

MCDB 4312/5312
Quantitative Optical Imaging

Time:

Fall 2017
MWF, 11:30-12:20

Location:

JSCBB B331

Office hours:

Monday 1-2 PM
Thursday 10-11 AM
JSCBB 3rd floor, A-wing common area

Instructor:

Joel Kralj, PhD
MCD Biology/BioFrontiers Institute
Office: JSCBB A321
Phone: 303 492-2642
Email: Quant.Optics@colorado.edu

Class description:

This class is designed to explore the fundamentals of optical imaging in biology. Covered topics include an introduction to optics and microscopes, fluorescence microscopy, probes and biosensors, and image analysis. MATLAB will be taught throughout the course and used for image processing. At the end of the class, students will be able to recognize the strengths and limitations of imaging techniques as well as analyze digital images of cells and molecules.

Optional Textbook and Resources:

“Fundamentals of Light Microscopy and Electronic Imaging, 2nd Edition”

Douglas B. Murphy, Michael W. Davidson

ISBN: 978-0-471-69214-0

This is a useful text with information on the nature of light, specific imaging modalities, and basics on image processing.

“From Photon to Neuron: Light, Imaging, Vision”

Philip Nelson

ISBN: 978-1-400-885-480

This is a very interesting, but much more mathematically inclined, book that covers the nature of light and how biological systems deal with light as a physical quantity.

Web resources:*General Microscopy*

Microscopy U - <http://www.microscopyu.com/> (Nikon)

Microscopy Resource Center - <http://www.olympusmicro.com/> (Olympus)

Zeiss Campus - <http://zeiss-campus.magnet.fsu.edu/index.html> (Zeiss)

Matlab

Matlab Onramp: <https://matlabacademy.mathworks.com/>

Intro to matlab (PDF) -

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0ahUKEwjYm8jdlbfOAhUX9mMKHVwaBywQFgg1MAI&url=https%3A%2F%2Fwww.mccormick.northwestern.edu%2Fdocuments%2Fstudents%2Fundergraduate%2Fintroduction-to-matlab.pdf&usg=AFQjCNEuH8v-uDmcq-fEDIAjpsUV3yV5ww&sig2=FfbgSmx_AxHaZyOrnBY2FQ&cad=rja

Basic image processing - <http://www.mathworks.com/help/images/getting-started-with-image-processing-toolbox.html>

Image processing - <http://www.getreuer.info/tutorials/matlabimaging>

Graduate Credit:

Graduate students can also be enrolled in a 1 credit practical class. This class meets weekly for 1 hour to use microscopes in the BioFrontiers Advanced Imaging Core to answer fundamental questions about optics and microscopy and is led by Joe Dragavon. Students will have additional homeworks in the section, and will be required to design, perform, and analyze measurements on live cells.

Grading:

10% Class attendance/discussion

40% Homeworks

15% Midterm 1 – 2017-09-27

15% Midterm 2 – 2017-11-01

20% Final exam – 2017-12-19 (4:30 – 7:00)

Topics:**Unit 1: Light and optics**

1. Fundamentals of Light and color
2. Intro to refraction, lenses and ray optics
3. Images, virtual images, and magnification

4. Reflection, diffraction and microscope components
5. Diffraction, spatial resolution, and NA
6. Aberrations and corrections
7. Light sources, speckle

Unit 2: Microscopy contrast mechanisms

8. Phase contrast and dark field microscopy
9. Polarized light and microscopy
10. DIC microscopy
11. Fundamentals of fluorescence
12. Dyes, proteins, and filters
13. Limitations of fluorescence and practical applications

Unit 3: Techniques in fluorescence

14. Imaging in cells: FRET and TIRF
15. Imaging in cells: FRAP, photoactivation, and FLIM
16. Principles of biosensors
17. Sensing pH, calcium, voltage, ATP etc...
18. High content screening
19. Confocal optics
20. Spinning disk confocal
21. Superresolution techniques 1
22. Superresolution techniques 2
23. Multiphoton fluorescence
24. Adaptive optics
25. Imaging live cells, light sheet, Bessel
26. Imaging live cells, light field, ultra wide field

Unit 4: Image detection and analysis

27. Fundamentals of digital detectors
28. Noise and sensitivity
29. Image analysis: Contrast, gamma correction, and histograms
30. Image analysis: Filters and segmentation 1
31. Image analysis: Filters and segmentation 2
32. Image analysis: Time course analysis
33. Image analysis: Cell tracking
34. Image analysis: Cell tracking 2

Administrative:

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<http://www.colorado.edu/policies/classbehavior.html> and at

http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

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