

CORSO DI DOTTORATO IN BIOLOGIA

Ph.D. COURSES

Offerta didattica esclusiva

2025/2026

RESEARCH METHODS AND EXPERIMENTAL DESIGN IN BIOLOGY

Course coordinator: Margherita Gioria (Università di Pisa)

Schedule: yearly course 2025/2026

Duration: 12 hours

Description: This course explores the principles and practice of designing studies and experiments in biology, an essential skill for early-career researchers in the life sciences. Emphasising the deductive approach, the course will guide students in formulating testable hypotheses, designing experimental and correlational studies, and distinguishing between explanatory and predictive models. Students will explore strategies for addressing the spatial and temporal variability in biological systems and selecting appropriate statistical methods based on their study design. By the end of the course, students will submit a written plan and deliver a 5 to 10-minute presentation in which they detail their research questions, explain the rationale behind their experimental design, and describe the statistical methods they plan to use.

Prerequisites: None required

Preliminary Program: The Scientific Method and Hypothesis Formulation. The deductive method and scientific reasoning; Hypothesis formulation and testing; Correlational vs. experimental designs; Observational studies; Experimental Design and Sampling Strategies; Sampling units, replication, randomization, and control; Mitigating the effects of confounding variables; Addressing temporal and spatial variability (factorial, blocked, and repeated-measures designs); Common pitfalls in experimental design. Linking Design to Statistical Methods. Matching experimental design to appropriate statistical approaches; Univariate vs. multivariate analysis; Parametric vs. non-parametric methods; Understanding and checking data assumptions; applying data transformations when needed; Explanatory vs. predictive models; Introduction to mixed-effects models and their applications in biological data; Determining adequate sample sizes and test sensitivity; Criteria for selecting the most appropriate analytical methods based on data structure, hypothesis type, and study design. Practical Activities. Throughout the course, students will apply theoretical concepts to their own research by: Defining research questions and initial hypotheses based on their PhD topic; Developing a conceptual model linking observations, hypotheses, and predictions; Designing an experimental or observational study, including: Identification of variables, sampling units, replication levels, and control structure; Specification of randomization and blocking strategies; Consideration of alternative designs and their trade-offs; Proposing a statistical protocol for each hypothesis, including: Analytical approach; Assumptions, transformations, and alternative methods; Potential limitations and solutions.

Final exam: not provided