



School of Molecular & Cellular Biology

# MCB 493 (PBC), Fall 2024

Principles of Physical Biochemistry, 4 Credit Hours

## Instructional Team

### Instructor

Chang Cui

RAL318G

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### TAs

Shashank Shastry: [ss171@illinois.edu](mailto:ss171@illinois.edu)

Mani Schmidt: [is11@illinois.edu](mailto:is11@illinois.edu)

### MCB Instructional Program Office

127 Burrill Hall

[ipsupport@mcb.illinois.edu](mailto:ipsupport@mcb.illinois.edu)

phone/voicemail: 217-244-6239

### Class Meeting Schedule *(all times are Central)*

Lecture/Class T/Th from 9:30-10:50 am

Lecture/Class Location: Lincoln Hall 1000

Office Hours: Friday 4-5 pm RAL 318G

TA Help Office Hours: Tuesday 11 am-12 pm RAL 419

## Course Overview and Description

This course delves into the fundamental physical principles that underlie biochemical systems, integrating concepts from thermodynamics, quantum mechanics, and kinetics. The course is divided into four parts:

- **Part I** covers the principles of thermodynamics, including the first law, Gibbs free energy, and chemical equilibria.
- **Part II** introduces quantum mechanics and molecular orbitals, focusing on the De Broglie equation, the Schrödinger equation, and their biochemical relevance.
- **Part III** explores protein folding kinetics, structural analysis using techniques such as X-ray scattering and electron microscopy, and the latest predictive tools like Rosetta and AlphaFold.

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- **Part IV** focuses on enzyme kinetics and reaction mechanisms, from transient-state theory to modern kinetic methods.

Students will engage with problem sets, group presentations, and case studies to apply these principles to biochemical processes like enzyme activity, molecular folding, and electron transfer. Frequent discussions of primary literature will highlight ongoing research and innovations in the field. This course is essential for those seeking to bridge the gap between physical chemistry and molecular biology in their research.

### **Course Prerequisites and Requirements met**

MATH 220 or 221 and CHEM 102 and 104 or instructor consent.

### **Student Learning Outcomes for the Course**

At the end of the course, through assignments, discussions, activities and assessments, students will be able to:

- Understand the physical chemistry principles governing biochemical reactions and processes such as those involved in, e.g., membrane transport, bioenergetics of a living cell, and protein structure and stability, among others.
- Analyze the literature describing quantitatively (or qualitatively) such basic concepts in molecular sciences in general, and in biochemistry in particular
- Apply quantitative relationship established during the course to biochemical problems and to determine and identify useful values describing their values.

### **Course Calendar**

The dates listed in the calendar are approximate and may be adjusted based on the pace of the course and student feedback.

#### **Part I: Principles of thermodynamics (Lectures 1 - 5)**

8/27 Lecture 1 First law of thermodynamics, work and heat

8/29 Lecture 2 Enthalpy, entropy and principle of multiplicity

9/3 Lecture 3 Boltzmann distribution and degrees of freedom

Problem set 1

9/5 (continued) Lecture 3 Boltzmann distribution and degrees of freedom

9/10 Lecture 4 Gibbs free energy and chemical equilibrium

9/12 Lecture 5 Reduction potential and Nernst equation

9/17 (continued) Lecture 5 Reduction potential and Nernst equation

9/19 In class exam (Lectures 1-7)

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## **Part II: Introduction to quantum mechanics and molecular orbitals (Lectures 6-7)**

9/24 Lecture 6 De Broglie equation and uncertainty principle

9/26 Lecture 7 Schrödinger equation, Pauli exclusion principle and molecular orbitals

## **Part III: Protein folding kinetics, structural analysis and prediction (Lectures 8-13)**

10/1 Lecture 8 Kinetics of protein folding and unfolding

10/3 Lecture 9 Protein folding *in vivo* and molecular chaperones

Problem set 2

10/8 Lecture 10 Small-angle X-ray scattering

10/10 Lecture 11/12 Time-resolved X-ray crystallography and electron microscopy

10/15 In class exam (Lectures 8-13)

10/17 Lecture 13 Introduction to Rosetta design and alpha fold

## **Part IV: Enzyme kinetics and kinetic methods (Lectures 14 - 24)**

10/22 Lecture 14 Reaction kinetics, on-rates and off-rates, order of reactions

10/24 Lecture 15 Ligand binding, allostery and cooperativity

10/29 Lecture 16 Transient state theory and inhibitor design

10/31 Lecture 17/18 Steady-state kinetics and Michaelis-Menten Equation, Arrhenius plot and temperature dependence of enzyme reactions

Problem set 3

11/5 Lecture 19 Marcus theory of electron transfer and redox biology

11/7 Group presentation on selected topics\* (15 minutes presentation)

11/12 Group presentation on selected topics\* (15 minutes presentation)

11/14 Group presentation on selected topics\* (15 minutes presentation)

\* Photosynthesis, respiratory chain, motor proteins etc

11/19 Lecture 20 pH-rate profile, kinetic isotope effects (KIE) and hydrogen tunneling

11/21 Lecture 21 Pre-steady state burst kinetics

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12/3 Lecture 22 Rapid kinetic methods

12/5 Lecture 23 Enzyme inhibitors

12/10 Lecture 24 Review

### Course Website

Canvas: <https://canvas.illinois.edu/>

### Required or Recommended materials

The manuscripts of the textbook and other teaching materials will be shared via Canvas. Students do not need to purchase additional textbooks or references.

### Course Grading Totals and Scale

Our course has a standard grade scale. The final grade is composed of 2 in-class exams (15% each), 1 group presentations (15%), 3 problem sets (10% each), 1 final exam (25%). The letter grade will be assigned according to the following scale.

100-97 A+	89-87 B+	79-77 C+	69-67 D+
96-93 A	86-83 B	76-73 C	66-63 D
92-90 A-	82-80 B-	72-70 C-	62-60 D-
			< 60 F

The instructor reserves the right to lower the scale but not raise the standard for each letter grade. Problem sets are due on the following week on Thursdays (in class) or as indicated.

- NO LATE homework without valid excuse; otherwise, ZERO credit.
- 10 points (max) for each homework

Each student is responsible for reporting possible discrepancies to their instructor/TA within one week of receiving their graded score.

### Course Policies

Students are expected to commit approximately 8 hours of work each week to attend the lectures, complete the problem sets and group presentations and review the course contents.

### Adding the Course after the Semester Start:

We understand that the University has an add deadline 10 days into the semester, but the University allows individual courses and/or programs determine their policies for late adds. Students who choose to add a course late do so at their own discretion with knowledge that material has been missed and points may be lost as a result.

### Class & Exam Absences and Conflicts

Absences and conflicts for in-class and final exams need to be approved by the instructor with valid proof of medical conditions and/or conflict events.

### Academic Integrity:

The Student Code will be applied in all instances of academic misconduct committed by students. This applies to all exams, presentations, assignments, and materials distributed or used in this course. You can review these policies in the Student Code, specifically

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(<https://studentcode.illinois.edu/article1/part4/1-401/>) Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

## Religious Observances and Practices

It is the policy of the University of Illinois Urbana-Champaign to reasonably accommodate its students' religious beliefs, observances, and practices that conflict with a student's class attendance or participation in a scheduled examination or work requirement, consistent with state and federal law.

Students must request a reasonable accommodation for their religious belief, observance, and practice **in advance of the conflict** to allow time for both consideration of the request and alternate procedures to be prepared. Not requesting an accommodation reasonably in advance of the conflict may result in a delay or denial of the accommodation.

A reasonable accommodation for a religious belief, observance, and practice is defined as a change that allows the student to participate in their religious belief, observance, and practice and which does not fundamentally alter the educational requirement or place an undue hardship on an instructor, department, or office.

Students must direct a request for a reasonable accommodation for a religious belief, observance, and practice to the instructor(s) of the affected course(s), who shall review the request and determine whether a reasonable accommodation can be made. **This form serves as a resource to assist students as they are making such requests to their instructors.** PLEASE NOTE: This form asks you to clarify whether you are requesting an absence or an accommodation other than absence.

Once submitted, students will receive a copy of this request form. Students must then forward the form to each instructor in order to request the accommodations.

Request to Instructor Religious Accommodation form:

[https://cm.maxient.com/reportingform.php?UnivofIllinois&layout\\_id=42](https://cm.maxient.com/reportingform.php?UnivofIllinois&layout_id=42)

## Disability Resources and Educational Services (DRES) Accommodations

1. We are committed to providing a learning environment where our students can succeed. If you require special accommodations, please contact us and the DRES as soon as possible. To contact DRES, you may visit 1207 S. Oak Street, Champaign, call 217-333-4603, or email [disability@illinois.edu](mailto:disability@illinois.edu). We will try to meet all accommodations once the process has started. Please note that accommodations are not retroactive to the beginning of the semester, but begin the day you contact your professor, instructor, or coordinator with a current letter of accommodation from DRES.
2. If a student has DRES accommodations, documentation must be submitted to course personnel by the end of the second week of class.
3. If a student believes that they need DRES accommodations, they should contact DRES at [disability@illinois.edu](mailto:disability@illinois.edu).

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## Attendance Policies

Regular class attendance is expected of all students at the University.  
(<https://studentcode.illinois.edu/article1/part5/1-501/>)

## FERPA (Family Educational Rights and Privacy Act)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the coordinator for the course to ensure protection of the privacy of their attendance in this course. See <https://registrar.illinois.edu/academic-records/ferpa/> for more information on FERPA.

## Disruptive Behavior

Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem and may be reported to the Office for Student Conflict Resolution (<https://conflictresolution.illinois.edu>; [conflictresolution@illinois.edu](mailto:conflictresolution@illinois.edu); 333-3680) for disciplinary action.

## Course Policy on Electronic Media Use + Recording & Posting Policy

### Electronic Media/Device Use:

- Use of any social or electronic media to share information, request information or make confidential information public is prohibited. Any use of this type may earn you a zero or a more extreme penalty at the discretion of the instructor on an assignment or assessment.
- Any violation of the social media policy on your account may result in a zero on an assignment or exam or a more extreme penalty at the discretion of the instructor.
- Any social media sites created in relation to MCB courses must grant access to course personnel upon request. Failure to provide access will result in a failing grade in the course for the group/site's administrator(s).
- No electronic devices, including smart watches, are allowed at exams.

### Course Material:

- The material recorded is intellectual and copyrighted property of the University of Illinois Board of Trustees and may be made for personal use only.
- Video recordings of any kind are strictly forbidden.
- Posting of audio recordings or transcriptions on social or electronic media platforms is strictly prohibited.
- Recording material from this course (including lectures, discussions, or other activities) is forbidden.
- Any violation of these policies will be forwarded to the Office of Student Conflict Resolution for disciplinary action.

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### For non-academic campus assistance and support:

- See Office of Diversity, Equity and Access (ODEA) information at the end of this document.

### Student Advocacy Resources:

- For student-centered advocacy programs and services visit:  
[mcb.illinois.edu/undergrad/advising/resources](http://mcb.illinois.edu/undergrad/advising/resources).

### University Information of Student Safety - Active Threats:

- **General Emergency Response Recommendations (Emergency Response Guide):**
- **Security Threat.** The Department of Homeland Security and the University of Illinois at Urbana-Champaign Office of Campus Emergency Planning recommend the following three responses to any emergency on campus: [RUN > HIDE > FIGHT](#)
- **Only follow these actions if safe to do so.** When in doubt, follow your instincts - you are your best advocate!
- **RUN** – Action taken to leave an area for personal safety.
  - Take the time to learn the different ways to leave your building **before** there is an emergency.
  - Evacuations are mandatory for fire alarms and when directed by authorities! No exceptions!
  - Evacuate immediately. Pull manual fire alarm to prompt a response for others to evacuate.
  - Take critical personal items only (keys, purse, and outerwear) and close doors behind you.
  - Assist those who need help, but carefully consider whether you may put yourself at risk.
  - Look for **Exit** signs indicating potential egress/escape routes.
  - If you are not able to evacuate, go to an Area of Rescue Assistance, as indicated on the front page of this plan.
  - Evacuate to Evacuation Assembly Area, as indicated on front page of this plan.
  - Remain at Evacuation Assembly Area until additional instructions are given.
  - Alert authorities to those who may need assistance.
  - Do not re-enter building until informed by emergency response personnel that it is safe to return.
  - Active Threat: IF it is safe to do so, run out of the building. Get as far away as possible. Do NOT go to the Evacuation Assembly Area.
- **HIDE** – Action taken to seek immediate shelter indoors when emergency conditions do not warrant or allow evacuation.
  - Severe Weather:
    - If you are outside, proceed to the nearest protective building.
    - If sheltering-in-place due to severe weather, proceed to the identified Storm Refuge Area or to the lowest, most interior area of the building away from windows or hazardous equipment or materials.
  - Active Threat:

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- Lock or barricade your area.
  - Get to a place where the threat cannot see you.
  - Place cell phones on silent.
  - Do not make any noise.
  - Do not come out until you receive an Illini-Alert advising you it is safe.
  - **FIGHT** – Action taken as a last resort to increase your odds of survival.
    - Active Threat: If you cannot run away safely or hide, be prepared to fight with anything available to increase your odds for survival.

## **Student Resources/Where to go for Help:**

### **Community of Care**

As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the Connie Frank CARE Center (217-333-0050 or <http://odos.illinois.edu/community-of-care/referral/>). Based on your report, the staff in the Connie Frank CARE Center reaches out to students to make sure they have the support they need to be healthy and safe.

Further, as a Community of Care, we want to support you in your overall wellness. We know that students sometimes face challenges that can impact academic performance (examples include mental health concerns, food insecurity, homelessness, personal emergencies). Should you find that you are managing such a challenge and that it is interfering with your coursework, you are encouraged to contact the [Connie Frank CARE Center \(SAC\)](#) in the Office of the Dean of Students for support and referrals to campus and/or community resources.

### **Sexual Misconduct Reporting Obligation at Illinois:**

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: [wecare.illinois.edu/resources/students/#confidential](http://wecare.illinois.edu/resources/students/#confidential).

Other information about resources and reporting is available here: [wecare.illinois.edu](http://wecare.illinois.edu).

### **Mental Health**

Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.

- Counseling Center (217) 333-3704



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- McKinley Health Center (217) 333-2700
  - National Suicide Prevention Lifeline (800) 273-8255
  - Rosecrance Crisis Line (217) 359-4141 (available 24/7, 365 days a year)

If you are in immediate danger, call 911.

**The Office of Diversity, Equity and Inclusion:** [www.diversity.illinois.edu](http://www.diversity.illinois.edu)

- Discrimination & Harassment Prevention
- Title IX
- Accessibility & Accommodations
- Inclusive Illinois

### **The Jeffries Center**

For Fall 2024, the Jeffries Center's Tutoring and Academic Services will continue delivering services in person with some limited online availability. The OMSA offers free tutoring and academic services. Matched tutoring, online self-paced workshops and academic skills coaching are among the services featured in the OMSA's Academic Services Center (ASC) located at 1103 W. Oregon, Suite E, Urbana, IL. OMSA's services are designed to help students excel in college. As you have probably already noticed, college-level learning is different from what it was in high school. No matter how well you performed before attending Illinois, there is always room to hone your study skills.

- To learn more about OMSA's tutoring services and to sign up for a tutor, visit <https://jeffriescenter.illinois.edu/academic-services-center/tutoring/tutoring>.
- To learn more about the self-paced workshops and to take advantage of this opportunity, visit: <https://jeffriescenter.illinois.edu/academic-services-center/tutoring/workshops>.

You are encouraged to make the most of your tutoring and workshop session(s) by:

- Requesting a tutor at the beginning of the term before tutors' work schedules are booked up.
- Come to each of your tutoring or workshop sessions prepared. Preparation includes having your textbooks, notes, and specific questions concerning the material. The more you prepare, the more you will get out of the session.
- Tutors do not serve as a substitute for our instructional faculty. Tutors will not "lecture" or "re-teach." They will provide strategies to help you improve your approach to mastering your course content. Tutoring is not a substitute for missed classes. If you miss class, make sure you get notes from a classmate and meet with your professor during office hours.

### ***Safety and Emergency:***

<a href="#">University Police Department</a>	<i>Emergency, 9-911</i>
	<i>Non-emergency, 217-333-8911</i>
University Fire Department Emergency	9-911
<a href="#">Rosecrance Crisis Line</a>	217-359-4141

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<a href="#"><u>Emergency Dean</u></a>	300 Turner Student Services Bldg., 610 E. John St., 217-333-0050
<a href="#"><u>Counseling Center</u></a>	110 Student Services Bldg., 610 E. John St., 217-333-3704
<a href="#"><u>McKinley Health Center</u></a>	217-333-2700
<a href="#"><u>McKinley Mental Health Center</u></a>	1109 S. Lincoln, 217-333-2705
<a href="#"><u>Psychological Services Center</u></a>	3 <sup>rd</sup> Floor, 505 E. Green St., 217-333-0041
<a href="#"><u>Local Sexual Assault Center, RACES</u></a>	217-384-4444
<a href="#"><u>Women's Resources Center</u></a>	703 South Wright Street, 2nd Floor, 217-333-3137
Suicide and Crisis Lifeline	988
<a href="#"><u>SafeRides</u></a> (free nighttime campus ride program)	217-384.8188
<a href="#"><u>SafeWalks</u></a> (free walking escort service by Student Patrol 9 PM - 2:30 AM)	217-333-1216
<b>Student Services and Advocacy</b>	
<a href="#"><u>Office of the Dean of Students</u></a>	300 Student Services Bldg., 610 E. John St., 217-333-0050
<b>Classroom Support, Teaching Skills, and Instructional Strategies</b>	
<a href="#"><u>Center for Innovation in Teaching &amp; Learning (CITL)</u></a>	249 Armory Building, 217-333-1462
<b>Disability Services</b>	
<a href="#"><u>Disability Resources and Educational Services (DRES)</u></a>	1207 S. Oak St., 217-333-1970
<b>Gender &amp; Sexuality Resource Center</b>	
<a href="#"><u>Gender &amp; Sexuality Resource Center</u></a>	323 Illini Union, 1401 W. Green St., 217-244-8863
<b>Veterans Services</b>	
<a href="#"><u>Chez Veterans Center</u></a>	908 Nevada Street, 217-300-3515
<b>General Study Skills Assistance</b>	
<a href="#"><u>The Jeffries Center</u></a>	130 Turner Student Services Bldg., 610 E. John St, 217-333-0054
<a href="#"><u>The Jeffries Center Tutoring &amp; Academic Services</u></a>	1103 W. Oregon Street Suite E, 217-333-7547
<a href="#"><u>Writer's Workshop</u></a>	100b Main Library, 1408 W. Gregory Dr., 217-333-8796
**Additional academic assistance may be available through individual departments	
<b>Health Resources</b>	
<a href="#"><u>Health Education, McKinley Health Center</u></a>	1109 S. Lincoln Ave., 217-333-2700
<a href="#"><u>Alcohol &amp; Other Drug Outreach Team</u></a>	Counseling Center, 610 E. John St., 217-333-3704
<a href="#"><u>Sexual Health Educator</u></a>	McKinley Health Center, 1109 S. Lincoln Ave., 217-333-2700

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<a href="#">Dial-A-Nurse, McKinley Health Center</a> (24-hour)	1109 S. Lincoln Ave., 217-333-2700
Health Resource Center, McKinley Health Center, Main Lobby	1109 S. Lincoln Ave., 217-333-6000 Monday-Friday 9:00 AM - 5:30 PM
Health Resource Center, Room 40 Illini Union,	1401 W. Green St., 217-244-5994
<a href="#">Other Campus Locations Self Care Stations (FA/SP Semesters) locations and hours</a>	Bruce Nesbitt African American Cultural Center Asian American Cultural Center La Casa Cultural Latina, Library 2 <sup>nd</sup> Floor Native American House, Main Library

Sexual Harassment/Assault & Acts of Intolerance/Hate Crimes  
[Office of the Dean of Students](#) 300 Students Services Bldg., 610 E. John St., 217-333-0050

## Inclusivity Statement

The effectiveness of this course is dependent upon the creation of an encouraging and safe classroom environment. Exclusionary, offensive, or harmful speech (such as racism, sexism, homophobia, transphobia, etc.) will not be tolerated and in some cases may subject to university harassment procedures. We are all responsible for creating a positive and safe environment that allows all students equal respect and comfort. Students are expected to help establish and maintain an environment where you and your peers can contribute without fear of ridicule or intolerant or offensive language.

## Netiquette

In any social interaction, certain rules of etiquette are expected and contribute to more enjoyable and productive communication. The following are tips for interacting online via e-mail or discussion board messages, adapted from guidelines originally compiled by Chuq Von Rospach and Gene Spafford (1995):

- Remember that the person receiving your message is someone like you, deserving and appreciating courtesy and respect.
- Avoid typing whole sentences or phrases in Caps Lock.
- Be brief; succinct, thoughtful messages have the greatest effect.
- Your messages reflect on you personally; take time to make sure that you are proud of their form and content.
- Use descriptive subject headings in your e-mails.
- Think about your audience and the relevance of your messages.
- Be careful when you use humor and sarcasm; absent the voice inflections and body language that aid face-to-face communication, Internet messages are easy to misinterpret.
- When making follow-up comments, summarize the parts of the message to which you are responding.

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- Avoid repeating what has already been said; needless repetition is ineffective communication.
  - Cite appropriate references whenever using someone else's ideas, thoughts, or words

### **Contacting MCB Course Personnel**

1. MCB course personnel are more than happy to assist students.
2. Emails to instructors, TAs, or course coordinators will only be answered if they come from an @illinois.edu account. As a student, please remember that when you email a staff member, it is important to include all pertinent information so that we can assist you in the most efficient and effective manner possible. This information includes:
  - The course rubric in the subject line
  - Your full first and last name
  - Your NetID (the first part of your illinois.edu email account)
  - Your UIN (9-digit number that you use to register for classes)
  - The course that you are concerned about (the course personnel often work with multiple courses)
  - Your section letter/number
  - The previous email "thread" or previous communicated information pertinent to the situation
3. Your cooperation will help us respond much more quickly to your concerns