CHEM 372

Bioorganic Chemistry

Goals:

Biochemistry is the study of the variety of chemical structures and chemical reactions that occur in living organisms. In order to truly understand the detailed mechanisms of these diverse reactions, one must assimilate aspects of organic chemistry, inorganic chemistry, and physical chemistry and apply these chemical principles to the complex structural environment presented by natural proteins, nucleotides, and membranes.

The goal of this course is to learn about general aspects of biochemical pathways from the perspective of chemical principles and chemical reactions. We will cover:

1. **Biochemical structures.** We will study detailed aspects of the three-dimensional structure of proteins, and how this translates into differences in the function of these proteins.

2. **Energy metabolism.** Biological systems use sugars and fatty acids to store energy. We will learn how this chemical energy is carefully harvested through stepwise oxidation, electron capture, proton and ion gradients, and conversion to mechanical energy. In addition, we will explore the thermodynamics of electron transport, proton pumping, and ATP biosynthesis.

3. **Molecular biosynthesis.** Most organisms can biosynthesize amino acids, lipids, nucleotides, vitamins, and cofactors using a host of complex enzymes that demonstrate fundamental chemical principles. By contrasting specific enzymes that use organic and inorganic catalytic cofactors, we can illustrate these catalytic principles while learning important pathways.

4. **Frontiers in biochemistry.** Current research in biochemistry focuses on understanding complex biochemical environments, such as the human brain (neurochemistry) or the control of gene expression in eukaryotic cells (genomics and proteomics). The growth of microorganisms in extreme environments using complex metalloenzymes will also be examined.

This course is intended to provide a solid background in the fundamental chemistry of biological systems in preparation for a career in biochemical research or for future graduate study in chemistry or biochemistry. This course fulfills the biochemistry requirement for an American Chemical Society certified Bachelor of Science in Chemistry, however, BIOC 441 and BIOL 402 also fulfill that requirement, so you don't have to take more than one of these three courses.

This course is NOT intended to prepare students for the health professions or for professional school admissions exams (MCAT, PCAT, DAT, etc.); although it may suffice for that purpose, there is no attempt to cover the full range of topics that will be found on those exams. Only BIOC 441 and BIOL 402 fulfill the medical school requirement for 4 credits of biochemistry.
**Professor:** Joseph Jarrett

Bilger 245  
jtj@hawaii.edu  
956-6721

**Lectures**

Tues & Thurs  
10:30 – 11:45 am

**Office Hours**

Tues  
12 - 1 pm  
(or email for an appt)

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**Text:**  
*The Organic Chemistry of Biological Pathways, 2nd Edition*  
Authors: John E. McMurry and Tadhg P. Begley  
Publisher: W.H. Freeman  
This course will cover Chapters 1 – 6 of the textbook in order.  
UH Bookstore: $110 new, $80 used, $50-60 rental.  
Amazon: $100 new, $60-90 used  

Some lecture material will be taken from *Fundamentals of Biochemistry, 5th edition*, Voet, Voet & Pratt, Wiley (2016). Handouts will be provided as pdf documents for topics not covered in the textbook. The slides will be made available on Laulima.

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**Lectures:**  
• The class will be divided into 4 blocks with 4-8 lectures per block.  
• Most lectures will be based on the textbook and will follow the order of material in the text.  
• Information from other sources will be included as well.  
• Most lectures will be held as face-to-face lectures at the scheduled time and place.  
• For selected topics that should be easier to learn and understand, there will be short pre-recorded lectures posted online.  
• Lecture slides will be made available through Laulima. A draft version of the slides will be uploaded prior to class but may be replaced following class if any new material is added at the last minute.

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**Quizzes & Exams:**  
• Reading assignments will be given prior to each lecture. You are responsible for everything in the reading, even material not covered in the lectures.  
• All exams will be conducted in person in Bilger 335. Exams will be primarily short answer requiring that you be able to draw chemical structures and mechanisms, like an organic chemistry exam. A typical exam will have 8-10 questions and should be completed in 75 min.  
• On weeks with no exam, there will be in-person quizzes. A typical quiz will have 3-4 questions and should be completed in 20 min.

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**Grading:**  
• Six (out of seven) quizzes worth 20 pts each (120) (lowest quiz score will be dropped)  
• Three midterm exams worth 100 points (300)  
• Cumulative final exam worth 180 pts  
• There will be no extra credit assignments. Your grade will be based entirely on quizzes and exams. A missed exam (17%) will drop your grade by at least one letter grade.  
• Total score out of 600 pts will then be converted to a percentage

**Grading Scale:**  
A+, 95-100%; A, 85-94.9; A-, 80-84.9  
B+, 75-79.9; B, 70-74.9; B-, 65-69.9  
C+, 60-64.9, C, 55-59.9;  
D, 45-54.9, F, ≤44.9

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**Student Learning Outcomes:**

1. Students can describe the basic elements of amino acid, peptide, and protein structure.  
2. Students can explain the common features of enzyme catalysts, and some of the basic methods used in studying enzyme function.  
3. Students can outline the basic metabolic pathways for carbohydrate metabolism, amino acid biosynthesis and breakdown, fatty acid/lipid production and breakdown, and nucleotide biosynthesis and degradation.  
4. Students can describe fundamental chemical mechanisms for each of the major types of chemical reactions observed in biochemistry, including at least one specific example for each.  
5. Students can use research databases, journal articles, and reviews to learn more about modern topics in bioorganic chemistry.
Course information, policies, and resources:

**Attendance policy:**
- Attendance at lectures will not be recorded.
- **You may drop or miss one quiz with no penalty.** There will be no makeup quizzes.
- If you have a planned university-related activity that coincides with an exam date, please work with me to determine an alternative date that you can take the exam.
- If you miss an exam for medical reasons, please contact me as soon as possible to arrange a make-up exam date and time. The last date for a make-up exam will be 6 days after the scheduled exam date. There will be no dropped exams and you will receive a zero if you don’t make up the missed exam.

**Use of internet, mobile devices, and social media:**
- Homework: you may use any information from any source for homework assignments, but you may not copy answers directly from another student, either in person or using a chatroom or other social media site. Any obvious incidents of copying will result in a zero for all individuals involved.
- Exams and quizzes: all exams and quizzes will be closed book with no devices allowed.

**KOKUA program:**
If you have a disability and/or related access needs, please contact the KOKUA program (UH Disabled Student Services Office) at 956-7511, KOKUA@hawaii.edu, or go to Room 013 in the Queen Lil‘uokalani Center for Student Services. Please know that I will work with you and KOKUA to meet your access needs based on disability documentation.

**Academic Integrity and Ethical Behavior: Office of Student Conduct**
Cheating, plagiarism, or other forms of academic dishonesty are not permitted within this course and are prohibited within the System-Wide Student Conduct Code (EP 7.208). Examples include: fabrication, facilitation, cheating, plagiarism, and use of improper materials. Any incident of suspected academic dishonesty will be reported to the Office of Student Conduct for review and possible adjudication. Additionally, the instructor may take action in regards to the grade for the course as they see fit.

**Department of Public Safety:** (808) 956-6911 (Emergency) / (808) 956-8211 (Non-Emergency)
https://manoa.hawaii.edu/dps/

**UH System Basic Needs** include food and housing, childcare, mental health, financial resources and transportation, among others. Student basic needs security is critical for ensuring strong academic performance, persistence and graduation and overall student well-being. If you or someone you know are experiencing basic needs insecurity, please see the following resources: https://www.hawaii.edu/student-basic-needs/resources/manoa/

**Office of Title IX:**
The University of Hawai‘i is committed to providing a learning, working and living environment that promotes personal integrity, civility, and mutual respect and is free of all forms of sex discrimination and gender-based violence, including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence, and stalking. If you or someone you know experiences any of these, UHM has staff and resources on campus to support and assist you. Staff also can direct you to resources in the community. Here are some of your options:

<table>
<thead>
<tr>
<th>If you wish to remain ANONYMOUS, speak with someone CONFIDENTIALLY, or would like to receive information and support in a CONFIDENTIAL setting, contact: (* Confidential Resource)</th>
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</thead>
<tbody>
<tr>
<td><strong>Counseling &amp; Student Development Center</strong> (808) 956-7927 • manoa.hawaii.edu/counseling/</td>
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<tr>
<td><strong>Office of Gender Equity</strong> (808) 956-9499 • <a href="mailto:manoaadv@hawaii.edu">manoaadv@hawaii.edu</a></td>
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<tr>
<td><strong>Lesbian, Gay, Bisexual, Transgender, Queer (LGBTQ+) Center</strong> (808) 956-9250 manoa.hawaii.edu/lgbt</td>
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<td><strong>Respondent Support</strong> (808) 956-4392 • <a href="mailto:PAUrs@hawaii.edu">PAUrs@hawaii.edu</a></td>
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<tr>
<td><strong>Student Parents at Mānoa (SP@M)</strong> (808) 956-8059 • manoa.hawaii.edu/studentparents/</td>
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<tr>
<td><strong>UH Confidential Advocacy</strong> • <a href="mailto:advocate@hawaii.edu">advocate@hawaii.edu</a></td>
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<tr>
<td><strong>University Health Services Mānoa</strong> (808) 956-8965 • hawaii.edu/shs/</td>
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If you wish to **REPORT** an incident of sex discrimination or gender-based violence including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence or stalking as well as receive information and support, contact:

**Jennifer Solidum Rose**  
Interim Director and Title IX Coordinator  
Hawaii Hall 112  
2500 Campus Road  
Honolulu, HI 96822  
(808) 956-2299  
t9uhm@hawaii.edu

As a member of the University faculty, I am **required to immediately report** any incident of sex discrimination or gender-based violence to the campus Title IX Coordinator. Although the Title IX Coordinator and I cannot guarantee confidentiality, you will still have options about how your case will be handled. My goal is to make sure you are aware of the range of options available to you and have access to the resources and support you need. For more information regarding sex discrimination and gender-based violence, the University’s Title IX resources and the University’s Interim Policy, EP 1.204, go to:  
[http://www.manoa.hawaii.edu/titleix/](http://www.manoa.hawaii.edu/titleix/)
<table>
<thead>
<tr>
<th>Lec #</th>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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<tbody>
<tr>
<td>1</td>
<td>08/22</td>
<td><strong>Biochemical Structure</strong></td>
<td>Page numbers are from the 2nd edition</td>
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<tr>
<td>2</td>
<td>08/24</td>
<td>Organic Chemistry Review</td>
<td>Ch 1 (pp 1 – 44) and your old OChem Book</td>
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<tr>
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<td>08/29</td>
<td><strong>Quiz #1 – Organic Chemistry</strong></td>
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<tr>
<td>3</td>
<td>08/29</td>
<td>Biomolecules - lipids &amp; carbohydrates</td>
<td>Ch 2 (pp 51 – 99)</td>
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<td>09/05</td>
<td><strong>Quiz #2 – Biomolecules</strong></td>
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<tr>
<td>5</td>
<td>09/05</td>
<td>Protein and enzyme structure</td>
<td>handout</td>
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<tr>
<td>6</td>
<td>09/07</td>
<td>Enzyme mechanisms, enzyme kinetics, review of some energy concepts</td>
<td>handout</td>
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<td><strong>Lipid Metabolism</strong></td>
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<tr>
<td>7</td>
<td>09/12</td>
<td>Fatty acid degradation: di- and triglycerides, lipase mechanism, fate of glycerol</td>
<td>Ch. 3 (pp 109 – 131)</td>
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<td>8</td>
<td>09/14</td>
<td>Fatty acid degradation: fatty acid β-oxidation</td>
<td>Ch. 3 (pp 109 – 131)</td>
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<td>09/19</td>
<td><strong>Quiz #3 – Fatty acid catabolism</strong></td>
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<td>9</td>
<td>09/19</td>
<td>Fatty acid biosynthesis</td>
<td>Ch. 3 (pp 131 – 140)</td>
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<tr>
<td>10</td>
<td>09/22</td>
<td>Ketone bodies and terpenes</td>
<td>Ch. 3 (pp 141 – 172) &amp; handout</td>
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<tr>
<td>11</td>
<td>09/26</td>
<td>Steroids</td>
<td>Ch. 3 (pp 141 – 172) &amp; handout</td>
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<td>09/28</td>
<td><strong>Exam 1 (100 pts)</strong></td>
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<td><strong>Carbohydrates and energy</strong></td>
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<tr>
<td>12</td>
<td>10/03</td>
<td>Glycolysis</td>
<td>Ch. 4 (183 – 201)</td>
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<tr>
<td>13</td>
<td>10/05</td>
<td>Pyruvate and thiamine-dependent enzymes</td>
<td>Ch. 4 (202 – 208) &amp; handout</td>
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<tr>
<td></td>
<td>10/10</td>
<td><strong>Quiz #4 – Glycolysis</strong></td>
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<tr>
<td>14</td>
<td>10/10</td>
<td>The citric acid cycle (TCA cycle)</td>
<td>Ch. 4 (208 – 215)</td>
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<tr>
<td>15</td>
<td>10/12</td>
<td>Gluconeogenesis &amp; Pentose P Pathway</td>
<td>Ch. 4 (215 – 232)</td>
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<tr>
<td>Date</td>
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<td>Chapter/Handouts</td>
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<tr>
<td>10/17</td>
<td>Photosynthesis: the Calvin cycle</td>
<td>Ch. 4 (232 – 238) &amp; handout</td>
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<tr>
<td>10/19</td>
<td>Exam 2 (100 pts)</td>
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<td>4</td>
<td><strong>Amino Acid Biochemistry</strong></td>
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<tr>
<td>10/24</td>
<td>Nitrogen recycling, excretion, and the urea cycle</td>
<td>Ch. 5 (pp 245 – 257)</td>
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<tr>
<td>10/26</td>
<td>Mechanisms of pyridoxal phosphate enzymes</td>
<td>Handout</td>
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<tr>
<td>10/31</td>
<td>Quiz #5 – The Urea Cycle</td>
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<tr>
<td>10/31</td>
<td>Amino acid carbon chain degradation: the “simple” glucogenic amino acids</td>
<td>Ch. 5 (pp 257 – 271)</td>
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<tr>
<td>11/02</td>
<td>Amino acid carbon chain degradation: a few selected ketogenic amino acids</td>
<td>Ch. 5 (pp 272 – 298)</td>
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<tr>
<td>11/07</td>
<td>Quiz #6 – Amino acid catabolism</td>
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<tr>
<td>11/07</td>
<td>Amino acid biosynthesis: nonessential amino acids</td>
<td>Ch. 5 (pp 298 – 323)</td>
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<tr>
<td>11/09</td>
<td>Amino acid biosynthesis: a few selected examples of essential amino acids</td>
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<tr>
<td>11/14</td>
<td>Amino acid biosynthesis: more examples of essential amino acids</td>
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<tr>
<td>11/16</td>
<td>Exam 3 (100 pts)</td>
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<td>5</td>
<td><strong>Nucleotide Biochemistry</strong></td>
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<tr>
<td>11/28</td>
<td>Nucleotide catabolism and recycling</td>
<td>Ch. 6 (333 – 342) &amp; handout</td>
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<tr>
<td>11/30</td>
<td>Purine biosynthesis</td>
<td>Ch. 6 (348 – 355)</td>
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<tr>
<td>12/05</td>
<td>Quiz #7 – Nucleotide catabolism</td>
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<tr>
<td>12/05</td>
<td>Pyrimidine and deoxyribonucleotide biosynthesis</td>
<td>Ch. 6 (342 – 347, 355 – 359)</td>
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<tr>
<td>12/07</td>
<td>Final exam review</td>
<td>handouts</td>
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<tr>
<td>12/14</td>
<td><strong>Cumulative Final Exam (180 pts)</strong></td>
<td>9:45 am – 11:45 am</td>
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</table>

- There may be 1-2 lectures that will be delivered via Zoom, depending on my schedule.
- All exams are scheduled to be held in Bilger 335. Exam rules will be explained via email just prior to the first exam.