CH922-10 Microscopy and Imaging

21/22

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 confocal 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, with an emphasis on soft matter and materials. 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.

1. Outline Syllabus
   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. Parallelisation and high throughput analysis and the underlying principles will be taught. 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 and confocal microscopy. Novel super-resolution techniques. Time-series and high-throughput techniques.
- 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 understandingUnderstand imaging techniques and their application in structural and chemical characterisation of 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 biophysical and materials 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 SkillsKnow how a wide range of different types of microscopes workKnow how to prepare samples and collect data for each technique studied.Know how to analyse data from

each technique.Know how to use the data to deduce structure, interactions, and dynamics.Ability to write reports on practicals undertaken.Able to present the results of research to the class.Ability to coordinate an experiment in a small team.

- (c) Cognitive SkillsThe key challenge for this module is for mathematical scientists to be able to collect experimental data and for physical scientists to understand the mathematical processes of data manipulation.
- (d) Subject-Specific/Professional SkillsFaced 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

Illustrative Biography

1. Atomic Force Microscopy for Biologists, VJ Morris, AR Kirby, AP Gunning, Imperial College Press.
2. Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications, D Bonnell, Wiley-VCH.Confocal Laser Scanning Microscopy, CJR Sheppard, DM Hotton, D Shotton, Springer-Verlag.
3. Scanning Electrochemical Microscopy, AJ Bard and MV Mirkin, Marcel Dekker.
4. The Image Processing Handbook, John C. Russ, CRC Press.
5. Handbook of biological confocal microscopy. 3rd edition. James Pawley (Editor). Springer, 2006.

Subject specific skills

Subject knowledge and understanding:

- Understand the range of microscopy techniques that can be used in characterisation of surfaces, interfaces, 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 write reports on work undertaken.
- Ability to present the results of frontier research as a short article for a general scientific audience.
  Cognitive Skills:
- The key challenge for this module is for mathematical scientists to be able to analyse experimental imaging data and for physical 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.

Transferable skills

TBC

Study

Teaching split

Provider	Weighting
Warwick Medical School	70%
Physics	5%

Study time

Type	Required
Lectures	11 sessions of 2 hours (22%)
Demonstrations	1 session of 2 hours (2%)
Practical classes	8 sessions of 2 hours (16%)
Assessment	60 hours (60%)
Total	100 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 C1

	Weighting	Study time
Assignment 1	20%	12 hours
Assessed coursework: image analysis task (implementation of filter) and peer-peer feedback		
Assignment 2	30%	18 hours
assessed coursework: image analysis task (implementation of segmentation, counting and/or tracking procedure into a macro), report		
Oral examination	50%	30 hours
Oral exam with two lecturers		

Feedback on assessment

Written work will be annotated and returned to students, while performance in the oral examinations can be made available orally, along with the marks.

Past exam papers for CH922

Availability

Courses

This module is Core for:

- TCHA-F1PL Postgraduate Taught Molecular Analytical Science
  - Year 1 of F1PL Molecular Analytical Science
  - Year 1 of F1PL 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-F1PB MSc in Chemistry with Scientific Writing
- Year 1 of TCHA-F1PX Postgraduate Taught Analytical and Polymer Science
- TCHA-F1PE Postgraduate Taught Scientific Research and Communication
  - Year 1 of F1PE Scientific Research and Communication
  - Year 2 of F1PE Scientific Research and Communication

- 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)

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:

- RCHA-F1P9 Postgraduate Research Analytical Science
    - Year 1 of F1P9 Analytical Science
    - Year 1 of F1P9 Analytical Science