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AGILE Doctoral Training Event #2

Fundamentals of Microscopy Imaging for Plant Sciences

Lecturers: Hubert Bauch (Zeiss, Germany), Joe McKenna **(**University of Warwick, UK), Célia Baroux (University of Zürich, CH), Veit Schubert and Maria Cuacos (IPK, Gatersleben, Germany).
Instructors at Hands-On Sessions: Hubert Bauch, Andreas Lutter, Dario Furlani, Jan-Erik Heil (Zeiss, Germany). Maria Cuacos, Twan Rutten/Michael Melzer, Veit Schubert (IPK, Gatersleben, Germany)

Location: IPK, Gatersleben (Germany)
Dates: 18.11.2026-20-11.2026
Credit Points: 1 ECTS

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Learning objectives

This course covers the fundamentals of fluorescence microscopy, introduces cutting-edge modalities for high spatial and temporal resolution, and provides targeted solutions for imaging plant tissues and cells.

By the end of this course, participants will be able to:

- **Apply foundational optical principles**—including magnification, resolution, numerical aperture, and contrast—to correctly operate, align, and maintain a microscope using Köhler illumination and proper cleaning techniques.
- **Compare imaging modalities** like brightfield, phase contrast, DIC, polarization, and basic fluorescence microscopy.
- **Optimize digital images** by understanding camera sensor technology, gray values, histograms, and file formats.
- **Demonstrate basic operational proficiency** on Confocal, Lightsheet, and SIM platforms to independently acquire high-quality images during hands-on sessions.
- **Design a quantitative imaging workflow** by selecting the optimal advanced 3D modality (Confocal, Lightsheet, or SIM), preparing plant samples using adapted clearing, staining, and mounting techniques, and configuring image acquisition parameters during hands-on system operation.

Course content

(1) Core Microscopy Fundamentals & Imaging Modalities

Hands-on sessions and lectures cover fundamental microscopy principles, including magnification, resolution, numerical aperture, and contrast. Participants will learn to identify microscope parts, decode standard objective labeling, align Köhler illumination, and explore contrast methods—such as brightfield, phase contrast, DIC, polarization, and basic fluorescence microscopy. In addition,participants will learn about digital imaging optimization by comparing sensor types, photon effects, and gray values using image histograms and appropriate file formats.

Learning objectives:

- Align and maintain microscopes using Köhler illumination and proper lens cleaning protocols.
- Select appropriate contrast methods including brightfield, phase contrast, DIC, polarization, and fluorescence.
- Optimize digital image quality using camera sensor data, gray values, and histograms.

Topic	Instructors	Lecture	Hands-On	Duration
Introduction to microscopy and Contrast methods	Hubert Bauch	x		2h
Basics in Digital Imaging and 3D imaging	Hubert Bauch	x		2h
Total				**4h**

Recommended Reading / Online tutorials

- A free, comprehensive video course covering optics, diffraction, resolution, Köhler illumination, contrast techniques (phase contrast, DIC, darkfield), and fluorescence https://www.ibiology.org/online-biology-courses/microscopy-series/
- Interactive visual tutorials detailing microscope anatomy, Köhler illumination alignment, fluorescence filters, and digital imaging basics https://www.microscopyu.com/tutorials

(2) 3D and 4D Modalities for Plant Biology Applications

Hands on session and lectures cover the assessment of optical sectioning technologies for 3D and live-cell imaging. Through dedicated hands-on rotations, participants will operate advanced systems, including Confocal Laser Scanning, Lightsheet, and Structured Illumination Microscopy (SIM), applying theory directly to practical sample imaging. Additionally, lectures cover challenges and solutions for optimal plant sample preparation techniques—such as clearing, staining, and mounting, and provide examples of how these (and others) advanced imaging technologies can be used to study plant nuclei, chromatin and chromosome organisation.

Learning objectives:

- Evaluate advanced imaging modalities (Confocal, Lightsheet, and SIM) based on their underlying principles to select the optimal system for a given research application
- Select optimal plant preparation protocols by evaluating and adapting clearing, staining, and mounting methods for specific tissue types.

Topic	Instructors	Lecture	Hands-On	Duration
Confocal Laser Scanning Microscopy	Dario Furlani Zeiss, Twan Rutten Michael Melzer	x	x	4h
LightSheet Microscopy	Andreas Lutter Zeiss	x	x	4h
Structured Illumination Microscopy	Jan-Erik Heil Zeiss	x	x	4h
Challenges and solutions for optimal plant sa preparation	Joe McKenna	x		1h
Designing an informed imaging workflow fron sample preparation to image acquisition	Célia Baroux	x		1h
Advanced Imaging Modalities for Plant Nucle Chromatin and Chromosome Studies	Celia Baroux Joe McKenna Veit Schubert Maria Cuacos	x		2h
Assignment: Imaging modalities beyond your	Célia Baroux and Verena Kriechbaumer		x	10h
Total				**26h**

Recommended Reading / Online tutorials

- **Multiphoton**: Mizuka (2021) Advances in Two-Photon Imaging in plants doi: 10.1093/pcp/pcab062
- **LSFM**: Ovecka et al. 2022 Imaging plant cells and organs with light-sheet and super-resolution microscopy doi: 10.1093/plphys/kiab349
- **SRM**: Schermelleh et al. 2019 Super-resolution microscopy demystified, doi: 10.1038/s41556-018-0251-8
- **SIM, STED**: Wegel et al. 2016 Imaging cellular structures in super-resolution with SIM, STED and Localisation Microscopy - A practical comparison, doi: 10.1038/srep27290

Additional references will be provided for the assignment

Detailed Programme

Notes

- Lectures are in the Lecture Hall.
- Hands-On Sessions are running over three parallel sites and are preceded by a general introduction (1h). DCs rotate in groups

Microscope	Building	Room	Wed 18/11	Thu 19/11	Fri 20/11
Confocal	Miescher Haus	0.62	DC1-5	DC11-15	DC6-10
LSFM	Genetics Building	0.33	DC6-10	DC1-5	DC11-15
SIM	Genetics Building	0.41	DC11-15	DC6-10	DC1-5

Day 1 : November 18th 2026

9:00 - 9:05 Presentation of the Training Programme (C.Baroux).
9:05 - 10:30 Introduction to microscopy (H. Bauch).
10:45 - 11:15 Contrast Methods incl. Basics in Fluorescence Microscopy (H.Bauch).
11:15 - 11:45 Basics in Digital Imaging (H. Bauch).
11:45 - 13:00 Optical Sectioning and 3D Microscopy (H. Bauch).
14:00-18:00 Hands-On Rotation on CSLM, SIM and LSM – Session I

Day 2 : November 19th 2026

9:00 - 10:00 Challenges and solutions for optimal plant sample preparation (J.McKenna)
10:00 - 11:00 Designing an informed imaging workflow from sample preparation to image acquisition (C.Baroux)
11:00-13:15 Advanced Imaging Modalities for Plant Nuclei, Chromatin and Chromosome Studies (4 presentations, 30min each)
11:15 Multiphoton microscopy, Stimulated Emission Depletion Microscopy (C.Baroux)
11:45 Structured Illumination Microscopy, Spinning-Disk Confocal (J McKenna)
12:15 Structured Illumination Microscopy, Single-Molecule Localization Microscopy (V.Schubert)
12:45 Light sheet fluorescence microscopy (M.Cuacos)
14:00-18:00 Hands-On Rotation on CSLM, SIM and LSM – Session II

Day 3 : November 20th 2026

09:00-13:00 Hands-On Rotation on CSLM, SIM and LSM – Session III
14:00 Course Wrap Up and Evaluation