Chemistry 668

Biophysical Spectroscopy

Syllabus

- Fall 2019 -

LECTURES:	8:50 – 9:40 a.m. Mon, Wed, Fri, rm. 8335 Chemistry (typically two lectures/week, often on Mon and Wed, unless otherwise stated). See schedule below for details.
LECTURER:	Prof. Silvia Cavagnero Office: 5357 Chemistry Phone: 262-5430 Email: cavagnero@chem.wisc.edu
OFFICE HOURS:	After class: 9:40 - 10:40 a.m., and by appointment
WEB SITE:	https://canvas.wisc.edu/courses/170455 use your UW login and password to access Canvas, click on the Chem668: Biophysical Spectroscopy icon to enter the class web site

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Course description: Chemistry 668 focuses on fundamental principles and applications of spectroscopic and microscopy methods commonly employed to solve biological problems at molecular and atomic resolution. Techniques covered in this class include electronic absorption and fluorescence spectroscopy, general aspects of microscopy, fluorescence microscopy, circular dichroism, light scattering, multidimensional nuclear magnetic resonance, X-ray crystallography and cryo-electron microscopy.

Requisites: While there are no official pre-requisites for this class, undergraduate-level physical chemistry classes Chem 561 and Chem 562 or equivalent are recommended.

Course Designations: Advanced level; physical science breadth; counts as L&S credit.

Instructional mode: Face-to-face.

Number of credits: 2-3: The variable number of credits provides interested students with the opportunity of earning one extra credit by composing a written report on a biological problem-solving case study using biophysical spectroscopy, due at the end-of-the-semester.

Credit-hour policy standards: The course meets the credit-hour policy standard by offering 2 weekly lectures, with the expectation that students will work on course learning activities for about 2 hours out of classroom for every class period. Learning activities include in-class attendance, participation and discussion, reading, studying, problem sets, and a final oral presentation. The instructor will have 2 weekly office hrs to facilitate and foster student learning.

Learning outcomes: The expected learning outcomes of this course are the acquisition of a thorough knowledge of the fundamental principles of spectroscopy and their applications to biological systems. The primary objective of this course is to enable students gain a deep understanding and, in some cases acquire predictive power, on how chemical and biological processes work.

Textbook:

W.W. Parson *"Modern Optical Spectroscopy with Exercises and Examples from Biophysics and Biochemistry", 2nd edition,* Springer-Verlag, Berlin, 2015

Other Useful Books & Resources:

Physical Chemistry and Spectroscopic Techniques:

I. Tinoco, K. Sauer, J.C. Wang, J.D. Puglisi *"Physical Chemistry, Principles and Applications to Life Sciences",* Prentice Hall, 2002

D. Sheehan *"Physical-Biochemistry-Principles and Applications",* 2nd ed., Wiley, 2008 (*ebook)*

I.N. Serdyuk, N.R. Zaccai, J. Zaccai, "*Methods in Molecular Biophysics"*, Cambridge Un. Press, 2007

C.R. Cantor, P.R. Schimmel *"Biophysical Chemistry, Vol. II "Techniques for the Study of Biological Structure and Function",* W.H. Freeman, 1980

Fluorescence:

J. R. Lakowicz *"Principles of Fluorescence Spectroscopy"*, 3rd ed., Springer, 2006 (*ebook)*

Optics and Microscopy:

D.B. Murphy *"Fundamentals of Light Microscopy and Electronic Imaging",* 2nd ed., Wiley-Liss, 2013 (*ebook)*
Molecular Expression web site: http://micro.magnet.fsu.edu/, and
Nikon online tutorials: www.microscopyu.com

Single-Molecule Techniques:

C. Gell, D. Brockwell, A. Smith *"Handbook of Single Molecule Techniques",* Oxford Un. Press, 2006

D.E. Makarov *"Single Molecle Science – Physical Principles and Models",* CRC Press, 2015

YouTube lecture on super-resolution microscopy by Xiaowei Zhuang (parts 1 and 2)

Nikon online tutorials: www.microscopyu.com

NMR Spectroscopy:

J. Keeler *"Understanding NMR Spectroscopy",* Wiley, 2010

G.S. Rule, T.K. Hitchens *"Fundamentals of Protein NMR Spectroscopy"*, Springer, 2005

Electron and Cryo-Electron Microscopy:

YouTube lecture: "Introduction to Electron Microscopy" by Eva Nogales

YouTube lecture on "Single Particle Cryo-EM" by Yifan Chen

YouTube lecture on "A On-line Cryo-EM Course" by Grant Jensen

Protein-Protein Interactions:

P. Schuck "Protein Interactions - *Biophysical Approaches for the Study of Complex Reversible Systems*" (vol 5), Springer 2007 (*ebook)*

General Physical Chemistry:

P. Atkins, J. de Paula *"Physical Chemistry"*, 9th Ed., W.H. Freeman, 2009

I. Levine *"Physical Chemistry"*, 6th Ed., McGraw-Hill, 2008

D.A. McQuarrie, J.D. Simon *"Physical Chemistry: A Molecular Approach"*, University Science Books, 1997

K.E. van Holde, W.C. Johnson, P.S. Ho *"Physical Biochemistry",* Prentice Hall, 1998

NOTE: Some of the above books are available in ebook format and can be accessed via the UW-Madison CATALOG at www.library.wisc.edu. The other books are on reserve at the Chemistry or Steenbock Library.

Grading scheme:

2-credits:
30% attendance and participation to class
30% homeworks and literature assignments
40% oral or poster presentation

3-credits:
30% attendance and participation to class
30% homeworks and literature assignments
20% oral or poster presentation
20% written report

Poster and oral presentations: 10 min oral presentations to be delivered to the class either during class or as a Biophysical Spectroscopy poster session. The oral presentations will be in class as outlined in the schedule below. The poster sessions will be during the last week of classes (see schedule below). Student evaluation will be based on the quality of the slides, ability to integrate spectroscopic insights and problem-solving strategies, oral delivery and effectiveness in answering questions. Please select your favorite presentation delivery style (oral presentation or poster) at the end of the first class.

Lecture schedule:

Wed 9-4-19	Introduction to Spectroscopy: choosing the right technique(s) to solve biological problems *(NOTE: class will be on Wed and Fri this week)*
Fri 9-6-19	Introduction to Spectroscopy: basic principles (foundations of quantum mechanics
Mon 9-9-19	Introduction to Spectroscopy: basic principles (interaction of light with matter)
Wed 9-11-19	Introduction to Spectroscopy: basic principles (interaction of light with

matter)

Fri 9-13-19	*No class*
Mon 9-16-19	Introduction to Spectroscopy: basic principles (sensitivity and resolution), and Electronic absorption: basic principles
Wed 9-18-19	Electronic absorption: basic principles and applications
Fri 9-20-19	*No class*
Mon 9-23-19	Electronic absorption: basic principles and applications
Wed 9-25-19	Electronic absorption: more applications
Fri 9-27-19	*No class*
Mon 9-30-19	Fluorescence spectroscopy: general principles
Wed 10-2-19	Fluorescence spectroscopy: general principles
Fri 10-4-19	*No class*
Mon 10-7-19	*No class* *(NOTE: class will be on Wed and Fri this week)*
Wed 10-9-19	Fluorescence spectroscopy: lifetimes, spectral shifts, instrumentation
Fri 10-11-19	Fluorescence spectroscopy: lifetimes, spectral shifts, instrumentation
Mon 10-14-19	Fluorescence spectroscopy: principles of energy transfer and distance-dependent quenching *(NOTE: there will be three lectures on Mon, Wed, Fri this week)*
Wed 10-16-19	Fluorescence spectroscopy: applications of energy transfer
Fri 10-18-19	Fluorescence spectroscopy: anisotropy principles and applications
Mon 10-21-19	General principles of microscopy and molecular imaging (Campagnola)
Wed 10-23-19	Single-molecule fluorescence microscopy: wide field illumination, CONFOCAL, PALM / FPALM / STORM, TIRF
Fri 10-25-19	*No class*
Mon 10-28-19	How do ion channels work? Insights from fluorescence (Chanda)
Wed 10-30-19	Dynamic and static light scattering: principles and applications (Murphy)
Fri 11-1-19	*No class*
Mon 11-4-19	Small angle X-ray scattering (SAXS)
Wed 11-6-19	Circular dichroism: principles
Fri 11-8-19	*No class*
Mon 11-11-19	Circular dichroism: applications
Wed 11-13-19	In-class group work on optimal technique selection, practical tips, and how to prevent pitfalls

Fri 11-15-19	*No class*
Mon 11-18-19	*No class*
	(NOTE: class will be on Wed and Fri this week)
Wed 11-20-19	X-ray crystallography: basic principles and applications (Rayment)
Fri 11-22-19	X-ray spectro-microscopy: principles and applications (Gilbert)
Mon 11-25-19	NMR spectroscopy: basic principles
Wed 11-27-19	NMR spectroscopy: selected applications
Fri 11-29-19	*No class (Thanksgiving break)*
Mon 12-2-19	Cutting-edge techniques: Cryo-electron microscopy (*guest lecturer*)
	(NOTE: there will be three lectures on Mon, Wed, Fri this week)
Wed 12-4-19	Multi-technique approaches to study protein-protein interactions
Fri 12-6-17	Problem solving in biology using multiple techniques: class discussion
Mon 12-9-19	**Student Oral Presentations** (during class)
	Student Poster Presentation #1 (12 - 4 pm, in Shain Atrium, Chemistry)
Wed 12-11-19	Student **Oral Presentations** (during class)
	Student Poster Presentation #2 (12 - 4 pm, in Shain Atrium, Chemistry)

<u>WRITTEN REPORT DUE DATE</u>

This note is directed to the students taking the course for 3 credits: the **written report** is due on Fri Dec 13 by 9 pm.