Module syllabus: ***Electric phenomena in plant cells***

1. Overall information

Module coordinator	Prof. dr hab. Waldemar Karcz
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ECTS	**2**
Method for the verification of learning outcomes	The final grade for the module is weighted on the average of the following student's activities: - Active participation in the laboratory classes (continuous evaluation of practical skills and final report) (0.5) - Written final exam (0.5) To be awarded a final grade, the student must have passed each activity of the module. Grades: below 51% – fail (F); 52-60% – with minimum academic criteria (E); 61-65% – satisfactory (D); 66-75% – good (C); 76-85% – very good (B), ≥ 85% – excellent (A)

2. Description of student activity and work

Lecture/discussion sessions	
Responsible instructor	Prof. dr hab. Waldemar Karcz
Content	The module enables students to gain specialised knowledge and the theoretical and practical scopes of the methods for investigating the electrical response. Students will be acquainted with the physical fundamentals of the transport through the biological membranes, the types of membrane ion transport systems (pumps, ion channels, transporters) and the electrophysiological techniques that serve to record and analyse the currents flowing through the biological membranes. **Lectures/discussion sessions** comprise the core subjects in plant electrophysiology, including the characteristics of the biomembrane, transport through the membranes and the electric response of plant cells to various factors. **Lecture/discussion session content:** Structure and functioning of biomembranes**.** The physical basis of transport across the biological membranes – the forces that determine the movement of ions. Nernst Equation, Goldman-Hodgkin-Katz Equation. Mechanisms of ion transport through membranes – pumps, transporters, ion channels. Electrophysiological techniques used in the acquisition of currents – classic electrophysiology and the patch-clamp technique. Methodology of patch-clamp experiments. Patch-clamp configurations.
Number of didactic hours (contact hours)	**5**
Literature	Molleman A., (2003). *Patch Clamping: An Introductory Guide to Patch Clamp Electrophysiology.* John Wiley & Sons.

	Taiz, L. and Zeiger, E. (2006). *Plant Physiology.* 4th Edition. Sinauer Associates. Sunderland, MA. Buchanan B. B., Gruissem W., Jones R. L. (Eds.). (2015). *Biochemistry and Molecular Biology of Plants.* John Wiley & Sons.

Laboratory	
Responsible instructors	Staff of the Department of Plant Physiology
Laboratory projects	1. The classic electrophysiology method. Membrane potential measurements of maize coleoptile parenchymal cells. Effect of plant growth substances and selected ion concentrations. 2. Introduction to the patch-clamp technique. Preparation of electrodes and micropipettes. Isolating vacuoles from beet taproots (*Beta vulgaris* L.) 3. First patch-clamp experiment preparation, attempt to obtain the basic patch-clamp configurations. 4. Patch-clamp experiments in the selected configurations. Calculating and analysing the results. 5. Discussing and interpreting the results of the measurements. Summary classes. Preparing a written, final report of the experiments that were performed. Final exam.
Methodology of laboratory classes	Experiments will be performed in small groups under the supervision of the instructors and will include: • Designing and accomplishing the procedure • Calculating and presenting the results • Protocols commitment and test
Number of didactic hours (contact hours)	20
Literature	Molleman A., (2003). *Patch Clamping: An Introductory Guide to Patch Clamp Electrophysiology.* John Wiley & Sons. Taiz, L. and Zeiger, E. (2006). *Plant Physiology.* 4th Edition. Sinauer Associates. Sunderland, MA. Buchanan B. B., Gruissem W., Jones R. L. (Eds.). (2015). *Biochemistry and Molecular Biology of Plants.* John Wiley & Sons.

3. Forms of verification

Continuous evaluation of knowledge, activity and practical skills	
Grades	Grades are awarded on a scale: A-F, where A is the best and F is a fail. An excellent performance (A) – the student actively participates in laboratory work, demonstrates an excellent understanding of the experimental procedures (its aims, sequence and outcomes) is engaged and creative in solving current problems and in an assessment and presentation of experimental results. A very good performance (B) – the student actively participates in laboratory

	work, demonstrates very good understanding of the experimental procedures, is engaged in solving problems and in an assessment and presentation of experimental results. A good performance (C) – the student demonstrates a good judgment and knowledge, correctly provides an experiment, correctly exhibits a sense of an experimental procedure, properly provides an assessment and presentation of experimental results. A satisfactory performance (D) – the student demonstrates a satisfactory judgment and knowledge, is poorly engaged and needs additional help to finish the experiment and final assessment of the experimental results correctly, satisfactorily presents experimental results. A performance that meets the minimum academic criteria (E) – the student demonstrates poor judgment and knowledge, is hardly engaged and needs help to conduct the experiment and final assessment of the experimental results needs help to presents experimental results. A performance that does not meet the minimum academic criteria – fail (F) – the student is not engaged in experiment, does not exhibit sense of experimental procedures, poorly interprets and presents experimental results.

Reports from realised laboratory projects	
Evaluation	Evaluation comprises judgment and knowledge related to the sense and methods of the laboratory project, engagement in realisation, quality of assessing and presenting the experimental results, use of reference materials. Grades for reports are awarded on a scale: A-F, where A is the best and F is a fail. An excellent report (A) – without any essential errors Fail (F) – no report

Final exam	
Grades	Grades are awarded on a scale: A-F, where A is the highest and F is a fail. Excellent (A) – the student presents a fluent knowledge of the electric phenomena in plant cells and methods of their measurements. Very good (B) – the student presents a very good knowledge of the electric phenomena in plant cells and methods of their measurements, has minimal errors that do not affect the quality of the presentation. Good (C) – the student presents a good knowledge of the electric phenomena in plant cells and methods of their measurements, makes rare but subtle errors. Satisfactory (D) – the student exhibits a satisfactory knowledge, but with a poor understanding of the electric phenomena in plant cells and makes subtle errors. Meets the minimum academic criteria (E) – the student exhibits a minimum knowledge with a poor understanding of the electric phenomena in plant cells with numerous errors. Fail (F) – the student does not present a satisfactory knowledge of the electric phenomena in plant cells and methods of their measurements and makes many substantial errors, which disqualify their presentation.