CH922-10 Microscopy and Imaging

26/27

Department
Chemistry
Level
Taught Postgraduate Level
Module leader
Anne Straube
Credit value
10
Module duration
10 weeks
Assessment
50% coursework, 50% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module provides a foundation in the principles and applications of microscopy, starting with basics of light microscopy and progressing to state of the art superresolution microscopy, electron microscopy and scanned probe microscopy. The latter includes atomic force microscopy and electrochemical imaging techniques for which Warwick is particularly well-known. The module includes workshops on image analysis and seminars that cover the most recent developments in the field.

Module web page

Module aims

Aim: To introduce students from a range of different backgrounds to the latest techniques for high resolution imaging and image processing. In each case, a comprehensive understanding of a microscopy technique will be motivated by the theory of how an image is formed in the instrument and what determines its resolution and quality. A practical on image processing will range from everyday tasks that students encounter when working with images of different sources to more advanced techniques of quantitative imaging. At the end of the module, the students will be able to assess the relative merits of the various microscopy techniques and understand the advantages and limitations of each. They will have acquired a solid background to independently solve more

complex image processing problems and rigorously assess the quality of images in scientific publications.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

The focus is on high resolution techniques (spatial and time) capable of providing new insights into the structure and function of biomolecules and biomolecular assemblies (artificial systems and living cells). Recent advances in powerful new microscopy techniques will receive particular attention. For each technique considered, basic principles and theory, instrumentation, experimental considerations and sample preparation will be covered. (The structure of the course is designed in a modular way such that it is possible for other researchers to attend specific parts.) Topics will include:

- Light microscopy: Principles of light microscopy with an emphasis on fluorescence microscopy. Super-resolution techniques. Live cell imaging. Force measurements.
- Image Processing: Introduction to digital image processing with ImageJ, Convolutions and filtering, Working with colour images, Working with time-series, Filtering in frequency space, Deconvolution.
- Atomic force microscopy (AFM): Intermolecular forces, imaging techniques (contact versus tapping mode), force curve analysis: ligand-receptor binding, elasticity measurements.
- Scanning tunnelling microscopy (STM): Atomic level imaging, scanning tunnelling spectroscopy (STS) and conductivity measurements, electrochemical STM.
- Electrochemical Scanned Probe Microscopy (Scanning electrochemical microscopy (SECM) and Scanning Ion Conductance Microscopy (SICM): Theory of transport and diffusion phenomena , imaging, probing surface reactivity (e.g. immobilised enzyme kinetics, membrane transport, lateral diffusion in membranes), ion channel activity, smart patch clamping., signalling in cell assemblies.
- Cryo electron microscopy: Review of electron microscopy, advantages, disadvantages, applications.

Learning outcomes

By the end of the module, students should be able to:

- (a) Subject knowledge and understanding: Understand imaging techniques and their application in structural and chemical characterisation of cellular dynamics, biophysical and materials systems on a wide range of length scales and environments. What signal the instrument produces and how that is transformed into the output the user receives. How the instrument output is used to deduce information, particularly on structure, properties and dynamics. How to improve signal:noise, sample environment and resolution (space and time). How images are formed and methods for their quantitative analysis.
- (b) Key Skills: Explain how a wide range of different types of microscopes work and how to prepare samples and collect data for each technique studied. Design image analysis approach and explain how to use the data to deduce structure, interactions, and dynamics.

- (c) Cognitive Skills: Critically evaluate the relative merits and limitations of light microscopy, electron microscopy and scanned probe microscopy techniques. Demonstrate how to automate image analysis problems and verify analysis routines..
- (d) Subject-Specific/Professional Skills: Faced with a new problem, students will be capable of choosing the most appropriate method and be able to analyse data and understand the type of information that the technique provides.

Indicative reading list

Reading lists can be found in Talis

Interdisciplinary

Students learn how to use physical methods and mathematical image manipulation to understand biological systems.

Subject specific skills

Subject knowledge and understanding:

- Understand the range of microscopy techniques that can be used in characterisation of surfaces, interfaces, cells, molecules and materials.
- Understand the construction and operation of a wide range of microscopes and the origin of measured signal.
- Know what signal the microscope produces and how that is transformed into the image the user receives.
- Understand how to analyse and derive information from images
  Key Skills
- Ability to present on work undertaken and answer questions.
  Cognitive Skills:
- The key challenge for this module is for mathematical scientists to be able to analyse experimental imaging data and for life scientists to understand the mathematical processes of image analysis.
  Subject-Specific/Professional Skills:
- Know how to prepare samples and collect data for each microscopy technique studied.
- Know how to analyse data from each technique.
- Know how to use the data to deduce information about surfaces, interfaces, molecules and materials.
- Understand instrument output versus data file produced.
- Understand limitations of each technique

Transferable skills

Communication skills (verbal and written)
Problem solving skills
Information and digital literacy (coding)

Critical thinking

Study

Study time

Type	Required
Lectures	11 sessions of 2 hours (55%)
Demonstrations	1 session of 2 hours (5%)
Practical classes	8 sessions of 2 hours (40%)
Total	40 hours

Private study description

No private study requirements defined for this module.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group C4

	Weighting	Study time	Eligible for self-certification
Assessment component			
Image Analysis Presentation	50%	30 hours	No
Presentation on image analysis group work on macro programming to automate an image analysis task and verification through manual analysis, answering questions from the audience			
Reassessment component			
Image Analysis			No

	Weighting	Study time	Eligible for self-certification
Presentation Presentation on image analysis task using macro programming to automate an image analysis task and verification through manual analysis, answering questions from the audience			

Assessment component

Oral examination Oral exam with two lecturers	50%	30 hours	No

Reassessment component is the same

Feedback on assessment

Feedback on performance in the group presentation and examination can be made available orally, along with the marks.

Past exam papers for CH922

Availability

Courses

This module is Core for:

- Year 1 of TCHA-F1PY Postgraduate Taught Analytical Science and Instrumentation
- Year 1 of TCHA-F1PL Postgraduate Taught Molecular Analytical Science
- TBSA-C1P9 Postgraduate Taught Systems Biology
    - Year 1 of C1P9 Systems Biology
    - Year 1 of C1P9 Systems Biology
    - Year 2 of C1P9 Systems Biology

This module is Core optional for:

- TMDA-B91Z Postgraduate Taught Interdisciplinary Biomedical Research
    - Year 1 of B91Z Interdisciplinary Biomedical Research
    - Year 1 of B91Z Interdisciplinary Biomedical Research

This module is Optional for:

- Year 1 of TCHA-F1PX Postgraduate Taught Analytical and Polymer Science
- Year 1 of ULFA-C1A2 Undergraduate Biochemistry (MBio)

- Year 1 of ULFA-C1A1 Undergraduate Biological Sciences (MBio)
- Year 1 of ULFA-C1A3 Undergraduate Biomedical Science (MBio)
- Year 4 of UMDA-CF10 Undergraduate Integrated Natural Sciences (MSci)

This module is Core option list A for:

- Year 2 of TCHA-F1PY Postgraduate Taught Analytical Science and Instrumentation

This module is Core option list B for:

- Year 1 of TCHA-F1PY Postgraduate Taught Analytical Science and Instrumentation

This module is Option list A for:

- Year 1 of RCHA-F1P9 Postgraduate Research Analytical Science