

Component	What to Consider	Typical Options
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Variables	• Independent (manipulated) • Dependent (measured) • Controlled (kept constant)	Temperature, gene expression, light intensity, etc.
Controls	Negative control (no treatment) Positive control (known effect)	Untreated cells, wild-type strain
Replication	Number of independent repeats to estimate variability	Biological replicates (different organisms) vs. technical replicates (same sample)
Randomization	Random assignment of subjects/treatments to avoid bias	Random block design, Latin square
Blinding	Conceal treatment identity from observer/analyst	Single-blind, double-blind
Sample Size	Power analysis to ensure sufficient statistical power	Use software (G*Power, R pwr package)

4. Common Biological Research Methods

Category	Techniques	Typical Applications
Observational	Field surveys, microscopy, phenotypic scoring	Biodiversity inventories, cell morphology
Comparative	Phylogenetic analysis, morphometrics, transcriptomics	Evolutionary relationships, gene expression patterns
Experimental	• Manipulative experiments (e.g., knock-out, drug treatment) • Controlled growth chambers • Microfluidic assays	Causal inference, functional genomics, physiological testing
Molecular	PCR, qPCR, RNA-seq, CRISPR/Cas9, Western blot	Gene detection, expression quantification, genome editing
Physiological	Respirometry, electrophysiology, calorimetry	Metabolic rates, neuronal activity, energy budgets
Ecological	Mark-recapture, transect sampling, remote sensing	Population dynamics, habitat use, climate impact

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Category	Techniques	Typical Applications
Computational	Bioinformatics pipelines, modeling, machine learning	Genome assembly, protein structure prediction, ecosystem simulation

5. Data Types & Measurement