- RESTORATION ECOLOGY AND BIOLOGICAL INVASION
Restoration ecology: concept, historical perspectives, strategies; Plan and rehabilitation measures, success stories.
Forest fire: causes, impact, prevention, control, and post fire restoration of ecosystem.
Biological invasion: nature and status; Invasion process and hypothesis, Characteristics of invasive species; Impact, prevention and mitigation of invasion.

UNIT IV- POPULATION ECOLOGY
Population regulation: extrinsic and intrinsic mechanisms, oscillation, dispersal, competitive exclusion principle.
Intraspecific interactions and density dependence.
Interspecific interactions: commensalism, mutualism, ammensalism, competition and predation.
Community stability and disturbance.
Concept of metapopulations: theories and applications.
Life history strategy: *r*-selection, *k*-selection.
Life table, survivorship curves.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Viva-Voce, Group Discussion, Fish Bowl Technique, Quiz, Seminar.	Presentation, Seminars, Field Assignments, Poster Presentations.
Summative Marks: 50%	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Reading

1. Freeland, J. R., Kirk, H. & Petersen, S. (2011). Molecular Ecology. Willey-Blackwell.
2. Hosetti, B. B. (2005). Concepts in Wildlife Management. 2nd Revised & Enlarged edn, 2005. Daya Publishing House, Delhi.
3. Kato, M. (2000). The Biology of Biodiversity. Springer.
4. Kothari, A. S. & Chapgar. (2005). Treasure of Indian Wildlife, BNHS, Mumbai.
5. Mayr, E. & Ashlock, P. D. (2014). Principles of Systematic Zoology (second Edition). McGraw Hill Education.
6. Odum, E. P. (1983). Fundamentals of Ecology. Saunders, Philadelphia.
7. Ricklefs, R. E. & Miller, G. L. (1999). Ecology. W.H. Freeman & Company.
8. Simpson, G. G. (1990). Principles of Animal Taxonomy. Columbia University Press, New York.
9. Singh, J., Singh, S. P. & Gupta, S. R. (2017). Ecology, environmental Science & Conservation. S. Chand (G/L) & Company Ltd
10. Smith, R. L. & Smith, T. M. (2002). Ecology and Field Biology. Addison – Wesley Educational Publishers Inc.
11. Trigunayat, M. M. & Trigunayat, K. (2019). Introductory Biosystematics, Taxonomy. Scientific Publishers.
12. Wells, K. D. (2007). Ecology and Behaviour of Amphibians. The University of Chicago Press.
13. Wheeler, Q. D. (2008). The New Taxonomy. CRC Press, New York.

ZOO-V-503
Indian Contribution to Animal Science

Semester: First Semester	Course Level: 500	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: recognize the contribution made by Indian scientists in the field of animal sciences.
CLO 2: illustrate the importance of animals in the Indian society.
CLO 3: discuss the contribution of India on health and nutrition.
CLO 4: recognize the various methods used for conservation and management of indigenous breeds.

UNIT I- Animal and Indian society
Importance of animals in Indian society: animals in the ancient Indian text, cultural beliefs and faiths related to animals with reference to ethnic communities of northeast India.
Conservation approaches of animals in ancient and medieval India; cultural practices and animal conservation.

Unit II - Indian scientists and animal science
Contribution of scientist of ancient, medieval and modern India: Sushruta, Charaka, Vagbheta, Har Gobind Khorana, Lalji Singh, Salim Ali, Kailash Sankhala, G. N. Ramachandran, Raghavendra Gadagkar, G.P. Talwar, Indira Nath, Ullas Karanth.

UNIT III- India in the context of human health
Vaccines and antibiotics developed in India, Contribution of India for Polio free, Leprosy free world, indigenously developed insecticides, indigenously developed COVID 19 vaccines.
AYUSH and health sciences.

Unit IV-Indian contribution to animal husbandry
Development and conservation of indigenous animal breeds.
Blue and White revolution.
Traditional methods of treatment for livestock diseases.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Viva-Voce, Group Discussion, Fish Bowl Technique, Quiz, Seminar.	Presentation, Seminars, Field Assignments, Poster Presentations.
Summative Marks: 50%	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings

3. Acharya, R. M. (1982). Sheep and goat breeds of India. Food and Agriculture Organization of the United Nations.
4. Bala, P. (2007). Medicine and medical policies in India: Social and historical perspectives. Lexington Books.
5. Gupta, S. S., Nair, G. B., Arora, N. K., & Ganguly, N. K. (2013). Vaccine development and deployment: opportunities and challenges in India. Vaccine, 31, B43-B53.
6. Ivtzan, I., & Lomas, T. (Eds.). (2016). Mindfulness in positive psychology: The science of meditation and wellbeing. Routledge.
1. Krishna, N. (2010). Sacred animals of India. Penguin Books India. 2. Rubab, S. (2012). Philatelic Tribute to Indian Scientists.
7. Loukas, M., Lanteri, A., Ferrauiola, J., Tubbs, R. S., Maharaja, G., Shoja, M. M., Yadav, A. & Rao, V. C. (2010). Anatomy in ancient India: a focus on the Susruta Samhita. Journal of anatomy, 217(6), 646-650.
8. Madhavi, Y. (2005). Vaccine policy in India. PLoS medicine, 2(5), e127.
9. Rao, K. V. (2008). Immunology in India: An emerging story. Nature immunology, 9(12), 1319-1322.
2. Siddique, A. R., Singh, P., & Trivedi, G. (2016). Role of Social Mobilization (Network) in Polio Eradication in India. Indian pediatrics, 53.
10. Sthana, C. (2001). Charaka Samhita. Edited by: Acharya, J. T.

ZOO-P-504
Field Based Zoological Study

Semester: First Semester | Course Level: 500 | Total Marks: 50
L+T+P: 0 +0+2 = 2 Credits | Lecture: 0 Hrs + Tutorial: 0 Hrs + Practical: 60 Hrs

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: appreciate the importance of field-based study in understanding aspects of animal science.
CLO 2: develop skills for team work.
CLO 3: prepare field report based on the information collected from field and present the same as a seminar.

Course content
Students have to undertake short term field visits in zoologically important locations/sites under the supervision of teacher(s). Students have to collect the data on the theme provided to them by the teachers and prepare a report following standard format i.e., Introduction, Materials and Methods, Observation, Discussion and Conclusions. Students have to make a group presentation on their findings in the presence of faculties of the department.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Literature reading.
2. Field visits under the guidance of teacher.
3. Discussions on the findings.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Data recording.	Group Discussion.	Field visits, learning aptitude in the field.
Summative Marks: 50%	Report preparation and submission. Assessment of submission and presentation followed by viva voce. Assessment would be made based on the observation, writing and communication skill.		

ZOO-P-505

Non-Chordates, Chordates, Ecology, Physiology

Semester: First Semester | Course Level: 500 | Total Marks: 100
L+T+P: 0 +0+ 4= 4 Credits | Lecture: 0 Hrs + Tutorial: 0 Hrs + Practical: 120 Hrs

Course Learning Outcomes:
After completion of the course students will be able to:

- **CLO 1:** construct the identification keys of insects.
- **CLO 2:** understand the location and distribution of cranial nerves of chicken, structure of mouthparts of mosquitoes, pituitary gland of carp.
- **CLO 3:** identify the locally available species of mosquito, soil nematodes, common pests, life history stage of some insect species.
- **CLO 4:** estimate and interpret various physicochemical parameters of water.
- **CLO 5:** determine the glucose absorption by chicken gut, ascorbic acid, casein in milk,
- **CLO 6:** estimate Amino-N, ESR, blood platelets, blood glucose.

UNIT I – NON-CHORDATES

Identification of locally available mosquito species.
Mounting of mouthparts of mosquitoes.
Isolation and identification of soil nematodes.
Preparation of identification keys of insects.
Identification of some common pests found in agricultural farms of Sikkim.
Identification of life history stages of insects: mosquito, *Drosophila*.

UNIT II- CHORDATES

Identification of cranial nerves in chicken head.
Preparation of pituitary extract of carp.
Identification of spawn, fry and fingerling of fish.
Identification of important Himalayan vertebrates- Chinese pangolin, Eurasian Otter, Snow Leopard, Blue Sheep, Pika, Blood pheasant, Himalayan Griffon Vulture, Sikkim Grass Lizard, Himalayan Pit Viper, Mon Paa, Copper Mahseer

UNIT III – ECOLOGY

Water Analysis: estimation of total hardness, chloride, calcium, magnesium, phosphate, salinity, TDS.
Demonstration of limnological apparatus: Secchi disk, Jacksons candle turbidometer, Ekmann's grab.

UNIT IV – ANIMAL PHYSIOLOGY

Determination of glucose absorption by chicken gut.
Estimation of ascorbic acid in an unknown solution.
Estimation of casein content in milk.
Estimation of Amino-N by Sorenson's Formol Titration method.
Estimation of blood glucose during fasting and PP.
Estimation of ESR from human blood.
Enumeration of blood platelets using haemocytometer.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum demonstration.
2. Self-practice under the guidance of teacher.
3. Discussions on the results.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Laboratory notebook submission, Group or individual demonstration, field report submission.	Viva-Voce, Group Discussion.	Demonstrations, Field visit, Seminar.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested readings

1. Sinha, J., Chatterjee, A. K. & Chattopadhyay, P. (2011). Advanced practical zoology. Books and Allied (P) Ltd. Kolkata, India.
2. Verma, P. S., & Srivastava, P. C. (2015). Advanced Practical Zoology. S. Chand Publishing.

ZOO-S-506

Adolescent health and well-being/ Yoga and positive psychology/ Introduction to proteomics

Semester: First Semester	Course Level: 500	Total Marks: 50
L+T+P: 2+0+0 = 2 Credits	Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

As given in the MOOCS course:

1. Adolescent Health and Well-Being: (8 weeks MOOCS course).
2. Yoga and Positive Psychology for Managing Career and Life (8 weeks MOOCS).
3. Introduction to proteomics (8 weeks MOOCS).

[The students can opt for any one of the available courses based on their interest and should be of minimum eight weeks duration. The course content will be selected from the available MOOCS course and is subject to change over time]

SUGGESTED TEACHING LEARNING STRATEGIES

1. As per MOOCS for each course.

ASSESSMENT FRAMEWORK

Average assignment score = 25% of average of best 6 assignments out of the total 8 assignments given in the course.
Exam score = 75% of the proctored certification exam score out of 100.
Final score = Average assignment score + Exam score.

Suggested readings

As given in the MOOCS.

SEMESTER II
ZOO-O-551

Cell and Molecular Biology

Semester: Second Semester | Course Level: 500 | Total Marks: 100
L+T+P: 3+1+0 = 4 Credits | Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: explain the types, composition and organization of chromatin.
CLO 2: illustrate the mechanism of cellular communication, and cell cycle.
CLO 3: comprehend the genetic basis of cancer, and recognize the factors involved in cancer.
CLO 4: develop the concept of gene expression and their regulation.

UNIT I – CHROMATIN AND CELL CYCLE

Chromatin: types, chemical compositions, histones, molecular organization of nucleosomes, nucleoplasmin, chromatin to chromosomes, histone modifications, chromatin remodeling complex.
Cell cycle: cyclins and cyclin dependent kinases, cell cycle checkpoints.

UNIT II-CELLULAR COMMUNICATION AND CANCER BIOLOGY

Cellular communication: cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins.
Cancer: Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.

UNIT III- DNA EXPRESSION AND REPAIR

Transcription: mechanism of transcription- initiation, elongation and termination, sense and antisense strands, structural properties of RNA polymerases, RNA processing, RNA editing, RNA splicing.
Translation in prokaryotes and eukaryotes: initiation, elongation and termination, post translational modifications, Targeting and sorting of proteins.
DNA repair mechanisms.

UNIT IV-REGULATION OF GENE EXPRESSION

Prokaryotic gene expression: positive and negative control, lac operon in *E. coli*, tryptophan operon in *E. coli*, repression and attenuation, role of chromatin regulating gene expression and gene silencing.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Viva-Voce, Group Discussion, Fish Bowl Technique, Quiz, Seminar.	Presentation, Seminars, Field Assignments, Poster Presentations.
Summative Marks: 50%	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Reading

1. Abbas, A. K., Lichtman, A. H. & Pillai, S. (2014). *Cellular and molecular immunology E-book*. Elsevier Health Sciences.
2. Balasubramanian, D., Bryce, C. F. A., Dharmalingam, K., Green, J. & Jayaraman, K. Concepts in Biotechnology. Revised edition. University Press (India).
3. Chakravarty, A. K. (2003). Immunology II. N. L. Publishers.
4. Cooper, G. M. (2009). The Cell: A Molecular Approach. Sinauer Associates, Inc.
5. Glick, B. R., Pasternak, J. J. & Patten, C. L. (2010). Molecular Biotechnology: principles and applications of recombinant DNA. 4th Edition. ASM Press.
6. Karp, G. (2009). Cell & Molecular Biology Concepts and Experiment. Willey Blackwell Publisher.
7. Khan, F. H., (2009). The elements of immunology. Pearson Education India.
8. Lewin, B. (2007). Genes IX. Jones & Bartlett Publishers.
9. Owen, J. A., Punt, J., Stranford, S. A. & Jones, P.P. (2013). *Kuby immunology* (p. 574). New York: WH Freeman.

ZOO-C-552
Genetics, Evolutionary Biology

Semester: Second Semester | Course Level: 500 | Total Marks: 100
L+T+P: 3+1+0 = 4 Credits | Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 50 Hrs

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: comprehend gene mapping methods, and various aspects of genetics such as extra chromosomal inheritance, microbial genetics, transposable genetic elements and somatic cell genetics.
CLO 2: develop concept on application of genetics in understanding population and evolution.
CLO 3: built the idea of origin of unicellularity and multicellularity of eukaryotes.
CLO 4: debate on the trends of origin of higher categories.
CLO 5: relate Darwinism with Neo-Darwinism.
CLO 6: explain the various mechanism of genome evolution.

UNIT I – GENETICS

Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids.
Extra chromosomal inheritance: inheritance of mitochondrial and chloroplast genes, maternal inheritance.
Microbial Genetics: methods of gene transfers - transformation, transduction, conjugation, sexduction.
Transposable genetic elements in prokaryotes and eukaryotes: IS element, composite transposons, Tn3 element, mechanism of transposition, P element and hybrid dysgenesis in *Drosophila*, retrotransposons.
Somatic cell genetics: concept and applications, transfection of cells - principles and methods, cell fusion, hybridoma, applications of embryonic stem cells.

UNIT II – POPULATION GENETICS

Natural Selection: components of fitness, gametic selection, zygotic selection, models of selection (directional, stabilizing and disruptive).
Destabilizing forces influencing allele frequencies: mutation and estimation of mutation rates;
Inbreeding: inbreeding depression, inbreeding and heterozygosity.
Optimum phenotype and selection pressure, canalization, genetic homeostasis, genetic load and genetic death.
Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.
Founder principle, bottleneck effect and genetic drift as factors in speciation.

UNIT III – MICROEVOLUTION

Origin of eukaryotic cells; Evolution of unicellular eukaryotes.
Origin of multicellularity.
Genome Evolution: evolution of multigene family, acquisition of new genes - mechanisms and exon theory.
Concerted evolution.
Concept of molecular evolution: molecular clock and molecular drive, neutral hypothesis.

UNIT IV – MACROEVOLUTION

Macro evolution: concept, phylogenetic gradualism, punctuated equilibrium.
Major trends in the origin of higher categories.
Isolation mechanisms and their role in evolution; Implication of geographical distribution for modes of speciation.
Human evolution.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Viva-Voce, Group Discussion, Fish Bowl Technique, Quiz, Seminar.	Presentation, Seminars, Field Assignments, Poster Presentations.
Summative Marks: 50%	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested readings

1. Cooper, G. M. (2009). The Cell: A Molecular Approach. Sinauer Associates, Inc.
2. Freeland, J. R., Kirk, H. & Petersen, S. (2011). Molecular Ecology. Willey-Blackwell
3. Futuyama, D. J. & Kirkpatrick, M. (2017). Evolution, 4th Edition. Sinauer Associates, Inc., Sunderland, U.S.A.
4. Gardner, E. J., Simmons, M. J. & Snustad, D. P. (2000). Principles of Genetics. John Wiley & Sons.
5. Graur, D. & Li, W-H. L. (2000) Fundamentals of Molecular Evolution, 2nd Ed., Sinauer Associates.
6. Griffiths, A. J. F., Wessler, S. R., Carroll, S. B. & Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman Publisher.
7. Hartwell, L. (2010). Genetics: From Genes to Genomes. McGraw-Hill.
8. Karp, G. (2009). Cell & Molecular Biology Concepts and Experiment. Willey Blackwell Publisher.
9. Pierce, B. A. (2010). Genetics: A Conceptual Approach. W. H. Freeman Publisher.
10. Strickberger, M. W. & Hallgrimsson, B. (2013). Strickberger's Evolution (5th Edition). J. Jones and Bartlett Publishers, Inc.
11. Strickberger, M. W. (2015). Genetics. Pearson Education India.

ZOO-C-553
Developmental Biology, Fundamentals of Immunology, General Parasitology

Semester: Second Semester	Course Level: 500	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: illustrate the developmental processes in animals including molecular mechanism.
CLO 2: demonstrate basic knowledge of the organization and function of the immune system.
CLO 3: describe major historical events in the development of immunology.
CLO 4: differentiate innate and adaptive immunity in terms of components and type of immune response.
CLO 5: describe the mechanisms used by the body to defend itself in an innate and adaptative immune response.
CLO 6: outline the concept the parasites, their life cycle and mechanism of pathogenicity.

UNIT I – FERTILIZATION AND EARLY EMBRYONIC DEVELOPMENT

Fertilization: Molecular mechanism to block polyspermy, activation of egg metabolism, fusion of genetic material.

Cleavage: characteristics, plane and patterns of cleavage; Mechanism and products of cleavage; types of blastulae.

Gastrulation and formation of germinal layers; Gastrulation in amphibians; Concept of organizer, induction and competence.

UNIT II – DEVELOPMENT AND AGEING

Morphogenesis in animals: axes and pattern formation in *Drosophila*, frog, and chick.

Organogenesis: vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis.

Nuclear transplantation experiments and genomic equivalence.

Programmed cell death, aging and senescence.

UNIT III–GENERAL IMMUNOLOGY

Humoral and cell-mediated immune responses, primary and secondary immune response.

Antigen: physical and chemical nature, general properties of antigens, superantigens, haptens, adjuvants, antigenicity and immunogenicity, antigen processing and presentation.

Immunoglobulin structure: CDR/hypervariable region, framework region, biological and physical properties; Antibody subclass, isotype, allotype, idiotype; Antibody mediated effector functions.

Cells of immune system: lymphoid and myeloid lineages. B and T cell receptors.

B and T cell activation and differentiation.

UNIT IV – GENERAL PARASITOLOGY

General characters and classification of parasitic protozoans and helminths.

Parasitic adaptations in protozoans and helminths.

Distribution, life cycle and pathogenicity of medically important protozoans and helminth parasites of man - *Naegleria*, *Giardia*, *Toxoplasma, Paragonimus, Diphyllobothrium*, soil-transmitted helminths, filarial worms.

Plant parasitic nematodes: diversity and host-parasite relationship.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Group Discussion, Fish Bowl Technique, Quiz, Seminar.	Presentation, Seminars.
Summative Marks: 50%	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested readings

1. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2021). Cellular and Molecular Immunology, -South Asia Edition-E-Book. Elsevier Health Sciences.
2. Abbas, A., Lichtman, A., & Pillai, S. (2014). Cellular and molecular immunology E-book. Elsevier Health Sciences.
3. Balinsky, B. I. (1970). An Introduction to Embryology, Saunders, New York.
4. Berrill, N. J. (1974). Developmental Biology. Tata McGraw-Hill.
5. Cheng, T. C. (2012). General Parasitology, 2nd edn. Elsevier.
6. Cox, F. E. G. (1993). Modern Parasitology: A Text Book of Parasitology, 2nd edn. John Wiley & Sons.
7. Gilbert, S. F. (2013). Developmental Biology, 10thedn. Sinauer Associates Inc.
8. Khan, F. H. (2009). The elements of immunology. Pearson Education India.
9. Owen, J. A., Punt, J., Stranford, S. A., & Jones, P. P. (2013). Kuby immunology (p. 574). New York: WH Freeman.
10. Roberts, L. S., Janovy, J. & Nadler, S. (2013) Foundations of Parasitology, 9th edn. McGraw-Hill.
11. Smyth, J.D. & Wakelin, D. (1994) Introduction to Animal Parasitology, 3rd edn. Cambridge University Press, London.
12. Soulsby, E. J. L. (2004). Helminths, Arthropods and Protozoa of Domesticated Animals, 7th edn. Elsevier.
13. Subramoniam, T. (2011). Molecular Developmental Biology. Alpha Science International.
14. Wolpert, L. (2011). Principles of Development. Oxford University Press.

ZOO-V-554
Cyber Security and Privacy

Semester: Second Semester	Course Level: 500	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: describe the concepts, technologies, practices and challenges associated with cybersecurity.
CLO 2: illustrate and develop a wholesome understanding about cyber security and privacy risks covering
governance, compliance and risk mitigation.
CLO 3: explore cyber security along with information privacy and apply the same in personal data security.

Course layout

Foundations, cyber security, information security and related concepts, Principles of information security management, Confidentiality, Integrity, Availability and related concepts.

Security management, Governance, Risk and Compliance (GRC), Contingency planning, incidence response, disaster recovery and business continuity.

Understanding security policy, security behaviour, Risk management: Risk identification, threat modelling, strategies.

Control strategies and protection mechanisms (Guest lecture), Cryptography for security.

Information security and privacy, Regulatory landscape: Fair information practices, US regulatory frameworks.

Regulatory landscape: EU's GDPR and its implications and other privacy and cyber security regulations, Cyber security and privacy in the Indian context, evolution and issues.

Economics of privacy, privacy calculus and trade-offs, privacy paradox, Managing stakeholders, making choices on security and privacy.

[The students can opt for the course from the MOOCS subject to availability]

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings.
2. Video lectures, assignments.
3. Standard books and articles.

ASSESSMENT FRAMEWORK

Average assignment score = 25% of average of best 8 assignments out of the total 12 assignments given in the course.
Exam score = 75% of the proctored certification exam score out of 100.

Suggested readings

1. Acquisti, A., John, L. K., & Loewenstein, G. (2013). What is privacy worth? The Journal of Legal Studies.
2. Arce, I. et al. (2014). Avoiding the top 10 software security design flaws. IEEE Computer Society Centre for Secure Design (CSD).
3. Darktrace, "Technology" https://www.darktrace.com/en/technology/#machine-learning, accessed November 2018.
4. Johnston, A. C. & Warkentin, M. (2010). Fear appeals and information security behaviours: An empirical study. MIS Quarterly.
5. Smith, H. J., Dinev, T., & Xu, H. (2011). Information privacy research: an interdisciplinary review. MIS Quarterly.
6. Subramanian, R. (2010). Security, privacy and politics in India: a historical review. Journal of Information Systems Security (JISSec).
7. Van Kessel, P. Is cyber security about more than protection? EY Global Information Security Survey 2018-2019.
8. Whitman, M. E. & Mattord, H. J. (2018). Principles of Information Security, 6th edn, Cengage Learning, N. Delhi.
9. Xu, H., Luo, X. R., Carroll, J. M. & Rosson M. B. (2011). The personalization privacy paradox: An exploratory study of decision making process for location-aware marketing. Decision Support Systems.

ZOO-P-555

Immunology & Cell Biology, Genetics, Developmental Biology, Parasitology

Semester: Second Semester	Course Level: 500	Total Marks: 100
L+T+P: 0+0+4 = 4 Credits	Lecture: 0 Hrs + Tutorial: 0 Hrs + Practical: 120 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: demonstrate polytene chromosome from Chironomus larva and barr body from human buccal swab.
CLO 2: prepare the serum and plasma and lymphocytes from whole blood.
CLO 3: solve the problems related to abo blood group frequency.
CLO 4: identify the wild type and mutant form of *Drosophila.*
CLO 5: perform isolation and identification of chick embryo.
CLO 6: identify endocrine glands, histological sections, and parasites with reasons.
CLO 7: present a seminar on a given topic.

UNIT I – IMMUNOLOGY & CELL BIOLOGY

Collection of plasma and serum, separation and preparation of lymphocytes from the whole blood sample by ammonium chloride method, viability test of separated lymphocytes.
Barr body preparation from human buccal swab.
Preparation and staining of polytene chromosomes from chironomous/*Drosophila* larva.

UNIT II – GENETICS

Determination of allelic frequency and genotype frequency of ABO blood group.
Human leukocyte culture and Human chromosome karyotyping, analysis of some common Human chromosomal aberrations.
Drosophila genetics: study of various types of *Drosophila* mutants.

UNIT III – DEVELOPMENTAL BIOLOGY AND PARASITOLOGY

Preparation of developmental stages of chick embryo.
Display of endocrine glands in laboratory bred animals.
Histological study of endocrine glands (thyroid, adrenal, testis and ovary).
Identification with reasons of permanent mounts of protozoans, trematodes and cestodes viz. *Plasmodium, Leishmania, Polystoma, Paramphistomum, Gastrothylax, Fasciola, Fasciolopsis, Schistosoma, Clonorchis, Paragonimus, Taenia, Railletina, Cotugnia, Echinococcus, Diphyllobothrium, Dipylidium, Hymenoplepis, Gyrocotyle.*

UNIT IV – TERM PAPER PREPARATION AND PRESENTATION

Students have to prepare a term paper on any topic related to the subject in consultation with faculty members. Every student has to present a 10 minutes duration seminar on the topics chosen.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum demonstration.
2. Self-practice under the guidance of teacher.
3. Discussions on the results.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Laboratory notebook submission, Group or individual demonstration, field report submission.	Viva-Voce, Group Discussion.	Demonstrations, Field visit, seminar.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested readings

1. Cochet, O., Teillaud, J. L. & Sautes, C. (1998). Immunological techniques made easy. Wiley.
2. Ghosh, K. C., Manna, B. (2011). Practical Zoology 3rd edition. New Central Book Agency.
3. Hudson, L., Hay, F. C., & Hudson, L. (1989). Practical immunology (Vol. 3). Oxford: Blackwell scientific publications.
4. Sinha, J., Chatterjee, A. K., Chattopadhyay, P. (2011). Advanced practical zoology. Books and Allied (P) Ltd. Kolkata, India.

ZOO-S-556

Basic course in ornithology/Remote Sensing and GIS /Basic course on ecotourism

Semester: Second Semester	Course Level: 500	Total Marks: 50
L+T+P: 2+0+0 = 2 Credits	Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:
As provided in MOOCS:

BASIC COURSE IN ORNITHOLOGY

(8 weeks MOOCS course).

REMOTE SENSING AND GIS
Remote Sensing Data and Corrections.

Satellite Image Corrections.

Digital Image Processing.

Thermal and Microwave.

Imaging Spectroscopy.

GIS and Application.

BASIC COURSE ON ECOTOURISM

(As per MOOCs)

SUGGESTED TEACHING LEARNING STRATEGIES
As per MOOCS.

ASSESSMENT FRAMEWORK
Average assignment score = 25% of average of best 6 assignments out of the total 8 assignments given in the course.
Exam score = 75% of the proctored certification exam score out of 100.
Final score = Average assignment score + Exam score.

[The course content will be selected from the available MOOCS course and is subject to change over time]

Suggested readings

1. Lillesand, T. M. & Kiefer, R.W. (1987). Remote sensing and Image Interpretation, John Wiley.
11. Rencz, A.N. (2008). Remote Sensing for the Earth Sciences, Manual of Remote Sensing, 3, ASPRS, 703p.
12. De Jong, S. M., & Van der Meer, F. D. (2004). Remote Sensing Image Analysis: Including the Spatial Domain: Including the Spatial Domain, 5, Springer, 359p.
13. Claudia, K. & Stefan, D. (2014). Quantitative Remote Sensing in Thermal Infrared, 11, Springer, 281p.
2. Jensen, J. R. (1986). Introductory digital image processing a remote sensing perspective, Prentice Hall series in geographic information science.
3. Schowengerdt, R. A. (2007). Remote Sensing: Models and Methods for Image Processing, Academic Press.
4. Campbell, J. B. (1996). Introduction to Remote Sensing, Taylor & Francis, London.
5. Cracknell, P. (2007). Introduction to remote sensing, CRC Press.
6. Jensen, J. R. (2003). Remote Sensing of the Environment an Earth Resource Perspective, Pearson Education, Delhi.

7. Joseph, G. (2003). Fundamentals of Remote Sensing, University press.
8. Gupta, R. P. (2005). Remote Sensing Geology, Springer.
9. Van der Meer, F. D. & De Jong, S. M. (2006). Imaging spectrometry: Basic principles and prospective applications, Springer Publishers (The Netherlands), 451p.

SEMESTER III
ZOO-O-601
Biochemistry, Biotechnology

Semester: Third Semester	Course Level: 600	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: describe the various biochemical processes.
CLO 2: understand the enzyme kinetics.
CLO 3: illustrate about the various biotechnological processes.

UNIT I – BIOENERGETICS

Principles of glycolysis with regulation, citric acid cycle with regulation, glycogenolysis, gluconeogenesis, HMP-shunt pathway; amino acids: transamination and deamination reactions; oxidative phosphorylation in mitochondria, β-oxidation of fatty acids.
Protein structure, Ramachandran plot.

UNIT II – ENZYMOLOGY

Introduction to enzymes, classification, structure and properties, energetics of enzyme-catalyzed reaction, effects of different physico-chemical factors on enzyme activity. Enzyme kinetics: Michaelis-Menten equation and its derivation, Lineweaver-Burk plot, significance of Km, simple calculation on enzyme kinetics; Inhibition of enzyme, allosteric enzyme, isoenzyme, ribozyme.

UNIT III – RECOMBINANT DNA TECHNOLOGY

Genomic and cDNA libraries: construction and screening; Expression of vectors and expression of fusion proteins; Transgenic Animals: production, prospects, advantages and disadvantages; Site directed mutagenesis: strategies and prospects.
Gene editing: methods and applications.
Application of recombinant DNA technology in human gene therapy and vaccine development
Microbial synthesis of commercial products: restriction endonucleases and antibiotics.

UNIT IV- ENVIRONMENTAL BIOTECHNOLOGY

Biosensors for the detection of pollutants; bioremediation of soil and water; pollution through natural and genetically engineered micro-organisms.
Concept of environmental metagenomics.
Environmental bioremediation and biotransformation.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Viva-Voce, Group Discussion, Fish Bowl Technique, Quiz, Seminar.	Presentation, Seminars, Field Assignments, Poster Presentations.
Summative Marks: 50%	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings

1. Berg, J. M., Tymoczko, J. L. & Stryer, L. (2002). Biochemistry. W. H. Freeman & Company.
2. Botham, K. M., McGuinness, O., Weil, P. A., Kennelly, P. J. & Rodwell, V. W. (2012). Harpers Illustrated Biochemistry. McGraw-Hill Medical.
3. Cooper, G. M. (2009). The Cell: A Molecular Approach. Sinauer Associates, Inc.
4. De Robertis, E. D. P. (2006). Cell & Molecular Biology. Lippincott Williams and Wilkins.
5. Glick, B.R. & Patten, C. L. (2022). Molecular Biotechnology: principles and applications of recombinant DNA. 6th Edition. ASM Press.
6. Jördening, H. J. & Winter, J. (2004) Environmental Biotechnology: Concepts and Applications. John Wiley & Sons.
7. Mathews, C. K., van Holde, K. E., Appling, D. R. & Anthony-Cahill, S. J. (2012). Biochemistry. Prentice Hall Publisher.
8. Murray, R. K., Bender, D., Botham, K. M., Kennelly, P. J., Rodwell, V. W. & Weil, P. A. (2012). Harper's Illustrated Biochemistry (26th ed), Appleton and Lange.
9. Nelson, D. L. & Cox, M. M. (2008). Lehninger Principles of Biochemistry. W.H. Freeman & Company.
10. Rittmann, B. E. & McCarty, P. L. (2020) Environmental Biotechnology: Principles and Applications. McGraw-Hill.
11. Zubay, G. (1999). Biochemistry. William C Brown Publishers.

ZOO-C-602

Instrumentation Biology, Biostatistics, Bioinformatics

Semester: Third Semester	Course Level: 600	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:
After completion of the course students will be able to:

CLO 1: describe the principles of biophysical techniques.
CLO 2: comprehend the different biostatistical tests and methods.
CLO 3: illustrate about the various bioinformatics techniques.

UNIT I – MICROSCOPY & SPECTROSCOPIC TECHNIQUES

Microscopy: General concept, phase-contrast microscopy, scanning microscopy, transmission electron microscopy.

Fixation and staining techniques for electron microscopy, freeze-etch and freeze-facture technique.

Spectroscopic techniques: UV-visible spectroscopy, spectrophotometer, spectrofluorometer, circular dichroic spectroscopy, nuclear magnetic resonance (NMR), Magnetic Resonance Imaging (MRI), electron spin resonance (ESR), mass spectrometry, X-ray crystallography, surface plasmon resonance spectroscopy.

UNIT II –MOLECULAR BIOLOGY & RADIOISOTOPE TECHNIQUES

Electrophoresis: basic principles, polyacrylamide gel electrophoresis, isoelectrofocussing, agarose gel electrophoresis.

DNA sequencing methods, Fluorescence in situ hybridization (FISH), RFLP, RAPD, AFLP technique.

Radioisotope techniques: radioactivity and half-life, radioisotopes, G-M counter, solid and liquid scintillation counter, applications of radioisotopes, incorporation of radioisotopes in biological tissues and cells, Positron Emission Tomography (PET), safety guidelines.

UNIT III- BIOSTATISTICS

Probability distribution: concept, normal, binomial and Poisson's distribution.

Concept of hypothesis testing.

Statistical tests: correlation and regression analyses, student's "t" test (paired and unpaired), Chi-square test, Mann-Whiteny 'U' Test, Introduction to ANOVA.

Mathematical modelling: concept; different types of models – empirical, mechanistic, stochastic, deterministic. Application of different model types.

Basic introduction to multivariate statistics.

UNIT IV – BIOINFORMATICS

Introduction to Bioinformatics resources: tools and databases.

Sequence analysis: basic concepts of sequence similarity, identity and homology, homologues, orthologues, paralogues; Sequence-based database searches: BLAST and FASTA.

Pairwise and multiple sequence alignments: basic concepts of sequence alignment.

Phylogeny: phylogenetic analysis, definition, description and method of construction of phylogenetic trees.

Current advancements in bioinformatics.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Group Discussion, Fish Bowl Technique, Quiz.	Presentation, Seminars.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested reading

1. Attwood, T. K. (1999). Introduction to Bioinformatics. Pearson Education.
2. Boyer, R. F. (2001). Modern Experimental Biochemistry, 3rd Edition. Pearson Education
3. Higgs, P. G. & Attwood, T. K. (2013). Bioinformatics and Molecular Evolution. John Wiley & Sons.
4. Jørgensen, S. E. (2009). Fundamentals of Ecological Modelling, WIT Press.
5. Kumar, P. (2016). Fundamentals and Techniques of Biophysics and Molecular Biology. Pathfinder Publication.
6. Narayanan, P. (2007). Essentials of Biophysics. New Age International Publishers,
7. Primrose, S. B. & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Seventh Edition. Blackwell Publishing.
8. Rejeswari, M. R. (2013). An Introduction to Biophysics. Rastogi Publications.
9. Sharma, A. K. (2005). Text Book of Biostatistics. Vol. I. Discovery Publishing House.
10. Sokal, R. R. & Rohlf, F. J. (1994). Biometry: The Principles and Practices of Statistics in Biological Research. W. H. Freeman.
11. Xiong, J. (2006). Essential Bioinformatics. Cambridge University Press.

ZOO-E-603
Applied Ecology, Climate Change Biology

Semester: Third Semester	Course Level: 600	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: comprehend the concept of ecological niche and community assembly.
CLO 2: understand ecological energetics, ecosystem services and sustainable development.
CLO 3: analyse the impacts of climate change on natural and human modified systems.
CLO 4: appreciate the measures taken for mitigating climate change and its impacts.

UNIT I – ECOLOGICAL NICHE, COMMUNITY ASSEMBLY

Development of niche concept, niche width, niche overlap, diffuse competition, niche dynamics, ecological equivalents, character displacement, sympatry and allopatry; Concept of ecological niche modelling.
Unified Neutral theory, Niche and dispersal assembly theories, island biogeography model.

UNIT II – SYSTEMS ECOLOGY AND SUSTAINABLE DEVELOPMENT

Energy flow in ecological systems; Measuring ecosystem productivity, patterns in primary production.
Ecosystem services: overview, valuation.
Millennium Ecosystem Assessment: framework and synthesis.
Sustainable Development: principles, sustainability indicators, Sustainable development goals; Introduction to millennium development goals; Green economy; Environmental performance index.

UNIT III – CLIMATE CHANGE: CAUSES AND INITIATIVES

Greenhouse gases and greenhouse effect, ozone layer depletion and ozone depleting substances.
Introduction to UNFCCC.
Introduction to Intergovernmental Panel on Climate Change (IPCC).
Carbon trading, carbon footprint, concept of REDD (reducing emission through destruction and deforestation)
Concept of Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs)
El niño, La niña, southern oscillation and their ecological impact.

UNIT IV – IMPACT OF CLIMATE CHANGE

Impact on the physical environment: glacial melt including glacial retreat in the Himalaya, sea level rise, glacial lake outburst flood (GLOF), changes in rainfall and temperature patterns, snow fall events, ocean warming and acidification, carbon sequestration.
Impact on the faunal characteristics: species range shift, species migration, species extinction, changes in phenology and altered breeding pattern of animals (butterflies, herpetofauna, birds and mammals), changes in insect emergence pattern and effect on food chain, infestations of diseases and crop pests; coral reef bleaching.
Vulnerability assessment, resilience and adaptation of species.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Group Discussion, Fish Bowl Technique, Quiz.	Presentation, Seminars.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested readings

1. Begon, M. & Townsend, C. R. (2021). Ecology: From Individuals to Ecosystems. Wiley publishers.
2. Clarke, G. L. (2006). Elements of Ecology. John Wiley & Sons, Inc. New York.
3. Giller, P. S. (1984). Community Structure and the Niche. Chapman & Hall, London
4. Hannah, L. (2015). Climate Change Biology. Academic press, Elsevier
5. Henson, R. (2011). The Rough Guide to Climate Change. Rough Guides Publisher.
6. Hussain, M. (2013). Environment and Ecology: Biodiversity, Climate Change and Disaster Management. Access Publishing House.
7. IPCC (2022) Sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, United Kingdom.
8. Kaur, R. (2014). General Issues on Environment, Biodiversity and Climate Change. New Vishal Publication.
9. Kondratyev, K. Y. & Krapivin, V. F. (2014). Global Carbon Cycle and Climate Change. Springer publications.
10. Lovejoy, T. E. & Hannah, L. (2005). Climate Change and Biodiversity. Yale University Press, New Haven.
11. Newman, J. A., Anand, M., Henry, H. A. L. & Hunt, S. L. (2011). Climate Change Biology. Cabi Publishing.
12. Odum, E. P. & Barrett, G. W. (2004) Fundamentals of Ecology. Brooks/Cole.
13. Odum, E. P. (2004). Fundamentals of Ecology. Natraj Publishers, Dehradun.
14. Rafferty, J. P. (eds.) (2011). Climate and Climate Change (The living Earth). Britannica Educational Publishing, New York.
15. Rajan, S. I. & Bhagat, R. B. (eds.) (2017). Climate Change, Vulnerability and Migration. Taylor & Francis
16. Ramasamy, B. (2013). General Issues on Environmental Ecology, Biodiversity and Climate change. Pragun Publication.
17. Seidel, K. & Martinec, J. (2014). Remote Sensing in Snow Hydrology: Runoff Modelling, Effect of Climate Change. Springer publications.
18. Singh, J., Singh, S. P. & Gupta, S. R. (2017). Ecology, environmental Science & Conservation. S. Chand (G/L) & Company Ltd.
19. Sumi et al. (eds) (2010). Adaptation and Mitigation Strategies for Climate Change. Springer Publishers
20. The Little Data Book on Climate Change (2011). World Bank Publications.
21. Wormworth, J. & Sekercioğlu, Ç. H. (2011). Winged Sentinels: Birds and Climate Change. Cambridge University Press.

ZOO-E-604
Immunobiology, and Parasite & Vector Biology

Semester: Third Semester	Course Level: 600	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: illustrate the concept about antibody diversity generation.
CLO 2: outline different types of forces involved in antigen and antibody binding.
CLO 3: classify different types of cytokines and illustrate the mechanism of action of cytokines.
CLO 4: explain about complement, hypersensitivity and inflammation.
CLO 5: outline about diseases caused by the parasites and their control measures.
CLO 6: classify different forms of host parasite interactions and impact of climate change on parasites.
CLO 7: describe the role of vectors in parasite transmission and their control measures.

UNIT I – ANTIBODY DIVERSITY, BINDING FORCES OF ANTIGEN & ANTIBODY, CYTOKINES

Generation of antibody diversity: genetic organization of immunoglobulin genes, rearrangement of genes, allelic exclusion.

Antibody diversity: junctional diversity, gene conversion, somatic hypermutation, association of light and heavy chain; Membrane bound and secreted immunoglobulins, assembly and secretion of immunoglobulins, antibody class switching.

Binding forces of antigen and antibody: hydrogen bond, ionic bond, hydrophobic interaction, Van der Waals interaction.

Cytokines: classification of cytokines, properties of cytokine, mechanism of cytokine action, cytokine-related diseases, therapeutic uses of cytokines and their receptors.

UNIT II – COMPLEMENT, HYPERSENSITIVITY, INFLAMMATION

Complement: characteristic features, methods of complement activation - classical, alternative and MBL pathways.

Hypersensitivity: Gell and Coombs classification, process of immediate hypersensitivity, cytotoxic hypersensitivity, immune-complex and delayed hypersensitivity.

Inflammation: chemical mediators of inflammation, cell surface adhesion molecules, chemotaxis during inflammation, process of inflammation - localized and systemic inflammation, anti-inflammatory agents.

UNIT III – PARASITOLOGY CONCEPTS

General concept: Emerging infectious diseases, re-emerging infectious diseases, neglected tropical diseases, zoonoses, transmission of parasitic diseases.

Host-parasite interactions: molecular, cellular and physiological basis.

Epidemiology and control: principles and concepts; parasite control strategies.

Impact of climate change on parasitic diseases.

UNIT IV - VECTOR BIOLOGY

Vectors and its importance in transmission of parasites; Vector biology: special reference to blackflies, sandflies, tsetse flies and mollusks; parasite-vector interactions.

Vector-borne diseases, major parasite vectors in India.

Vector control strategies.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Group or individual presentation, Assignments, Reports.	Group Discussion, Fish Bowl Technique, Quiz.	Presentation, Seminars.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings

1. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2021). Cellular and Molecular Immunology, South Asia Edition-E-Book. Elsevier Health Sciences.
2. Abbas, A., Lichtman, A., & Pillai, S. (2014). Cellular and molecular immunology E-book. Elsevier Health Sciences.
3. Cox, F. E. G. (1993). Modern Parasitology: A Text Book of Parasitology, 2nd edn. John Wiley & Sons.
4. Khan, F. H. (2009). The elements of immunology. Pearson Education India.
5. Owen, J. A., Punt, J., Stranford, S. A., & Jones, P. P. (2013). Kuby immunology (p. 574). New York: WH Freeman.
6. Roberts, L. S., Janovy, J. & Nadler, S. (2013). Foundations of Parasitology, 9th edn. McGraw-Hill.
7. Smyth, J. D. & Wakelin, D. (1994). Introduction to Animal Parasitology, 3rd edn. Cambridge University Press, London.
8. Soulsby, E. J. L. (2004). Helminths, Arthropods and Protozoa of Domesticated Animals, 7th edn. Elsevier.

ZOO-P-605
Techniques in Biology, Bioinformatics, Histology, Biochemistry

Semester: First Semester	Course Level: 600	Total Marks: 100
L+T+P: 0 +0 +4 = 4 Credits	Lecture: 0 Hrs + Tutorial: 0 Hrs + Practical: 120 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: demonstrate techniques viz., PAGE, PCR, ELISA.
CLO 2: develop skills for use of bioinformatic tools for data retrieval, analysis and interpretation.
CLO 3: determine the presence of RNA, carbohydrate, tyrosine, and phosphatase in the histological sections.
CLO 4: estimate protein, sugar, DNA, RNA and urease enzyme in the samples provided.

UNIT I –MOLECULAR TECHNIQUES
Demonstration of polyacrylamide gel electrophoresis (PAGE).
Polymerase chain reaction (PCR).
Demonstration of ELISA.

UNIT II - BIOINFORMATICS
Retrieval of sequences (data mining).
Pairwise and multiple sequence comparisons.
Construction of phylogenetic tree, divergence dating.
Primer designing.

UNIT III- HISTOLOGICAL TECHNIQUES
Supravital staining of blood cells/spleen.
Histochemical detection of glycogen, acidic glycoprotein bypass and Alcian blue (pH2.5) techniques.
Histochemical detection of alkaline phosphatase *in situ.*
Cytochemical detection – SH group for blood sample.

UNIT IV – BIOCHEMISTRY
Estimation of protein using Folin's/Bradford reagent.
Estimation of sugar by anthrone reagent.
Estimation of DNA using DPA.
Estimation of RNA using orcinol reagent.
Assay of urease enzyme by titrimetric method.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum demonstration.
2. Self-practice under the guidance of teacher.
3. Discussions on the results.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Laboratory note book submission, Group or individual demonstration.	Viva-Voce, Group Discussion.	Demonstrations, Seminar.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested readings

1. Bancroft, J. D. & Stevens, A. (2002). Theory and Practice of Histological techniques. Churchill-Livingstone.
2. Walker, J. M. & Gaastra, W. (Eds.). (2012). Techniques in molecular biology. Springer Science & Business Media.
3. Wilson, K. & Walker, J. (Eds.). (2000). Principles and techniques of practical biochemistry. Cambridge University Press.

ZOO-P-606
Synopsis Preparation

Semester: Third Semester	Course Level: 600	Total Marks: 50
L+T+P: 0+0+2 = 2 Credits	Lecture: 0 Hrs + Tutorial: 0 Hrs + Practical: 60 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: identify the research problem, formulate hypothesis and develop the research plan.
CLO 2: apply PRISMA statement for preparation of systematic literature review.
CLO 3: prepare the research synopsis and present a seminar.

Course content
Students have to prepare a research synopsis in the field of their special paper (elective subject). Topics are to be decided in consultation with the course teacher(s). Along with the preparation of synopsis students have to present a seminar on the same in the presence of panel of examiners, followed by viva-voce.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture, demonstration and discussion.
2. Self-practice under the guidance of teacher.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Review submission.	Viva-Voce, Group Discussion.	Seminar.
Summative Marks: 50%	Assessment of presentation in presence of panel of examiners and submission. Assessment would be made based on the scientific content, writing and communication skill, presentation, analysis and interpretation.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

ZOO-S-607
Research Methodology

Semester: Third Semester	Course Level: 600	Total Marks: 50
L+T+P: 2+0+0 = 2 Credits	Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical: 0 Hrs.	

Course Learning Outcomes:

1. As given in MOOCS.

Research Methodology

A group discussion on what is research; Overview of research
Literature survey, Experimental skills
Data analysis, Modelling skills
Technical writing; Technical Presentations; Creativity in Research
Creativity in Research; Group discussion on Ethics in Research
Design of Experiments
Intellectual Property
Department specific research discussions

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum demonstration.
2. Video lectures, discussions.
3. Books and writeup shared.

ASSESSMENT FRAMEWORK

Average assignment score = 25% of average of best 6 assignments out of the total 8 assignments given in the course.
Exam score = 75% of the proctored certification exam score out of 100
Final score = Average assignment score + Exam score

Suggested Readings

1. As prescribed in MOOCS.

[The course content will be selected from the available MOOCS course and is subject to change over time]

ZOO-E-651
Biodiversity, Conservation Biology

Semester: Fourth Semester	Course Level: 600	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: relate to the concept of biodiversity and its past and present threats.
CLO 2: recognize various extinction processes.
CLO 3: reframe patterns and processes of biodiversity at various scales.
CLO 4: connect the concept of conservation genetics and its significance in biodiversity conservation.
CLO 5: comprehend the fundamentals of biodiversity conservation including legal framework at the national and international level.

UNIT I – BIODIVERSITY: CONCEPTS, COMPONENTS AND PATTERNS

Conceptual framework of biodiversity; Patterns and process of local, regional and global biodiversity.
Concept of metapopulations: theories and applications.
Biogeography of India, Concept of phylogeography.
Plate tectonics and continental drift.

UNIT II – BIODIVERSITY: THREATS AND ASSESSMENT

Biodiversity losses: past and present, natural and human induced threats and vulnerability of species to extinctions; Mass extinction, zero extinction, extinction vortex.
Restricted range species and endemism, key stone species, flagship species, indicator species, surrogate species.

UNIT III – CONSERVATION OF BIODIVERSITY

Population viability analysis-conceptual foundation; Minimum viable populations and recovery strategies for threatened species.
Conservation genetics: genetic variation and its significance, measure of genetic variability.
Traditional knowledge and biodiversity conservation: world heritage convention, Satoyama concept, Tani cultural landscape, Indrakil, Mayal-lyang and Demazong sacred landscape.

UNIT IV – LEGAL FRAMEWORK OF BIODIVERSITY CONSERVATION

Introduction to laws and policies for biodiversity conservation: convention on biological diversity and important protocols; Aichi targets; Ramsar convention on conservation of wetlands.
Indian Biodiversity Act 2002 and rules 2004, national biodiversity authority and state biodiversity boards, Biodiversity management committees and people's biodiversity register.
Wildlife protection act of India and its schedules.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Assignments.	Group Discussion, Fish Bowl Technique, Quiz, Seminar.	Presentation, Seminars.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings

1. Anderson, A.B. (2006) Applying Nature's Design - Corridors as a Strategy for Biodiversity Conservation (Issues, Cases, and Methods in Biodiversity Conservation). Columbia University Press.
2. Biodiversity: Convention on Biological Diversity, Abiotic Stress, International Treaty on Plant Genetic Resources for Food and Agriculture Books LLC, Wiki Series (2011).
3. Chapman Jr., W. B. (1973). Natural Ecosystems. Macmillan Pub. Co. Inc.
4. Chapman, J. L. & Reiss, M. J. (1999). Ecology: Principles and Applications, Cambridge University Press.
5. Clapham, W. B. (1973). Natural Ecosystems, Collier-Macmillan.
6. de Boef et al. (Eds.) (2013). Community Biodiversity Management: Promoting resilience and the conservation of plant genetic resources (Issues in Agricultural Biodiversity). Routledge.
7. Dyke F. V. (2008). Conservation Biology: Foundations, Concepts, Applications (2nd Edition). Springer.
8. Krihhnamurthy, K. V. (2008). An Advanced Textbook On Biodiversity: Principles And Practice, Oxford & Ibh Pub. Co. Pvt. Ltd.
9. Lanzerath, D. & Friele, M. (2014). Concepts and Values in Biodiversity (Routledge Studies in Biodiversity Politics and Management). Routledge.
10. Macdonald D. W. & Willis K. J. (eds.) (2013). Key topics in Conservation Biology 2. Wiley-Blackwell.
11. Novacek, M. J. (2010). The Biodiversity Crisis: Losing What Counts, The New Press.
12. Pyers, G. (2010). Biodiversity of Rain Forests, Benchmark Books.
13. Ricklefs, R. E. & Miller, G. L. (2000). Ecology, W. H. Freeman & Company.
14. Smith, R. L. & Smith, T. M. (1966). Ecology and Field Biology. Addison – Wesley Educational Publishers. Inc.
15. Tokeshi M. (1998). Species coexistence: ecological and evolutionary perspectives. Wiley-Blackwell, New York.
16. Turk, J. & Turk, A. (1988). Environmental Science, Saunders College Publishers.
17. Wilson, E. O. (1988). Biodiversity. National Academy Press.

ZOO-E-652
Cellular and Molecular Immunology

Semester: Fourth Semester	Course Level: 600	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: describe about MHC and its immunological and clinical implications.
CLO 2: record the mechanism of immunological response involving cytotoxic response, tolerance and autoimmunity.
CLO 3: illustrate about vaccines, TLR and immunodeficiency diseases.
CLO 4: recognize about the various immunological techniques.

UNIT I - MAJOR HISTOCOMPATIBILITY COMPLEX (MHC)

MHC and HLA: Major and Minor histocompatibility complex, genetic organization, classical and non-classical HLA genes; Molecular organization of HLA molecule; Polymorphism of HLA; Haplotype and Linkage disequilibrium, antigen presentation and MHC restriction; HLA and disease association; HLA (Human Leukocyte Antigen) typing; micro lymphocytotoxicity assay, molecular HLA typing, Clinical implication of HLA.

UNIT II - CYTOTOXIC RESPONSE, TOLERANCE AND AUTOIMMUNITY

Cell mediated cytotoxic responses: effector mechanisms, leukocyte activation and migration.
Tolerance: factors causing tolerance, types of tolerance, mechanism of tolerance.
Autoimmunity: characteristics, causes of autoimmune disease, pathogenesis, classification, common autoimmune disorder, therapeutic approaches to autoimmune disease.

UNIT III – TLR, VACCINES, IMMUNODEFICIENCY DISEASES

Toll-like receptors: structure, ligands, mechanism of action.
Vaccines: requirements and aims of a successful vaccine, types of vaccines, advantages and disadvantages, new vaccine strategies, concept of immunization.
Immunodeficiency diseases: combined immunodeficiency, acquired immunodeficiency syndrome (AIDS).

UNIT IV – IMMUNOLOGICAL TECHNIQUES

Agglutination reaction, precipitation reaction, immunodiffusion, immunoelectrophoresis.
Immunofluorescence microscopy, Radioimmunoassay.
Hybridoma technology and monoclonal antibody synthesis and usage.
Flow cytometry and fluorescence-activated cell sorting (FACS), immunohistochemistry, Antibody engineering.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Assignments.	Group Discussion, Fish Bowl Technique, Quiz, Seminar.	Presentation, Seminars.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings

1. Abbas, A. K. & Lichtman, A. H. (2006). Basic Immunology. 2nd ed. Elsevier.
2. Abbas, A. K., Lichtman, A. H. & Pillai, S. (2006). Cellular and molecular Immunology. 6th ed. Saunders.
3. Coico, R., Sunshine, G. & Benjamini, E. (2003). Immunology: A short Course. 5th ed. Wiley- Liss: New Jersey.
4. English, L. S. (1994). Technological Applications of Immunochemicals (BIOTOL). Butterworth-Heinemann, Oxford Freeman & Co.
5. Goldsby, R. A., Kindt, T. J., Kuby, J. & Osborne, B. A. (2003). Immunology. 5th ed. W. H. Freeman & Co.
6. Janeway Jr, C. A., Travers, P., Walport, M. & Shlomchik, M. J. (2005). Immunobiology – The immune system in health and disease, 6th ed, Garland Science Publishing, New York, USA.
7. Khan, F. H. (2009). The Elements of Immunology. Pearson.
8. Male, D., Brostoff, J., Roth, D. & Roitt, I. (2006). Immunology. 7th ed. Mosby.
9. Owen, J. A., Punt, J., Stranford, S. A., & Jones, P. P. (2013). Kuby immunology (p. 574). New York: WH Freeman.
10. Roitt, I. M. & Brostoff, J. (2006). Immunology, 7th ed., Mosby & Elsevier Publishing, Canada, USA.

ZOO-E-653
Wildlife Biology and Animal Behaviour

Semester: Fourth Semester	Course Level: 600	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

- **CLO 1:** develop insights on important wildlife of India, and their conservation measures.
- **CLO 2:** comprehend the application of modern tools in wildlife conservation.
- **CLO 3:** develop skills on wildlife census techniques.
- **CLO 4:** generate deep insights on animal behaviour, and their application in sociobiology and wildlife management.

UNIT I – WILDLIFE MANAGEMENT AND MONITORING

Ecology and conservation of Red Panda, Musk Deer, Great Indian Bustard, White-bellied Heron, Chinese Pangolin, Himalayan Salamander, Pygmy Hog and Olive Ridley Turtle.
Conservation approaches of important wildlife of India: project tiger, elephant and snow Leopard.
Applications of cloning in wildlife conservation and management.
Human animal conflict: type and nature of conflict, causes of conflict, measures of conflict mitigation.
Wildlife census/sampling techniques: direct and indirect methods with reference to insects, herpetofauna, birds and mammals.

UNIT II – WILDLIFE TRADE AND PROTECTION

Assessment, documentation, and prevention of wildlife trade; Concept of wildlife forensics.
Introduction to organizations: International Union for Conservation of Nature and Natural Resources (IUCN), IUCN red list of species, threat categories and assessment criteria, Convention on International Trade on Endangered Species of Flora and Fauna (CITES) and its appendices, Indian Board for Wildlife (IBWL).

UNIT III – ANIMAL BEHAVIOUR- I

Four propositions of Tinbergen.
Innate and learned behaviour; Classical conditioning; Instrumental learning, habituation and extinction.
Optimal foraging theory: patch choice, diet choice, pre-selectivity, group and solitary feeding.
Survival value of behaviour: experimental studies, Darwinian and inclusive fitness.
Altruism: Kin-selection, reciprocal altruism, parental care, cooperation.
Sexual selection: Intra and inter-sexual selection, sexual dimorphism, sexual strategies and social organization.
Theories on extreme male ornamentation and courtship displays: the Healthy Mates theory, the Good Gene theory, Fisher's hypothesis (runaway selection), Chase-away selection, Handicap hypothesis of Zahavi.

UNIT IV – ANIMAL BEHAVIOUR-II

Communications and signaling; Territoriality, home range and courtship display.
Mating systems: monogamy, polyandry and polygyny.
Social systems of mammals: primates; Contemporary theories in insect socio-biology.
Human behaviour: genetic differences and human behaviour, IQ differences.
Behavioural genetics: single and multiple gene effect.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Assignments.	Group Discussion, Fish Bowl Technique, Quiz.	Presentation, Seminars.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings

1. Alcock, J. (1975). Animal Behaviour: An evolutionary approach. Sinauer Assoc., Sunderland, Mass. USA.
2. Bailey, J. A. (1991). Principles of Wildlife Management. John Wiley & Sons, New York.
3. Bradbury, J, W. & Vehrencamp, S. L. (2011). Principles of animal communication. Sinauer Assoc., Sunderland, Mass, USA.
4. Clutton-Brock T. H. (1991). The evolution of parental care. Princeton Univ. Press, Princeton, NJ USA.
5. Dewsbury, D. A. (1978). Comparative animal behavior, McGraw Hill Book Company.
6. Drickamer, L. C., Vessey, S. H. & Jakob, E. M. (1991). Animal Behavior, McGraw Hill.
7. Eibl- Eibesfeldt, I. (1970). Ethology; The biology of behavior. Holt, Rinehart & Winston, New York.
8. Huntingford, F. (1984). The Study of Animal Behavior, Chapman and Hall.
9. Krebs, J. R. & Davies, N. B. (1978). Behavioral Ecology: An Evolutionary Approach.
10. McFarland, D. (1999). Animal Behavior: Psychobiology, Ethology and Evolution.

ZOO-E-654
Advances in Parasitology

Semester: Fourth Semester	Course Level: 600	Total Marks: 100
L+T+P: 3+1+0 = 4 Credits	Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: describe the mechanisms by which parasites establish inside their host.
CLO 2: determine the pathological mechanisms in different parasitic diseases.
CLO 3: demonstrate the concept of drug and vaccine strategies against parasites.
CLO 4: identify the techniques for diagnosis and control of parasitic diseases.

UNIT I - PROTOZOOLOGY

Parasitic protozoa: origin and evolution; energy metabolism.
Plasmodium: immunopathology; drug targets, drugs and mechanism of drug resistance; vaccine strategies.
Leishmania: mechanism of entry into host cell and immune evasion; immunopathology.
Trypanosoma: immunopathology and evasion of host immune system.

UNIT II - HELMINTHOLOGY

Origin and evolution of parasitic helminths; Larval form of helminths; Ultra structure of important helminth tegument/cuticle; Structure of scolex in cestodes.
Excretory-secretory products and extracellular vesicles; Energy metabolism in parasitic helminths.
Immunopathology of *Schistosoma, Echinococcus, Wuchereria.*

UNIT III – DIAGNOSTIC PARASITOLOGY

Laboratory diagnosis of parasitic infections: blood and stool examination and examination of biopsy material for parasitic infection; Identification and diagnostics: morphological, serological, DNA-based and *in silico* methods.
In vitro culture of parasites: *Plasmodium*, *Leishmania*, *Schistosoma.*

UNIT IV – MOLECULAR PARASITOLOGY

Principles and applications of PCR, RT-PCR, DNA sequencing, nucleic acid hybridization, blotting techniques, ELISA in parasitology.
Genomics, transcriptomics and proteomics and their application in parasite studies.
Introduction to drug designing, drug repurposing.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion on the recent research articles.
2. Guided readings of a standard book and discussions.
3. Presentations by students on selected themes.
4. Seminar, conference, workshops.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Assignments.	Group Discussion, Fish Bowl Technique.	Presentation, Seminars.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings

1. Bogitsch, B. J. & Cheng, T. C. (2000) Human Parasitology, 2nd ed. Academic Press.
2. Chandler, A. C. & Read. C. P. (1961). Introduction to Parasitology, 10th ed. John Wiley & Sons Inc.
3. Chandra, G. (2000). Mosquito. Sree Bhumi Publication Co. Kolkata.
4. Cheng, T. C. (2012). General Parasitology, 2nd ed. Elsevier.
5. Cox, F. E. G. (1993). Modern Parasitology: A Text Book of Parasitology, 2nd ed. John Wiley & Sons.
6. Hati, A. K. (2001). Medical Entomology. Allied Book Agency, Kolkata.
7. Hati, A. K. (2001). Medical Parasitology. Allied Book Agency, Kolkata.
8. Noble, E. R. & Noble G. A. (1982). Parasitology. The Biology of animal Parasites, 6th ed. Lippincott Williams and Wilkins.
9. Roberts, L. S., Janovy, J. & Nadler, S. (2013). Foundations of Parasitology, 9th ed. McGraw-Hill.
10. Smyth, J. D. & Wakelin, D. (1994). Introduction to Animal Parasitology, 3rd ed. Cambridge University Press, London.
11. Soulsby, E. J. L. (2004). Helminths, Arthropods and Protozoa of Domesticated Animals, 7th ed. Elsevier.

ZOO-P-655
Techniques in Biodiversity, Wildlife Biology, Animal Behaviour

Semester: Fourth Semester	Course Level: 600	Total Marks: 100
L+T+P: 0 +0+4 = 4 Credits	Lecture: 0 Hrs + Tutorial: 0 Hrs + Practical: 120 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: use standard techniques in the field for study of biodiversity components (both fauna and flora).
CLO 2: analyze biodiversity/ecological data using computer-based software packages.
CLO 3: learn the application of latest tools and techniques in ecology.
CLO 4: estimate nutrients from the soil and primary productivity of aquatic ecosystem.
CLO 5: understand various behavioral patterns of animals in the field and laboratory conditions.

UNIT I – BIODIVERSITY ASSESSMENT

Field based exercises on ecological sampling and census techniques: butterflies, amphibians, reptiles and birds.
Study of vegetation using quadrat method.
Calculation of species richness, diversity, equitability, similarity and generation of species accumulation curves based on study of any animal community.
Morphometric measurements of any two species of herpetofauna.

UNIT II – APPLICATION OF ECOLOGICAL TOOLS

Preparation of GIS Maps using Q-GIS/Arc GIS/R Packages.
Estimation of species using appropriate statistical package.
Use of clinometer, densiometer and range finder for height, canopy cover and distance estimation.
Study of the traditional knowledge/cultural practices of biodiversity conservation of any local communities.

UNIT III – PEDOLOGY AND PRIMARY PRODUCTIVITY

Pedology: estimation of phosphorus, zinc and magnesium from soil samples; Estimation of percentage of calcium carbonate in soil by rapid titration method; Estimation of Organic-carbon in soil by wet oxidation method; Analysis of pH, specific conductivity and moisture content of soil samples; Qualitative analysis of soil micro-arthropods.
Estimation of Primary productivity of water bodies.

UNIT IV – ANIMAL BEHAVIOUR

Field study of behaviour of any one species of mammal/birds.
Flocking behaviour in pigeons.
Foraging behaviour in ants: orientation and cues.
Aggressive and predatory behaviour in fish.
Study of any two types of animal interaction/association in field conditions.
Geotaxis behaviour in earthworm.
Video demonstration on animal behaviour.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum demonstration.
2. Self-practice under the guidance of teacher.
3. Discussions on the results.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Laboratory note book submission, Group or individual demonstration, field report submission.	Viva-Voce, Group Discussion.	Demonstrations, Field visit, Seminars.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings

1. Bibby, C. J., Burgess, N. D., Hill, D. A. & Mustoe, S. H. (2000). Bird census techniques. Academic Press, London.
2. Gibbs, J. P., Hunter Jr, M. L. & Sterling, E. J. (2008). Problem-solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.
3. Heyer, W.R., Donnelly, M. A., Mcdiarmid, R. W., Hayek, L. C., & Foster, M. S. (1994). Measuring and monitoring biological diversity: standard methods for amphibians. Washington: Smithsonian Institution Press.
4. Magurran, A. E. (2003). Measuring Biological Diversity. Wiley-Blackwell

ZOO-P-656
Techniques in Immunology and Parasitology

Semester: Fourth Semester	Course Level: 600	Total Marks: 100
L+T+P: 0+0+4 = 4 Credits	Lecture: 0 Hrs + Tutorial: 0 Hrs + Practical: 120 Hrs	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: demonstrate the basic knowledge of immunological and parasitological techniques.
CLO 2: develop skills to perform *in-vitro* antigen and antibody reactions for detection of antigens.
CLO 3: perform separation of cells and immunoglobulins for downstream immunological techniques.
CLO 4: evaluate the presence/absence of specific HLA genes in an individual based molecular techniques.
CLO 5: demonstrate the culture of human WBC.

UNIT I – *In vitro* ANTIGEN AND ANTIBODY REACTION TECHNIQUES

Agglutination test for antigen and antibody: Ring precipitation test, Ouchterlony double immunodiffusion test.
Haemagglutinin Assay.
Complement fixation test.
Immunodiffusion and immunoelectrophoresis: Radial immunodiffusion.
Immunohistochemistry technique.
Plaque forming cell (PFC) Assay and rosette forming cell (RFC) assay.
Raising of antiserum (ALS) and test of specificity of the serum in lysis of target.
Isolation of peritoneal macrophage from rodents.
Study of macrophage phagocytic activity.

UNIT II –CELLULAR AND MOLECULAR IMMUNOLOGY TECHNIQUES

Monocyte cell isolation.
Precipitation of immunoglobulins from the serum samples by ammonium sulphate preparation.
Characterization of immunoglobulin by SDS-PAGE.
Peritoneal lavage / Macrophage activity.
HLA Class I molecular typing by PCR-SSP.
HLA Class II molecular typing by PCR-SSP-RFLP.
Culture of human WBC.

UNIT III – PARASITOLOGY-I

Preparation of stains, preservatives and fixatives.
Collection, fixation, mounting of different helminth parasites from vertebrates (nematode, trematode and cestode).
Demonstration of DNA isolation, PCR and *in silico* sequence analysis for parasite identification.

UNIT IV – PARASITOLOGY-II

Measurement of size of parasites in light microscope.
Faecal examination: qualitative analysis - simple floatation and sedimentation methods; Quantitative analysis: McMaster counting technique.
Histochemical demonstration of alkaline phosphatase activity in tissues of parasitic helminths.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum demonstration.
2. Self-practice under the guidance of teacher.
3. Discussions on the results.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Laboratory note book submission, Group or individual demonstration, field report submission.	Viva-Voce, Group Discussion.	Demonstrations, field visit, Seminars.
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested readings

1. Chakraborty, P., & Pal, N. K. (2008). Manual of Practical Microbiology and Parasitology. New Central Book Agency Pvt Ltd.
2. Garcia, L.S. (2021). Practical Guide to Diagnostic Parasitology. John Wiley & Sons.
3. Halton, D. W., Behnke, J. M. & Marshall, I. (2001). Practical Exercises in Parasitology. Cambridge University Press.
4. Hudson, L., Hay, F. C. & Hudson, L. (1989). Practical immunology (Vol. 3). Oxford: Blackwell scientific publications.
5. Talwar, G. P. & Gupta, S. K. (2015). A Handbook of practical and clinical immunology. CBS Publishers & Distributors Pvt Ltd.
6. Verma, P. S. (2010). A Manual of Practical Zoology: Invertebrates. S. Chand Publishing.

ZOO-R-657
Dissertation

Semester: First Semester	Course Level: 600	Total Marks: 200
L+T+P: 0+0+8 = 8 Credits	Lecture: 0 Hrs + Tutorial: 0 Hrs + Practical: 240 Hrs.	

Course Learning Outcomes:

After completion of the course students will be able to:

CLO 1: formulate their own research plan.
CLO 2: put together the available literature on a topic and interpolate on the retrospective studies.
CLO 3: conduct experiment and collect data using appropriate scientific methodology.
CLO 4: organize research work, prepare scientific document using standard format and deliver the presentation.

Course content
Students have to undertake short term (minimum six months) research work in the field of their special paper (elective subject). Topics are to be decided in consultation with the course teacher(s). Dissertation should be prepared following standard format i.e., Introduction, Materials and Methods, Results, Discussion and Conclusions. Every student has to present a seminar on their research in the presence of panel of examiners appointed by the University followed by viva-voce.

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum demonstration.
2. Self-practice under the guidance of teacher.
3. Discussions on the results.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Dissertation preparation and submission.	Viva-Voce, Group Discussion.	Demonstrations, Field visit, Seminars.
Summative Marks: 50%	Assessment of submission and presentation followed by viva voce. Assessment would be made based on the research hypothesis, experimental design, scientific content, writing and communication skill, presentation, analysis and interpretation		

ZOO-S-658
Statistical techniques in Biology

Semester: Fourth Semester	Course Level: 600	Total Marks: 50
L+T+P: 2+0+0 = 2 Credits	Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical:0 Hrs	

Course Learning Outcomes:

As given in the MOOCS course.

Course content

1. Data Analysis for Biologists (MOOCS)
2. Biostatistics and Design of experiments (MOOCS)

[The course content will be selected from the available MOOCS course and is subject to change over time]