	COURSE SYLLABUS
1.	**Course title:**
	Cutting Edge Techniques Advancing Foraminiferal Culture experiments To be agreed individually with the staff and participants, within the period of April to August 2026, Kraków, Poland
2.	**Lecturers (incl. Instructors):**
	Prof. Jarosław Tyszka, PhD, Institute of Geological Sciences, Polish Academy of Sciences *Michael Lintner, PhD, Eng., Institute of Geological Sciences, Polish Academy of Sciences* *Jan Goleń, MSc, Institute of Geological Sciences, Polish Academy of Sciences* *Joanna Szałkowska, MSc, Eng., Inst. of Geological Sciences, Polish Academy of Sciences* *Karolina Godos, MSc, Institute of Geological Sciences, Polish Academy of Sciences*
3.	**Field, type and level of studies, year of study:**
	Earth sciences, oceanography, paleoecology, marine biology, environmental pollution (bachelor, master, and doctoral students) *all years students in area of geology, biology ecology, geography, chemistry or similar*
4.	**Course character:**
	Workshop with laboratory work and training sessions
5.	**Teaching method:**
	Lectures, practical exercises, and culture experiments
6.	**Language:** *English*
7.	**Course type and number of hours:**
	Workshop (35h)
8.	**Estimated load of student's independent work:** **10 h**

9.	**Total workload and number of ECTS points:**	**2 ECTS**
10.	**Short description and main focus of the course:**	

*The primary aim of this 5-day intensive workshop is to significantly enhance the laboratory skills of young scientists engaged in **actualistic studies of foraminifera**. Participants will gain the tools necessary to address complex biological and geological questions by mastering high-resolution imaging and physiological monitoring.*

The course bridges the gap between raw observation and analytical depth, focusing on three core research pillars:

- ***Biomineralization and Morphogenesis:** Visualizing how shells are formed and organized at a subcellular level.*
- ***Biomonitoring and Ecotoxicology:** Assessing the real-time physiological response of foraminifera to environmental stressors or pollutants.*
- ***Palaeoenvironmental Reconstructions:** Utilizing modern biological observations to improve the calibration of proxies used in deep-time climate studies.*

Key Thematic Areas & Methodologies

- ***Advanced Fluorescence & Confocal Imaging (FV4000 & AxiObserver Z.1)***
  - *Experimental Architecture: Designing protocols that balance signal-to-noise ratios by optimizing laser power, exposure times, and precise detection ranges.*
  - *Control imaging: Detection of autofluorescence*
  - *Dynamic Staining: Selecting and applying fluorescent dyes to target specific organelles or physiological processes.*
  - *Live Imaging Control: Introducing incubation and perfusion chambers to control environmental conditions and active application of reagents.*
- ***Physiological & Photosynthetic Assessment***
  - *MICROSCOPY-PAM: Utilizing Pulse Amplitude Modulated (PAM) Fluorometry to measure the photochemical efficiency and health of symbiotic algae within Large Benthic Foraminifera (LBFs).*
  - *Isotopic Labelling: Introduction to the fundamentals of tracer application to quantify metabolic rates and calcification pathways.*
- ***Digital Image Synthesis***
  - *Post-Processing & Deconvolution: Transforming raw optical sections into clear, high-contrast data sets by removing "out-of-focus" light blur.*
  - *Quantitative Analysis: Moving from qualitative "pretty pictures" to extracting measurable data for statistical scientific reporting.*

Krótkookresowa wymiana akademicka sposobem na podniesienie jakości kształcenia w instytucjach szkolnictwa wyższego i nauki
wysokość dofinansowania z Unii Europejskiej: 995 250 PLN; www.mapadotacji.gov.pl

11.	**References:**
	Dubicka Z., Tyszka J., Pałczyńska A., Höhne M., Bijma J., Jense, M., Klerks, N., & Bickmeyer U. (2024). Biocalcification in porcelaneous foraminifera. Elife, 13, RP91568, https://doi.org/10.7554/eLife.91568.3 *Frontalini F., Losada M.T., Toyofuku T., Tyszka J., Goleń J., de Nooijer L., Ikuta T. (2019). Foraminiferal ultrastructure: a perspective from fluorescent and fluorogenic probes. Journal of Geophysical Research: Biogeosciences, 124(9), 2823-2850, https://doi.org/10.1029/2019JG005113* *Goleń J., Tyszka J., Godos K., & Janse M. (2022). A Model of F-actin Organization in Granuloreticulopodia in Foraminifera: Morphogenetic and Evolutionary Implications from Novel Fluorescent and Polarised Light Observations. Protist, 173(4), 125886, https://doi.org/10.1016/j.protis.2022.125886* *Lintner, M., Schagerl, M., Lintner, B., Nagy, M., & Heinz, P. (2022). Photosynthetic performance of symbiont-bearing foraminifera Heterostegina depressa affected by sunscreens. Scientific Reports, 12(1), 2750, https://doi.org/10.1038/s41598-022-06735-1* *Lintner, M., Balzano, S., Keul, N., Heinz, P., Manecki, M., Klimek, A., ... & Tyszka, J. (2025). Biosorption of heavy metals by microalgae: Hazardous side effects for marine organisms. Chemosphere, 372, 144080, https://doi.org/10.1016/j.chemosphere.2025.144080* *Tyszka J., Bickmeyer U., Raitzsch M., Bijma J., Kaczmarek K., Mewes A., Janse M. (2019). Form and function of F-actin during biomineralization revealed from live experiments on foraminifera. Proceedings of the National Academy of Sciences, 116(10), 4111-4116, https://doi.org/10.1073/pnas.1810394116*
12.	**Prerequisites:**
	Micropaleontology, Biogeochemistry, Marine biology, Paleo/ecology, Environmental Toxicology
13.	**Educational outcomes:**
	Knowledge: *Upon successful completion of this course, students will be able to:* • *Microscopy Principles: Understanding the operational physics behind fluorescence and confocal microscopy (specifically the FV4000 and AxiObserver Z.1 systems).* • *Experimental Design: Learning how to select optimal imaging parameters, including laser power, exposure times, and appropriate fluorescent dyes/filter sets.* • *Physiological Monitoring: Understanding the basics of isotopic labeling and chlorophyll fluorometry (MICROSCOPY-PAM) to assess the metabolic and photosynthetic activity of foraminifera and their symbionts.*

Krótkookresowa wymiana akademicka sposobem na podniesienie jakości kształcenia w instytucjach szkolnictwa wyższego i nauki
wysokość dofinansowania z Unii Europejskiej: 995 250 PLN; www.mapadotacji.gov.pl

	• *Environmental Control: Knowledge of using incubation and perfusion chambers to manipulate CO2, O2, and temperature during live imaging.*
	Practical Skills: *This course provides a comprehensive introduction to:* • *Sample Preparation: Mastering the delicate process of picking, cleaning, and staining living foraminifera.* • *Advanced Imaging: Hands-on operation of confocal microscopes, including the application of inhibitors and stains during real-time imaging.* • *Data Processing: Competence in the processing, deconvolution, and quantitative analysis of complex biological images.* • *Equipment Operation: Direct experience with the MICROSCOPY-PAM system for measuring chlorophyll activity.*
	Social Skills: *During the workshop, students will:* • *Collaborate effectively within small research teams* • *Clearly and constructively present scientific observations in group discussions* • *Develop critical thinking and problem-solving skills through collaborative interpretation of scientific data* • *Demonstrate awareness of research ethics, data integrity, and open science principles in team-based research activities*
14.	**Evaluation of the educational outcomes:**
	Students will be evaluated based on their engagement in the workshop, participation in discussions, and performance in the practical exercises
15.	**Criteria to complete the course:**
	To successfully complete the course, students must: 1) Attend at least 80% of all scheduled classes and lab activities; 2) Actively participate throughout the workshop; 3) Obtain a positive evaluation of practical exercises
16.	**Contact with the course leader/lecturer:**
	Prof. Jarosław Tyszka, ndtyszka@cyfronet.pl *Dr Michael Lintner, ndlintne@cyfronet.pl* *Jan Goleń, MSc, ndgolen@cyfronet.pl*

Krótkookresowa wymiana akademicka sposobem na podniesienie jakości kształcenia w instytucjach szkolnictwa wyższego i nauki
wysokość dofinansowania z Unii Europejskiej: 995 250 PLN; www.mapadotacji.gov.pl