

SYLLABUS
Winter semester 2025/2026
Lecturer: Dorota Wiśniewska PhD

Title of the course	Statistical Methods for Biological Sciences
Institution where the course will take place	Institute of Bioorganic Chemistry, Polish Academy of Sciences
Language	English
Learning objectives	<p>To know fundamental concepts of statistical inference and their application in biological research.</p> <p>To know how to present data and statistical results effectively using appropriate visualizations.</p> <p>To understand the differences between parametric and non-parametric tests and their assumptions.</p> <p>To familiarize with various statistical tests for different research designs (independent samples, paired samples, multiple groups).</p> <p>To understand the principles of correlation and regression analysis.</p> <p>To be able to select appropriate statistical methods for different experimental designs and types of data.</p> <p>To be able to interpret statistical results correctly, including p-values, confidence intervals, effect sizes and distinguish between statistical significance and biological/clinical relevance.</p>
Type of the course	Lecture
Semester/Year	Winter semester 2025/2026
Name of the lecturer	Dorota Wiśniewska, PhD
Name of the examiner	Dorota Wiśniewska, PhD
Teaching methods	Lecture and problem-based teaching
Attendance requirements	70%
Number of ECTS points	2
Number of lectures	
Didactic methods	Conversational lectures; Analysis of examples; Case study; Review quizzes; Discussions; Software demonstrations

Methods of verification and assessment of learning outcomes	Final test
Conditions of a positive evaluation	Pass final test with $\geq 60\%$ score Submit mini-tasks (e.g. solving review quizzes).
Course content	<p>Session 1-2 (2h): Introduction to Statistics and Descriptive Statistics Types of variables (qualitative/quantitative, nominal/ordinal/interval/ratio); Descriptive statistics: mean, median, mode, SD, quartiles; Data visualization: histograms, boxplots, violin plots. Population vs. sample, sampling methods.</p> <p>Session 2 (1h): Normal Distribution and Its Importance Properties of normal distribution. Central Limit Theorem.</p> <p>Session 3. (2 h) Confidence Intervals and Sample Size Planning Mean, proportion and variation estimation; Distribution of estimator as the basis for statistical inference; Point vs. interval estimation; Standard error vs. standard deviation; Confidence intervals (95% CI).</p> <p>Session 4. (2h) Hypothesis Testing Fundamentals The logic of statistical testing: H_0 and H_1; Type I and Type II errors, One-sided and two-sided set of hypothesis. P-value interpretation and limitations; Significance level (α) and test power ($1-\beta$); Effect-size.</p> <p>Session 5. (3h) Tests for Independent and Dependent Samples – comparison of two groups Independent vs. dependent samples; Parametric vs nonparametric tests; Student's t-test (assumptions, interpretation; Mann-Whitney U test (non-parametric alternative); Paired t-test and Wilcoxon signed-rank test Statistical Significance vs. Effect Size; Visualization of results.</p> <p>Session 6 (2h): ANOVA and Multiple Comparisons One-way ANOVA; Two-way ANOVA and interaction effects; Post-hoc tests: Tukey HSD, Bonferroni; Kruskal-Wallis test (non-parametric); Repeated measures ANOVA; Effective scientific visualization of results.</p> <p>Session 7 (1 h): Correlation Pearson vs. Spearman correlation; Correlation \neq causation. Correlation significance test.</p>

	<p>Session 8 (1h): Chi-Square Test of Session 9 Session 9 (2 h) Linear regression Simple and multiply linear regression; Regression assumptions and diagnostics.</p>
<p>Literature of the course materials</p>	<p>Zar, J.H. (2010). "Biostatistical Analysis" (5th edition). Pearson https://lib.zu.edu.pk/ebookdata/Biostatistics/Biostatistical%20Analysis-by%20Jerrold%20H%20Zar.pdf</p> <p>Quinn, G.P. & Keough, M.J. (2002). "Experimental Design and Data Analysis for Biologists". Cambridge University Press. (planning biological experiments) https://www2.ib.unicamp.br/profs/fsantos/apostilas/Quinn%20&%20Keough.pdf</p> <p>Wasserstein, R.L. & Lazar, N.A. (2016). "The ASA Statement on p-Values: Context, Process, and Purpose." The American Statistician, 70(2), 129-133.</p> <p>Nuzzo, R. (2014). "Statistical errors." Nature, 506, 150-152.</p> <p>Lenth, R.V. (2001). "Some Practical Guidelines for Effective Sample Size Determination." The American Statistician, 55(3), 187-193.</p> <p>Ioannidis, J.P.A. (2008). "Why Most Discovered True Associations Are Inflated." Epidemiology, 19(5), 640-648.</p>