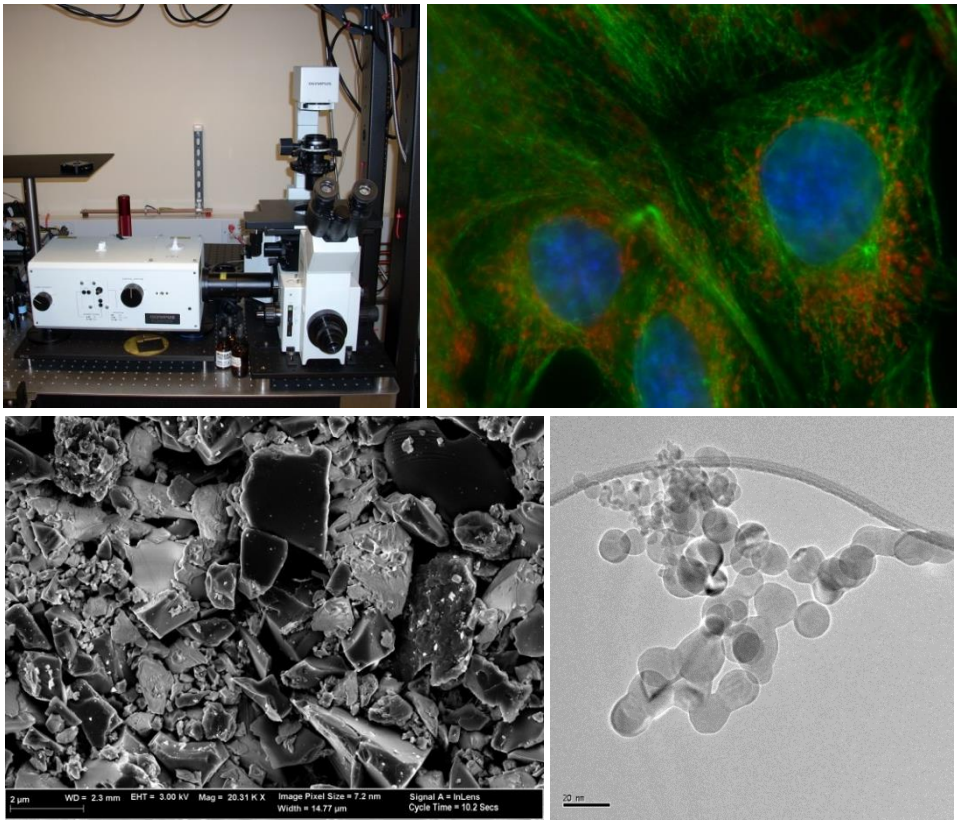
BIOS E-170: Introduction to Microscopy

Harvard Extension School, Fall 2015

Wednesdays, 5:30pm-7:30pm



Instructors:

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Course Description:

This comprehensive course on microscopy techniques introduces students to both the theory and practical use of modern microscopes. The course features lectures on the basic physical principles behind the most common modern microscopy techniques. We cover introduction to optics, principles of image formation, light microscopy techniques, principles of fluorescence, digital imaging, confocal microscopy, TIRF, STORM/PALM, STED, FRET-FLIM, and FRAP techniques, structured illumination, two-photon fluorescence, second harmonic generation, vibrational imaging, scanning probe microscopy (SPM) techniques, atomic force microscopy (AFM), electron microscopy (SEM, TEM and STEM), and X-ray microscopy/microCT. The lectures are reinforced with the laboratory sessions featuring extensive demonstrations and hands-on exercises on a wide variety of microscopes. These sessions are held in the state-of-the-art laboratories of the Center for Nanoscale Systems (CNS) at Harvard University. This course is designed to provide students and researchers from various fields a comprehensive and practical introduction to modern microscopy techniques and a background in modern optical research tools.

Prerequisites:

No prior knowledge of microscopy techniques is required for this course. One year each of college-level calculus and physics, or permission of the instructors is required.

Intended Audience:

This course is geared towards students and researchers in biology, medicine, physical sciences, and engineering interested in learning both the theory and practical uses of modern microscopy techniques.

Class Times and Locations:

Weekly on Wednesdays starting Sept. 2, 5:30pm-7:30pm
11 Oxford Street, LISE 303, Cambridge, MA 02138

Required Textbook:

There is no required textbook for this course. The course presentations, handouts and assigned readings will be provided on the course website.

Suggested Textbooks:

- "Fundamentals of Light Microscopy and Electronic Imaging" by Douglas B. Murphy and Michael W. Davidson (ISBN: 047169214X)
- "Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol. set)" by David B. Williams and C. Barry Carter (ISBN: 0387765026)
- "Atomic Force Microscopy" by Peter Eaton and Paul West (ISBN: 0199570450)

Other Textbooks:

- "Imaging: A Laboratory Manual" by Rafael Yuste (Editor) (ISBN: 0879699361)
- "Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM" by Ray F. Egerton (ISBN: 1441938370)
- "Low Voltage Electron Microscopy: Principles and Applications" by David C. Bell and Natasha Erdman (ISBN: 111997111X)
- "MicroComputed Tomography: Methodology and Applications" by Stuart R. Stock (ISBN: 1420058762)

Web Resources:

http://microscopyu.com/

http://zeiss-campus.magnet.fsu.edu/

http://www.leica-microsystems.com/science-lab/

http://olympusmicro.com/

http://www.microscope-microscope.org/

http://www.fei.com/Education-Resources/

Graduate Credit:

Students taking this course for graduate credit will be responsible of writing and submitting an individual final paper, in addition to the requirements set forth for undergraduate credit. The subject of the paper for each student will be discussed with the corresponding instructor (depending on the area of expertise; see below) and finalized during the first two weeks of the course. The paper should be 3-5 pages of written material. If there are any images, pictures, drawings etc. they should be titled as "Figure #: <description>", referenced in the main text, and appended on additional pages. Each page should have 1-inch margins all around, and the font size should be 11 or 12 points (titles could be larger). The text should be single-spaced.

David Bell – Electron Microscopy

Fettah Kosar – Scanning Probe Microscopy, X-ray Microscopy/MicroCT

Arthur McClelland – Light Microscopy, Vibrational Imaging

Grading:

<u>Undergraduate Credit:</u>
Class Participation and Preparedness – 10%
Lab Session Reports – 20%
Midterm Exam – 30%
Final Exam – 40%

<u>Graduate Credit:</u>
Class Participation and Preparedness – 10%
Lab Session Reports – 20%
Midterm Exam – 20%
Final Exam – 30%
Final Paper – 20%

Attendance:

Attendance and active participation at each classroom and laboratory session is an essential part of the coursework and part of the final grade. Since laboratory sessions are vital to learning the practical aspects of the techniques presented during the classroom lectures, they are an integral part of this course. One cannot expect to finish the course successfully without attending them all. Unexcused absences are not acceptable. Any laboratory session with an excused absence has to be rescheduled with the instructor as a one-on-one session. ("Excused absences" are medical and family emergencies and other life-altering events.)

Laboratory Reports:

Each student will be responsible of writing a short laboratory report summarizing each laboratory session and turning it in at the beginning of the next class. The report should be between 1-2 pages long. It should summarize in student's own words what she/he have learned and worked on during the last laboratory session. It should also include the advantages and disadvantages of each microscopy technique covered and discuss what types of samples are appropriate and why. If there are any images, pictures, drawings etc. they should be titled as "Figure #: <description>", referenced in the main text, and appended on additional pages. Each page should have 1-inch margins all around, and the font size should be 11 or 12 points (titles could be larger).

Course Website:

https://canvas.harvard.edu/courses/4245

Disability Services:

The Extension School is committed to providing an accessible academic community. The Disability Services Office offers a variety of accommodations and services to students with documented disabilities. For more information, please visit:

www.extension.harvard.edu/resources-policies/resources/disability-services-accessibility

Plagiarism:

You are responsible for understanding Harvard Extension School policies on academic integrity (www.extension.harvard.edu/resources-policies/student-conduct/academic-integrity) and how to use sources responsibly. Not knowing the rules, misunderstanding the rules, running out of time, submitting "the wrong draft", or being overwhelmed with multiple demands are not acceptable excuses. There are no excuses for failure to uphold academic integrity. To support your learning about academic citation rules, please visit the Harvard Extension School Tips to Avoid Plagiarism (www.extension.harvard.edu/resources-policies/resources/tips-avoid-plagiarism), where you'll find links to the Harvard Guide to Using Sources and two, free, online 15-minute tutorials to test your knowledge of academic citation policy. The tutorials are anonymous open-learning tools.

Date	Lecture Topics	Instructor
Sep. 2	History of Microscopy, Overview of Current Microscopy Techniques	Bell, Kosar
Sep. 9	Introduction to Optics (Geometric and Wave)	Kosar
Sep. 16	Components of a Light Microscope, Compound Light Microscope and Its Variations, Brightfield, Darkfield, Phase Contrast, Polarized, DIC	McClelland
Sep. 23	Light Microscopy Advanced Techniques 1: Wide Field Fluorescence, Sample Prep, STORM/PALM, Confocal, TIRF	McClelland
Sep. 30	**Lab Session (Light Microscopy Part 1)**	Kosar, McClelland
Oct. 7	Light Microscopy Advanced Techniques 2: Detectors, Deconvolution, Structured Illumination, Two Photon Fluorescence, Second Harmonic Generation, STED, FRET-FLIM, FRAP	McClelland
Oct. 8	**Take-Home Midterm Exam posted on website**	
Oct. 11	**Take-Home Midterm Exam due 11:59pm**	
Oct. 14	**Lab Session (Light Microscopy Part 2)**	Kosar, McClelland
Oct. 21	Scanning Probe Microscopy: AFM, STM, MFM	Kosar
Oct. 28	Vibrational Imaging: IR, Raman, CARS, SRS	McClelland
Nov. 4	**Lab Session (AFM and Vibrational Imaging)**	Kosar, McClelland
Nov. 11	Transmission Electron Microscopy (TEM), STEM	Bell
Nov. 18	Scanning Electron Microscopy (SEM)	Bell
Nov. 25	**THANKSGIVING BREAK – NO CLASS**	
Dec. 2	X-ray Microscopy and Micro-Computed Tomography (CT) + **Lab Session (X-ray µCT)**	Kosar
Dec. 9	**Lab Session (SEM and TEM Part 1)**	Bell
Dec. 10	**Take-Home Final Exam posted on website**	
Dec. 13	**Take-Home Final Exam due 11:59pm**	
Dec. 16	**Lab Session (SEM and TEM Part 2)**	Bell