**Methods in Biophysical Chemistry – CH 8613**
**Course Syllabus**

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*Catalog Description*

> CH 8613. Methods in Biophysical Chemistry. (3) Three hours lecture. Discussion of the physical methods and conceptual models used to describe the behavior of biological macromolecules and biochemical reactions.

*Overview*

Many of the advances in modern biochemistry have occurred because of the intense effort scientists have devoted to studying biomolecular function. By applying the principles of physical chemistry to biological systems, we have learned much about the chemistry of life, and we have started to understand the molecular basis of human disease. This class is designed to build upon an undergraduate background in physical chemistry and biochemistry; in it, we will study the behavior of proteins and DNA, and we will learn about several techniques that are commonly used to study biomolecular structure and function. We will also focus on how mathematical models can be used to describe protein and DNA behavior, and we will discuss in depth how those models can be related to experimental observables. When you have completed the course, you will be able to design and interpret experiments for studying biological macromolecules, and you will be able to apply biophysical concepts to understand how these systems work.

*Meeting Times / Attendance*

The course will meet Monday, Wednesday, and Friday from 8:00 to 8:50 AM in Hand Lab 3324. Because of the interactive nature of the lectures, attendance is mandatory for the course. Please contact the instructor if you must miss a class meeting.

Two exams will be given throughout the course, and these will be scheduled outside of class. The times and dates of these exams will be determined so all students can be present.

*Course Format*

The primary format for the course will be lecture; however, students will also have an opportunity to present journal-club discussions throughout the course. The lecture notes will be written on the board during the class, and occasionally PowerPoint slides or other visual aids will be used to supplement the course materials. These slides will be made available upon request, but in general you will be responsible for taking your own notes during class.

Journal discussions will occur throughout the semester. During each class period, two types of articles will be discussed: older "classic" articles, and newer articles describing the current state of biophysics research. Students will be selected to lead a class discussion on both types of articles, and all students will lead the journal presentation at least once during the semester (more details are given below). A portion of the attendance/participation grade will depend on class discussions of these journal articles.

*Reading / Textbook*

The primary textbook for the class is *Principles of Physical Biochemistry* by van Holde, Johnson, and Ho (2006 Pearson Education, Inc., ISBN 0-13-046427-9). In addition, we will use *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements* by Taylor (1996 University Science Books, ISBN 0-93-570275-X) to discuss models and model fitting. These books are available in the bookstore, but it may be cheaper for you to purchase them online (try www.addall.com). Readings from these books will be assigned throughout the course, and it is expected that you come to class having read the material.

In addition, the following texts may provide helpful information to supplement what is covered in the course. Many of these are classic biophysics text books and are worth having in your library if you plan to continue with biophysical research. You can often find them available used or on-line.

- Tinoco, Sauer, Wang, and Puglisi. (2003) *Physical Chemistry: Principles and Applications in the Biological Sciences.* Prentice Hall, Inc.
- Cantor and Schimmel (1980) *Biophysical Chemistry*. (Parts I, II, and III) W. H. Freeman and Company.
- Rule and Hitchens (2005) *Fundamentals of Protein NMR Spectroscopy*. Springer.
- Rhodes (2006) *Crystallography Made Crystal Clear: A Guide for Users of Macromolecular Models.* Academic Press.
- Glusker and Trueblood (2010) *Crystal Structure Analysis: A Primer*. Oxford.
- Atkins and de Paula. (2009) *Physical Chemistry*. W. H. Freeman and Company.
- Berg, Tymoczko, and Stryer. (2010) *Biochemistry*. W. H. Freeman and Company.

*Grade Distribution*

The grades for the course will be calculated according to the table below.

| **Course Component** | **Percentage** |
|---|---|
| Exams (2) | 40% |
| Homework (7) | 35% |
| Programing Assignment | 10% |
| In-Class Presentation(s) | 6% |
| Written Journal Summary | 4% |
| Attendance/Participation | 5% |

Details for these items are given on the following pages. Letter grades will be assigned using the standard grading scale, given below. At the instructor's discretion, final grades may be curved.

| **Final Grade** | **Final Course Grade** |
|---|---|
| 90 – 100 | A |
| 80 – 89 | B |
| 70 – 79 | C |
| 60 – 69 | D |
| 59 and below | F |

*Exams*

Two exams will be given during the semester. Although referred to as a "midterm" and a "final," the exams will not be cumulative. Each exam will count 20% toward your final grade. The exam format may be varied, and you should not expect the exams to be entirely multiple-choice. Because of the limited class time available for exams, the exams will be outside of class, at a time that is convenient for all students in the class. While the emphasis of each exam will be the material presented during class, you will also be tested on the assigned readings, including the journal presentations. There will be no cumulative final exam for the class.

*Homework*

Throughout the course, you will have seven bi-weekly problem sets to test you on the material taught. You will also have a long-term computer-based assignment to ensure that you learn a programming language. These assignments are graded and constitute 45% of your final course grade. Assignments will be graded on both completeness and correctness: for a majority of the problems, you will receive credit if you have shown effort and are mostly correct. Because of this, you should show all your work so that the instructor can follow your line of reasoning.

The first assignment (HW0) will be a programming assignment that requires you to learn a programming language to parse and process a PDB structure file. If you do not know how to program, you should begin learning *immediately*.

**Sloppy or illegible homework assignments will not be given credit!** You are responsible for submitting assignments that are easy to follow with justification given for each answer. If you cannot write legibly, type your answers. If there are large portions of your assignment that are crossed out or out of order, re-copy it to make it neater and easier to follow. Your assignments should be organized and stapled when you come to class.

The assignments will be collected at the beginning of the class period when they are due (see the schedule below). Late assignments will not be accepted unless prior arrangements have been made with the instructor.

*Presentations*

Several times during the semester, students will be required to lead a journal article discussion. These discussions will occur throughout the semester, and two articles will be discussed during the lecture. The journal article discussions have several goals: First, for the presenter, it is a valuable opportunity to develop public speaking and teaching skills. Second, it is a chance to see where current work in molecular biophysics is directed. Finally, it is a chance to look back at several classic papers and understand the context leading up to significant discoveries in biophysics.

The rubric for grading journal article presentations is attached at the end of the syllabus. The presentation grade will account for 10% of your final grade, and if you present multiple times, your presentation grades will be averaged. Depending on the size of the class, some students may present multiple times. If you have presented more than twice, your lowest presentation grade will be dropped from the average.

You are welcome to present your journal articles however you like: if you are comfortable using PowerPoint slides, a computer will be made available to you (or you can bring your own

computer). Alternatively, if you'd like to lead a discussion from the board, that's okay too, although it is recommended that you select some figures from the articles to discuss using the overhead display. Either way, **your presentation should last 15-20 minutes with 5-10 minutes additional for discussion.**

On the flip side, you should come to journal club having read the material deeply. Simply skimming the journal articles is not sufficient! The material covered in the journal articles will appear on your exams, regardless of whether the speaker has done a satisfactory job of presenting the material. I reserve the right to call on students directly if no one is willing to participate in discussion afterward.

*Journal Summaries*

On days when the instructor is unavailable (highlighted in orange below), you will be given a choice of two journal articles. You will be responsible for writing a two-page executive summary of one of these articles. Your summary should include a description of the key questions (hypotheses) addressed by the paper, the methods used, and the important findings. You should also discuss why the paper is significant.

Your summary must be written in single-spaced, 12-point Times New Roman font with one inch margins. At the top of your summary, include the ACS-formatted reference of the article you selected (examine any article in *J Am. Chem. Soc.* for an example of proper formatting). Your summary must be larger than 1.5 pages, and the summary itself must contain at least 750 words. Your grade will depend not only on the summary itself, but also grammar and your ability to follow directions.

*Attendance & Participation*

Attendance and participation constitute 5% of the final grade. Students are expected to arrive on time for lectures and stay through the entire lecture unless prior arrangements have been made with the instructor. Arriving more than 5 minutes late constitutes an ½ absence, arriving more than 30 minutes late constitutes a full absence. Two unexcused absences are permitted, after which the instructor will deduct 0.5% of the final grade for each absence. In addition, students are expected to ask questions throughout the journal article discussions – at least four questions throughout the semester. Excused absences do not count against the student. For more information on the absence policy, please visit http://www.policies.msstate.edu/policypdfs/1209.pdf.

*Office Hours*

Office hours are by appointment. You are welcome and encouraged to stop by my office to discuss the course material at any time, but I may need to reschedule our meeting if I am busy.

*Course Web Page*

The web page for this course is located at http://fitzkee.chemistry.msstate.edu/ch8613/. Please check this site frequently for course updates. You will be able to find PDF copies of this syllabus and other important course materials at this site.

*Supplemental Reading*

In the course schedule on the following pages, several places indicate additional reading to be completed before lecture (e.g "Reading #1"). These readings represent important papers that you should understand in addition to your textbooks. In most cases, you will be able to download these documents from the web; however, in some cases where a digital copy is not readily available you will receive a PDF of the document via email.

The list of readings is given below:

1. Kuriyan, Konforti, and Wemmer. *The Molecules of Life*, Chapter 1. Available for free at the Garland Science website: http://www.garlandscience.com/product/isbn/9780815341888

2. Johnson, M. L. (1992) *Anal. Biochem.* **206**: 215.

3. Dill, K. A. (1990) *Biochemistry.* **29**: 7133.

4. Rose, G. D., *et al*. (2006) *PNAS*. **103:** 16623.

5. Dill, K. A. and Chan, H. S. (1997) *Nat. Sturct. Biol.* **4:** 10.

6. Zanni, M. T., and Hochstrasser, R. M. (2001) *Curr. Op. Struct. Biol.* **11**: 516.

7. Wütrich, K. (2003) *J. Biomol NMR.* **27**: 13.

8. Lewis, E. A. and Murphy, K. P. (2005) *Meth. Mol. Biol.* **305:**1.

9. Johnson, C. M. (2013) *Arch. Biochem. Biophys.* **531:** 100.

10. Cantor and Schimmel. *Biophysical Chemistry Part II: Techniques for the Study of Biological Structure and Function*. Chapter 13. Will be provided in class.

Additional readings may be assigned throughout the course.

*Academic Integrity*

Collaboration is encouraged in this course, but all students are expected to complete their own assignments and submit their own work. Failure to do so not only cheats the system, but also diminishes your own understanding of the material. Instances of plagiarism and cheating will be addressed according to the Student Honor Code. In severe cases of academic dishonesty, students will be dropped from the class with an XF grade and will be required to take a class in academic integrity to have the "X" sanction removed. You are encouraged to read the Student Honor Code, available on the Honor Code Office website, http://www.honorcode.msstate.edu/.

Mississippi State has an approved Honor Code that applies to all students. The code is as follows: "As a Mississippi State University student, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do." Upon accepting admission to Mississippi State University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning, and to follow the philosophy and rules of the Honor Code. Student will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the MSU community from the requirements or the processes of the Honor Code. For additional information, please visit: http://honorcode.msstate.edu/policy.

*Title IX Compliance and Sexual Misconduct*

MSU is committed to complying with Title IX, a federal law that prohibits discrimination, including violence and harassment, based on sex. This means that MSU's educational programs and activities must be free from sex discrimination, sexual harassment, and other forms of sexual misconduct. If you or someone you know has experienced sex discrimination, sexual violence and/or harassment by any member of the University community, you are encouraged to report the conduct to MSU's Director of Title IX/EEO Programs at (662) 325-8124 or by e-mail to titleix@msstate.edu. Additional resources are available at http://www.msstate.edu/web/security, or at http://students.msstate.edu/sexualmisconduct/.

Note that, as your instructor, I am required by law to report any incident of sexual misconduct against a student of which I am made aware. Students wishing to speak confidentially with a professional are encouraged to call the sexual assault hotline at (662) 325-2091. This line is staffed by trained counselors and ensures your privacy should you choose to maintain it.

*Tentative Schedule of Topics*

| **Week 1** | | | |
|---|---|---|---|
| **Date** | **Description** | **Reading** | **Assignment** |
| | | | |
| August 17 | Introduction; Protein Structure I | VH: 1.1-1.3<br>Reading #1 | HW0 (out)<br>HW1 (out) |
| August 19 | Protein structure II | VH: 1.5 | |
| **Week 2** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| August 22 | DNA structure | VH: 1.5-1.6 | |
| August 24 | Review of uncertainties and experimental error | T: Chapt. 1-5 | |
| August 26 | Statistics, Error Propagation, Confidence Intervals | T: Chapt. 8, 12<br>Reading #2 | |
| **Week 3** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| August 29 | Fitting Models to Data | | |
| August 31 | Macromolecular forces | VH: 3.1-3.3<br>Reading #3 | |
| September 2 | **Journal Discussion** | | HW1 (due)<br>HW2 (out) |
| **Week 4** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| September 5 | Computational simulations | VH: 3.4 | |
| September 7 | Protein folding | Reading #4<br>Reading #5 | |
| September 9 | **No Class: Dr. Fitzkee at Iowa State**<br>**Journal Summary** | | |

| Week 5 | | | |
|---|---|---|---|
| **Date** | **Description** | **Reading** | **Assignment** |
| September 12 | Statistical mechanics | VH: 4.1-4.2 | Summary Due |
| September 14 | Helix-coil theory | VH: 4.4 | |
| September 16 | **Journal Discussion** | | HW2 (due)<br>HW3 (out) |
| **Week 6** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| September 19 | Review of quantum mechanics I | VH: 8.1-8.2 | |
| September 21 | Review of quantum mechanics II | VH: 8.3 | |
| September 23 | Interactions between light and matter | VH: 8.4-8.5 | |
| **Week 7** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| September 26 | **No Class: Gibbs Conference**<br>**Journal Summary** | | |
| September 28 | UV-Visible spectroscopy | VH: 9.1 | Summary Due |
| September 30 | UV spectroscopy of proteins, introduction to infrared spectroscopy | VH: 9.2 | HW3 (due)<br>HW4 (out) |
| **Week 8** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| October 3 | IR Spectroscopy | Reading #6 | |
| October 5 | Circular dichroism and optical activity | VH: 10.1-10.2 | |
| October 7 | **Journal Discussion** | | |

| Spring Break (Research Week) | | | |
|---|---|---|---|
| **Date** | **Description** | **Reading** | **Assignment** |
| October 10 | Circular dichroism and proteins, singular value decomposition | | |
| October 12 | Introduction to fluorescence | VH: 11.1-11.5 | HW4 (due)<br>HW5 (out) |
| October 14 | **No Class – Fall Break** | | |
| **Week 9** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| October 17 | Fluorescence quenching, FRET | VH: 11.6-11.8 | |
| October 19 | Fluorescence Polarization | VH: 11.9-11.10 | |
| October 21 | Introduction to NMR | VH: 12.1-12.4 | |
| **Week 10** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| October 24 | Chemical Shifts, J-Coupling, and Fourier Transforms | VH: 12.5-12.6 | |
| October 26 | Multidimensional NMR spectroscopy on proteins | VH: 12.7-12.8 | |
| October 28 | **Journal Discussion** | | HW5 (due)<br>HW6 (out) |
| **Week 11** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| October 31 | Methods for determining structure by NMR spectroscopy | Reading #7 | |
| November 2 | NMR Relaxation and Chemical Exchange | | |
| November 4 | **Journal Discussion** | | |

| Week 12 | | | |
|---|---|---|---|
| **Date** | **Description** | **Reading** | **Assignment** |
| November 7 | Isothermal Titration Calorimetry I | Reading #8 | |
| November 9 | Isothermal Titration Calorimetry II | | |
| November 11 | Differential Scanning Calorimetry | Reading #9 | HW6 (due)<br>HW7 (out) |
| **Week 13** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| November 14 | Introduction to X-Ray Crystallography | VH: 6.1-6.3<br>Reading #10 | |
| November 16 | X-Ray Diffraction | VH: 6.4-6.5 | |
| November 18 | Structure Factors and Phasing | | |
| **Week 14** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| November 21 | **Journal Discussion** | | |
| November 23 | **No Class: Thanksgiving Holiday** | | |
| November 25 | **No Class: Thanksgiving Holiday** | | |
| **Week 15** | | | |
| **Date** | **Description** | **Reading** | **Assignment** |
| November 28 | X-Ray Structure Refinement | | HW0 (due) |
| November 30 | **Journal Discussion** | | HW7 (due) |
| December 2 | No Class – Reading Day | | |

## JOURNAL PRESENTATION RUBRIC

## Methods in Biophysical Chemistry – CH 8613

| Category | Evaluation Criteria | Max. Score | Student Score |
|---|---|---|---|
| **Presentation Content** | **Presentation Fidelity**<br>• Student identifies the key questions asked by the article<br>• Student can explain at least two (preferably more) figures from the article | 20 | |
| | **Presentation Emphasis**<br>• Background: not too much, not too little<br>• Student focuses on *important* topics: figures, tables, etc.<br>• Less time is spent on unimportant details / minutiae | 10 | |
| | **Scientific Accuracy**<br>• At least one reference to course material<br>• No scientific inaccuracies in the presentation | 15 | |
| | **Biophysical Methods**<br>• Student relates methods in the paper to what is being discussed in class<br>• Between 1-3 slides included focusing on methodology | 5 | |
| | **Organization**<br>• Presentation flows logically<br>• Clear introduction and summary of what is covered | 5 | |
| **Technical Merit** | **Presentation Mechanics**<br>• Slides are appropriately chosen and helpful to audience<br>• Talk flows smoothly; no abrupt transitions<br>• Presentation does not go over or under time (must end between 15-20 minutes for full credit) | 10 | |
| | **A/V Aids**<br>• Slides containing phrases, not complete sentences<br>• Handwriting is clear (for written talks)<br>• Images are clear and professional, with no pixelated images<br>• Student shows mastery of presentation software | 10 | |
| **Audience Interaction** | **Speaker Clarity**<br>• Speaker doesn't mumble, projects and is easily understood<br>• Speaker doesn't simply read the slides | 10 | |
| | **Question and Answer Session**<br>• Student can candidly answer questions about the paper<br>• Student is polite and receptive to audience feedback<br>• Student can facilitate a discussion if no questions are forthcoming | 10 | |
| | **Real-Time Response to Audience**<br>• Student recognizes confusion in the audience and addresses it appropriately<br>• Student can elaborate on a slide during the talk if a question arises | 5 | |
| **Total Score** | | **100** | |