NIPGR 401

BIOSTATISTICS AND DATA SCIENCE 3 credit course

The course will provide information regarding basic concepts and common practices for analyzing biological data using statistical tools and allow students to apply these methods to available data sets. Upon completing this course, students will be able to understand the fundamental concepts of data, statistics, computational biology, and the role of programming languages in biological research. Students will develop problem-solving skills in computational biology and gain confidence in using programming languages to visualize and analyze biological data.

COURSE CONTENT

Scope of Statistics in Biological Research

Applications of statistics in biology, definitions (populations, samples), Basic Concepts, type of data, various data collection methods, Diagrams and graphs, Measures of averages and location, Measures of dispersion, Probability and probability theory, Use of statistical packages on biological data.

Statistical Methods

Descriptive: Graphical representation on various type of data, Use of each measure of location; Measures of spread: Variance and Standard Deviation, Standard Error; Skewness, Kurtosis; Quantiles, Outliers; Inferential: Framing hypothesis, Hypothetico-deductive method, Definition & Concept of types of hypothesis, types of errors, Power, Level of Significance, Rejection Region, p-value; Procedures of hypothesis testing based on objective: z- and t-test, Two-way contingency tables, Chi- square and Fisher's exact test.

Correlation & Regression

Karl-Pearson Correlation, Spearman Rank- Correlation, Regression, fitting data to a linear model; Variances and co-variances; least-square parametric estimates; Hypothesis test with regression; Assumptions, Analyses of variance, ANOVA and Partitioning of Sum of Squares, Assumptions; Hypothesis tests with ANOVA; Constructing F-Ratios; ANOVA tables, Analyses of categorical data, and G-Test.

Data Science

Basics of maintenance of computers and networking. Introduction to programming and programming languages. Basic concepts in algebra, trigonometry, numbers and their applications in biology. Importance of Python and R in computational biology. Basic syntax and data structures in Python and R. Reading, writing, and manipulating biological data using Python and R. Employing Numpy and Panda for effective data analysis. Applying basic statistical analysis techniques to explore and interpret biological datasets. Creating visually appealing and informative plots. Integrate Python and R for a seamless workflow in computational biology research. Case studies and applications.

SUGGESTED READING

1. Quinn GP, Keough MJ. Experimental Design and Data. Cambridge University Press.
2. Zar JH. Biostatistical Analysis, 5th Edition. Pearson Publishers.
3. Indrayan A. Medical Biostatistics, 2nd Edition, Chapman and Hall.
4. Altman DG. Practical Statistics for Medical Research, Chapman and Hall.
5. Jones M. Python for Biologists: A complete programming course for beginners. Createspace Independent Publishing Platform. ISBN 9781492346135.
6. Gentleman R. R Programming for Bioinformatics. Chapman and Hall/CRC. ISBN 1420063677.

NIPGR 402

SCIENTIFIC COMMUNICATION AND ETHICS

2 credit course

This course will cover the principles and methodologies of effective oral and written communication of scientific concepts, observations and conclusions in various formats to diverse audiences, including technically knowledgeable audiences and the lay person.

COURSE CONTENT

Principles of scientific communication

The different forms of scientific communication, the importance of effective scientific communication, and the benefits of scientific communication.

Communication in diverse platforms

Effective communication to peers and the non-scientific public, creating visual impact on your audience.

Academic writing

Basics of scientific writing, building a story, using voices and tenses during writing, maintaining the flow in text, manuscript and grant writing, condensing the story, and abstract writing.

Ethics, Commentary and Review Articles

Ethics in manuscript writing and other forms (authors and reviewer perspective), appropriate laboratory practices, and plagiarism.

Effective presentation strategies

Comprehension of the research article, difficulty faced during the presentation, better delivery of information, pitch talk, and poster presentation.

Exploring impactful presentation style communicating research content

Students will be divided into different groups to present a research paper; the student's presentation will be followed by discussion/interaction, and the final presentation will be in the form of a pitch talk by each student.

SUGGESTED READING

1. Schimel J. Writing Science: How To Write Papers That Get Cited And Proposals That Get Funded. ISBN 978-0-19-976023-7.
2. Gitlin LN & Kevin J. Lyon KJ. Successful Grant Writing: Strategies for Health and Human Service Professionals by ISBN 978–0–8261–3273.
3. Ethics in Science and Education, Research and Governance by K Muralidhar Amit Ghosh AK Singhvi. ISBN: 978-81-939482-1-7.
4. Ethics in Science: Ethical Misconduct in Scientific Research by John G. D'Angelo. ISBN: 9781138035423.
5. Ethics and Practice in Science Communication by Susanna Priest, Jean Goodwin, and Michael F. Dahlstrom. ISBN: 9780226497815.

NIPGR 403

PLANT PHYSIOLOGY AND DEVELOPMENT

3 Credit Course

Fundamental knowledge of plant physiology and development is the basis of unraveling nature's secret hidden in plant systems. The students are expected to refresh their knowledge of cellular biology, molecular biology, phytohormones and nutrient signaling for their integration into plant development and architecture. Through this course, emphasis will be given to explain the topics giving relevant examples that might help Ph.D. students in designing their experiments and interpreting their observations.

COURSE CONTENT

Plant Cell Biology, Biochemistry and Physiology (9 lectures)
Constituents of Plant Cells, Cell Cycle and Regulation, Genetic Material, Genome organization, Chromatin remodeling, DNA methylation, histone modifications, Enzyme: Nomenclature, Classification, Kinetics, Mechanism and regulation, Protein Turnover: Biosynthesis and degradation of proteins, Photosynthesis, Respiration and Photorespiration, Water and Solute Transport and Photo-assimilates Translocation

Plant Hormones and Signal Transduction (9 lectures)

Overview of cell signalling, Membrane receptors and receptor proteins, Secondary messengers, Kinase signalling and reversible phosphorylation, Plant Hormones (Growth and Defense): Biosynthesis, perception, signaling and role in plant growth and development, Light perception and signalling, Sugar and NO signalling and their role in plant growth and development

Plant Development and Architecture (9 lectures)

Stem cell concept in plants, Molecular regulation of shoot and root stem cell niche and its importance, Molecular basis of vascular, stem, leaf and root development, Molecular basis of reproductive development: Male and female gametophyte, Male sterility, Fertilization, Seed, Apomixis.

Plant Nutrients, Secondary Metabolism and Nutrition (9 lectures)

Essential nutrients (macro-nutrient & micro-nutrient) their deficiency disorders and anti-nutrients, Nitrogen metabolism: Nitrogen fixation, Ammonia uptake and transport, Nitrate uptake and reduction, Phosphorus uptake, metabolism and use efficiency, Potassium uptake and metabolism, Secondary Metabolism: Biosynthesis, evolution and uses of alkaloids, cyanogenic glycosides, glucosinolates, terpenoids and phenolics.

SUGGESTED READING

1. Buchanan BB, Gruissem W, and Jones RL. Biochemistry and Molecular Biology of Plants. 2nd Edition. Wiley-Blackwell.
2. Taiz L, Zeiger E, Moller IM and Murphy A. Plant Physiology and Development. 6th Edition, Sinauer Associates, Sunderland, CT.
3. Nelson D and Cox M. Lehninger Principles of Biochemistry, 5th Edition. Macmillan.
4. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts R, Walter P. Molecular Biology of the Cell, 6th Edition, Garland Science.

5. Lodish H, Berk A, Kaiser C, Krieger M, Scott M, Bretscher A, Ploegh H. Molecular CellBiology, 6th Edition. WH Freeman

NIPGR 404

GENETICS, STRESS BIOLOGY AND CROP IMPROVEMENT

3 Credit Course

The primary objective of this course is to familiarize students with fundamental concepts of plant genetics and genomics as well as modern genetic and molecular breeding approaches. This course further aims to help students gain a deeper understanding of the various abiotic and biotic stresses faced by plants and various strategies used for crop improvement. On the whole, the course will enhance students' overall comprehension of the subject and eventually assist in the proper planning, execution and analysis of their research work.

COURSE CONTENT

Genetics and Genomics (9 lectures)

Mendelian genetics, Cytoplasmic inheritance, Molecular markers and their applications in molecular breeding, Concept of linkage mapping: principles, mapping populations, recombination fractions, gene mapping tools and resources, Strategies to find gene function at genome-wide level: Gene tagging, TILLING and gene targeting, Epigenetic regulation in plants, Paramutation, Genomic imprinting, RNA-mediated epigenetic phenomenon. Noncoding transcription and non-coding RNAs in plant's development and stress.

Response to Environment (9 lectures)

Abiotic Stress: Drought, Salinity, Light, Temperature and heavy metals. Stress perception, Adverse effect of stresses on plant growth and development, Cellular, physiological and biochemical responses to stresses, Environmental and beneficial microbial signal perception and response, Climate Resilience and Conservation, Chemical Biology and Chemical Ecology.

Plant-Pathogen Interaction & Immunity (9 lectures)

Pathogen Biology, Plant Immunity: Genetics of immune response, Signal perception, Host-pathogen interaction (bacteria, fungus, virus and insect), Microbiomes, metagenomics and synthetic microbial community

Crop improvement (9 lectures)

Recombinant DNA technology, Genetic transformation, Gene editing & silencing, Qualitative and Quantitative traits, QTL analysis and concept of marker-assisted selection, Molecular breeding, Association mapping and their applications in crop improvement, improving agronomic, industrial and quality traits.

SUGGESTED READING

1. Gardner EJ, Simmons MJ, Snustad DP. Principles of Genetics. 8th Edition, Wiley.
2. Lesk AM. Introduction to Genomics, 3rd Edition, Oxford University Press.
3. Krebs, Jocelyn E., Elliott S. Goldstein, and Stephen T. Kilpatrick. Lewin's Genes XII. 12th ed., Jones & Bartlett Learning.
4. Hirt, H. Plant Stress Biology: From Genomics to Systems Biology. Wiley-VCH Verlag GmbH & Co. KGaA.

5. Primrose SB, Tyman RM, Old RW. Principles of Gene Manipulation, 6th Edition, Blackwell Publishing.
6. Brown, T.A. Gene Cloning & DNA Analysis. An Introduction. 8th Edition. Blackwell Publishing, Oxford.

NIPGR 405

RESEARCH METHODOLOGY

4 Credit Course

This course is strategically designed to provide students with a comprehensive understanding of the foundational principles and commonly practiced methodologies integral to research in life sciences and biotechnology. Emphasizing both theoretical knowledge and hands-on skills required to conduct high-quality research in the rapidly evolving fields of life sciences and biotechnology, the curriculum offers an in-depth exploration of contemporary research strategies, including experimental design/techniques, hypothesis formulation, insightful biological data acquisition/interpretation, bigdata analysis, statistical assessment, and effective scientific writing competence. Emphasis is placed on the integration of computational tools, where students will acquire skills in basic programming and the application of software platforms for basic statistical analysis, biological data processing/interpretation, and advanced data visualization. To cultivate scientific writing skills and analytical/technical abilities, students will also undertake the task of writing a comprehensive and well-structured review article, particularly relevant to any emerging area of biotechnology as a core component of the course.

COURSE CONTENT

General Instrumentation (2 lectures)

Introduction, basic principles, types, classifications, advancement and applications of instruments commonly used in molecular biology laboratory, General and specialized instruments: Micropipettes, Thermocycler, Gel electrophoresis, Autoclave, Hot-air oven, Incubators, Shakers, Water bath, Heat block, Precision and analytical balance, Laminar air flow chamber, Fume hood, Vortex, Cell mixer, Rocker, pH meter, Refrigerated/Bench Top centrifuges, Ultracentrifuges, UVP transilluminator, Gel documentation system, Lyophilizer, Central Instrumentation Facility (CIF), Hands-on skill training.

Radioisotope and Imaging (1 lectures)

Basics of radiation biology, Safe handling of radioisotopes, Use and applications of radioisotopes in biological research.

Photometry (1 lectures)

Properties of light (reflection, absorption and transmission), Beer-Lambert law, Principle and applications of colorimeter and spectrophotometer, Optical density calculation for DNA, RNA and Proteins.

Chromatography and Metabolomics (4 lectures)

Definition, principles, procedures, classifications and significance of chromatography, Chromatogram, Paper chromatography, Thin Layer Chromatography (TLC), Liquid chromatography, Gas chromatography, High-performance Thin Layer Chromatography (HPTLC), Column Chromatography, High-Performance Liquid Chromatography (HPLC), Normal phase and Reverse phase HPLC, Ultra-Performance Liquid Chromatography (UPLC), Mass spectrometry (MS), Gas Chromatography (GC), Definition, history, detection techniques and applications of Metabolomics, Metabolites, Hands-on skill training.

Proteomics and Mass spectroscopy (5 lectures)

Introduction to amino acids, and primary, secondary, and tertiary structure of proteins, Evolution of proteomics techniques: from traditional approaches to advanced methodologies, Protein extraction and principle of SDS-PAGE, Work flow of isoelectric focusing, Detailed method for 2DE Gel electrophoresis, staining, spot picking, trypsin digestion, and MALDI-TOF MS plate preparation, Function of chemicals used in proteomic studies, Principle of mass spectrometry and different types of mass analyzer, MASCOT search to identify proteins from peptide mass fingerprinting (PMF) peaks result, Western Blot, GC-MS, LC-MS, and native PAGE analysis, Post-translational modifications, Demonstration of instruments used in SDS-PAGE, 2DE, western blot, liquid chromatography-mass spectrometry LC-MS/MS (QTRAP 6500+) and Eksigent NanoLC 400-Triple TOF 6600 quadrupole time-of-flight.

Real-Time PCR (1 lectures)

Introduction, principles, methods and applications of Reverse Transcription Quantitative PCR (RT-qPCR), One-step vs. two-step RT-qPCR, Primer designing, Experimental designing, Ct value calculation, graph preparation, Data analysis and interpretation, Hands-on skill training.

Laboratory Biosafety (1 lectures)

Introduction to safe Laboratory Practices, Guidelines for safe laboratory practices, role of institution's safety committee, safe handling of chemicals, instruments and laboratory discard.

Intellectual Property Rights (IPRs) (2 c lectures)

Basics and evolving landscapes of IPRs in life sciences and plant biology, Basics of Technology and Innovation with case studies in India, Protection and IPRs of inventions, Introduction to Patents, Patentability criteria, National and international Patent filing, Practices involved in patenting and patent securing, Regulatory issues in Biotechnology, Biosafety guidelines, Basics of Bio-entrepreneurship and IP management, IPRs and governance issues in novel life science technologies, IPRs in Industrial applications, IPR management for technology transfer and product commercialization at government R&D organizations and private industry stakeholders.

Advanced Microscopy (3 lectures)

Principles and application of fluorescence microscopes, Confocal laser microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and Light sheet microscope in plant biology. Major methodologies of advanced microscopy: Optical sectioning and 3D/4D imaging workflows and data analysis, Fluorescent tagging and Live-cell imaging, Fluorescence recovery after photobleaching (FRAP)/Loss in Photobleaching (FLIP), Fluorescence resonance energy transfer (FRET), and Time-lapse imaging, Hands-on skill training.

Genomics and Genotyping Tools (3 lectures)

Basics, principles, strategies/procedures, applications and prospects of traditional and advanced genotyping tools commonly used in plant genomics and molecular breeding, Mining and low/medium/high-throughput genotyping of sequence-based genetic markers such as microsatellites, single nucleotide polymorphisms (SNPs) and insertions/deletions (InDels), Fluorescent dye-labelled-, mass array-, DNA array- and Next-generation Sequencing (NGS)-based marker genotyping, Reference genome- and Pangenome-based SNPs genotyping, Pros and cons of genotyping strategies, Large-scale genotyping applications in accelerated genomics-assisted breeding and crop genetic improvement, Hands-on skill training in National Genomics and Genotyping Facility (NGGF), Future prospects of genotyping tools for genomic research.

Biophysical Methods and Techniques in Structural Biology (4 lectures)

Fundamental principles of thermodynamics, Core concepts of electromagnetic waves including reflection, refraction, and diffraction, Introduction to Circular Dichroism (CD), Fourier Transform Infrared Spectroscopy (FT-IR), Biophysical techniques for studying protein-ligand interactions: fluorescence anisotropy, isothermal titration calorimetry (ITC), and surface plasmon resonance (SPR), Overview of structural biology methods encompassing X-ray crystallography, Nuclear Magnetic Resonance (NMR) spectroscopy, and Electron microscopy.

Hybridization and Genetic Transformation (2 lectures)

Introduction, principles, applications of Plant transformation techniques, Vectors for plant transformation, Stable and transient transformation, Floral dip transformation, Genetic and molecular analyses of transgenics, Data analysis and interpretation, Hands-on skill training.

Computer Networks (LAN/WAN) and Computational Facility (6 lectures)

Computer and network architectures, Different operating systems, Computational Server, Network Devices, High Performance Computing (HPC) clusters, Internet and connectivity, Storage Devices, Network Switches and connections, Web-services, web-servers for biological data analysis, Installation

of different pipelines and tools for high-throughput data analysis, Biological data storage and management, Hands-on skill training.

Data Book Writing (1 lectures)

Basics, principles, practices and importance of data recording and data book writing in life sciences and molecular biology research, Traditional laboratory data recording and documentation, Digital laboratory data documentation, E-Lab Notebook, Laboratory Information Management System (LIMS), Cloud-based laboratory data documentation and management, Best practices of structuring laboratory data recording and management, Personal and laboratory data documentation, Digital laboratory data management and organization, Tools for large-scale scientific data documentation and maintenance.

Review Article Writing (1 credit: 12 lectures)

Writing a comprehensive and well-structured scientific review article, especially related to emerging research area of plant molecular biology. Revisiting published literatures to derive hypothesis and identify research gaps, develop rationale, and deepen understanding on the current state of knowledge in specific research domain and enhancing scholarly writing capabilities.

SUGGESTED READINGS

1. Wilson K, Walker J. Principles and Techniques of Biochemistry & Molecular Biology, 7th Edition, Cambridge University Press.
2. Sambrook J, Fritsch EF, Maniatis T. Molecular Cloning: A Laboratory Manual Cold Spring Harbor Laboratory Press.
3. Allen T. Microscopy: A very short Introduction, Oxford University Press.
4. Volodymyr N-Z. Principles of Light Microscopy: From Basic to Advanced, Springer Nature B.V.
5. Paddock SW. Confocal Microscopy Methods and Protocols, Springer Protocols, Humana Press.
6. Kuo J. Electron Microscopy: Methods and Protocols, Springer Protocols, Humana Press.
7. Comai L, Katz JE, Mallick P. Proteomics: Methods and Protocols. Methods in Molecular Biology, Springer Protocols, Humana Press.
8. Evans CA, Wright PC, Moirel J. Mass Spectrometry of Proteins: Methods and Protocols. Methods in Molecular Biology, Springer Protocols, Humana Press.
9. Cooper A. Biophysical Chemistry, WILEY, BLACKWELL Publishing.
10. Rhodes G. Crystallography made crystal clear, ACADEMIC PRESS, INC.
11. Plummer DT. Introduction to practical biochemistry. New Delhi: Tata McGraw-Hill.
12. Hyötyläinen T, Wiedmer S. Chromatographic methods in Metabolomics. Cambridge: Royal Society of Chemistry.
13. Roessner U, Dias DA. Metabolomics tools for natural product discovery methods and protocols. Totowa: Humana Press.
14. Soni V, Hartman TE. Metabolomics: Recent advances and future applications. Springer.
15. Christou P, Klee H. Handbook of Plant Biotechnology. John Wiley & Sons.
16. Voet D, Voet JG. Biochemistry, 4th Edition, John Wiley & Sons.
17. Jones M. Python for Biologists: A complete programming course for beginners. Createspace Independent Publishing Platform.
18. Gentleman R. R Programming for Bioinformatics. Chapman and Hall/CRC.