**Even Semester**

## DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE)

## Environmental Genetics

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| Environmental Genetics | 4 | 3 | 0 | 1 | UG | NA |

**Course Objectives**
The course aims to:
- Introduce genetic and genomic tools used in environmental science.
- Explain how genetic variation supports adaptation, conservation, and ecosystem resilience.
- Train students in basic laboratory and data-analysis methods used in molecular ecology.
- Develop employable skills in DNA-based biodiversity monitoring, conservation genetics, and environmental reporting.

**Learning Outcomes**
By the end of this course, students will be able to:
- Explain key concepts of environmental genetics and molecular ecology.
- Assess genetic diversity, population structure, and adaptation in natural populations.
- Apply DNA barcoding, eDNA, and basic genomics in environmental monitoring.
- Perform simple laboratory and bioinformatics exercises related to environmental genetics.
- Prepare technical reports useful for research, consultancy, and conservation practice.

**Course Syllabus**
**Theory: 45 Hours**
**Unit I: Principles of Environmental Genetics (11 Hours)**
Genetic variation and its environmental importance; Alleles, genotypes, populations, and gene pools; Mutation, migration, drift, selection, and gene flow; Hardy –Weinberg principle; Genetic diversity and population fitness; Inbreeding, bottlenecks, founder effects, and habitat fragmentation.

**Unit II: Molecular Ecology and Conservation Genetics (11 Hours)**
Molecular markers: microsatellites, SNPs, mitochondrial DNA, chloroplast DNA; Population structure and connectivity; Phylogeography and evolutionary history; Conservation genetics of threatened species; Genetic rescue, captive breeding, reintroduction, and invasive species genetics.

**Unit III: Environmental Genomics and Adaptation (11 Hours)**
Ecological genomics and population genomics; Genomic responses to climate change, pollution, salinity, drought, and heat stress; Local adaptation; Ecotoxicogenomics and biomarkers; Epigenetic responses to environmental stress; Genomics in ecological restoration.

**Unit IV: Environmental DNA, Bioinformatics and Employability Applications (12 Hours)**
DNA barcoding and metabarcoding; Environmental DNA from water, soil, sediment, and air; eDNA in biodiversity monitoring, invasive species detection, pathogen surveillance, and environmental impact assessment; Introduction to sequence databases; Sequence alignment and analyses, diversity tables; Technical report writing and molecular ecology consultancy skills.

**Suggested Practicals / Field Visits/Applied Exercises (30 hours)**
- Isolation of genomic DNA from plant leaf tissue and soil microbial samples
- Isolation of DNA from water-filter samples for eDNA demonstration.
- Agarose gel electrophoresis for DNA quality checking.
- Quantification of DNA using a spectrophotometer or fluorometer.
- PCR amplification of a plant barcode gene such as rbcL or matK.
- PCR amplification of animal barcode gene COI, using available DNA samples.
- Gel documentation and interpretation of PCR products.
- Restriction digestion of DNA and fragment-pattern interpretation.
- DNA barcoding exercise using BLAST for species identification.
- Iszoyme polymorphism in a population of target plant species
- Construction of a simple phylogenetic tree using barcode sequences.
- Calculation of allele frequency and heterozygosity from sample genetic data.
- Hardy–Weinberg equilibrium calculation using classroom genotype data.
- Preparation of a technical report on an eDNA or conservation genetics case study.

**Essential Readings**
- Allendorf, F. W., Funk, W. C., Aitken, S. N., Byrne, M., & Luikart, G. (2022). Conservation and the genomics of populations (3rd ed.). Oxford University Press.
- Beebee, T. J. C., & Rowe, G. (2017). An introduction to molecular ecology (3rd ed.). Oxford University Press.
- Frankham, R., Ballou, J. D., & Briscoe, D. A. (2010). Introduction to conservation genetics (2nd ed.). Cambridge University Press.
- Hahn, M. W. (2018). Molecular population genetics. Oxford University Press.
- Lowe, A., Harris, S., & Ashton, P. (2004). Ecological genetics: Design, analysis, and application. Blackwell Publishing.

**Suggested Readings**
- Avise, J. C. (2004). Molecular markers, natural history, and evolution (2nd ed.). Sinauer Associates.
- Freeland, J. R., Kirk, H., & Petersen, S. D. (2011). Molecular ecology (2nd ed.). Wiley-Blackwell.
- Hamilton, M. B. (2009). Population genetics. Wiley-Blackwell.
- Hartl, D. L., & Clark, A. G. (2007). Principles of population genetics (4th ed.). Sinauer Associates.
- Taberlet, P., Bonin, A., Zinger, L., & Coissac, E. (2018). Environmental DNA: For biodiversity research and monitoring. Oxford University Press.
- Waldvogel, A.-M., et al. (2020). Evolutionary genomics can improve prediction of species' responses to climate change. Evolution Letters, 4(1), 4–18.

## Even Semester

## DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE)

## Ecology, Evolution and Biosystematics

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| Ecology, Evolution and Biosystematics | 4 | 3 | 0 | 1 | UG | - |

**Course Objectives**

The course aims to:

- Understand key concepts in ecology and evolution and bring quantitative methods (computing, morphological and molecular techniques) and biological concepts together to examine cutting-edge biological research problems
- Study how taxonomy and systematics provide the foundation for our understanding of biological diversity

**Learning Outcomes**

After the course, students will be able to:

- Examine fundamental concepts and theory, and their application to evolutionary ecology, conservation and biodiversity science.
- Apply taxonomic and systematic skills to diverse careers related to biodiversity and conservation.

**Course Syllabus**

**Theory (45 hours)**

**Unit 1- Fundamental concepts in Ecology (12 Hours)**

Population Ecology: Life tables, survivorship curves and age structures, population growth models, metapopulation dynamics; Community Ecology: Species interactions, niche theory, guilds, and competitive exclusion, succession, biodiversity and the Theory of Island Biogeography; Ecosystem Ecology: Trophic levels, food webs, and ecological pyramids, primary and secondary productivity, biogeochemical cycles; Behavioral Ecology: Foraging theory, sensory ecology, sexual selection and mating systems, altruism and kin selection.

**Unit II - Biosystematics & Taxonomy (12 Hours)**

Principles of Systematics: History of biological classification, alpha and beta taxonomy, phenetics vs. cladistics; Taxonomic Procedures: Species concepts, protocols for identification, preservation, and curation; Nomenclature: The International Code of Zoological Nomenclature (ICZN) and Botanical Nomenclature (ICN), operative principles, valid publication, and taxonomic ranks; Modern Trends: Chemotaxonomy, cytotaxonomy, and molecular systematics.

**Unit III – Evolutionary Biology (11 Hours)**

History & Fundamentals: Evolutionary thought; mechanisms of genetic variation; Population Genetics: Hardy-Weinberg equilibrium; natural selection; genetic drift and gene flow; Speciation & Phylogenetics: Reproductive isolation, sympatric and allopatric speciation; constructing and interpreting phylogenetic trees; Macroevolution & Coevolution: Evolutionary arms races, adaptive radiation, and mass extinctions.

**Unit IV- Computational Methods in Ecology and Evolution (10 Hours)**

Ecological and Evolutionary Data Science; Mathematical Modeling in Ecology and Evolution; Advanced Data Science, including Machine learning and AI; Numerical taxonomy; Statistics in R.

**Suggested Practicals/Field Components/Applied Exercises (30 hours)**

- Specimen Collection and Curation: Field collection, pressing/preservation, and herbarium/museum management.
- Biosystematics Lab: Designing indented and bracketed taxonomic keys. Multivariate statistical analysis of morphometric data.
- Ecological Fieldwork: Field sampling techniques (quadrats, line transects), Diversity Assessment using R.
- Molecular Taxonomy and Phylogenetic Lab: DNA extraction, sequencing, and alignment; constructing phylogenetic trees using computational tools

**Essential Readings**


- Begon, M., & Townsend, C. R. (2021). Ecology: From individuals to ecosystems (5th ed.). Wiley.
- Borcard, D., Gillet, F., & Legendre, P. (2018). Numerical ecology with R (2nd ed.). Springer.
- Davies, N. B., Krebs, J. R., & West, S. A. (2012). An introduction to behavioural ecology (4th ed.). Wiley-Blackwell.
- Futuyma, D. J., & Kirkpatrick, M. (2022). Evolution (5th ed.). Oxford University Press.
- Holmes, S., & Huber, W. (2019). Modern statistics for modern biology. Cambridge University Press.
- Mittelbach, G. G., & McGill, B. J. (2019). Community ecology (2nd ed.). Oxford University Press.
- Wiley, E. O., & Lieberman, B. S. (2011). Phylogenetics: Theory and practice of phylogenetic systematics (2nd ed.). Wiley-Blackwell.
- Zachos, F. E. (2016). Species concepts in biology: Historical development, theoretical foundations and practical relevance. Springer.

**Suggested Textbooks**:


- Chesson, P. (2000). Mechanisms of maintenance of species diversity. Annual Review of Ecology and Systematics, 31, 343–366.
- Herron, J. C., & Freeman, S. (2014). Evolutionary analysis (5th ed.). Pearson.
- Kapli, P., Yang, Z., & Telford, M. J. (2020). Phylogenetic tree building in the genomic age. Nature Reviews Genetics, 21, 428–444.
- Krebs, C. J. (2013). Ecology: The experimental analysis of distribution and abundance (6th ed.). Pearson.
- Mittelbach, G. G., & McGill, B. J. (2019). Community ecology (2nd ed.). Oxford University Press.
- Pichler, M., & Hartig, F. (2023). Machine learning and deep learning—A review for ecologists. Methods in Ecology and Evolution, 14(4), 994–1016.
- Sneath, P. H. A., & Sokal, R. R. (1973). Numerical taxonomy: The principles and practice of numerical classification. W. H. Freeman.