MMBB 442/542, Chem 542

Advanced Biochemistry II

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Office Hours: Tuesdays and Thursdays 9:30-10:30 am or by appointment

Required Text: *Lehninger Principles of Biochemistry* by David L. Nelson and Michael M. Cox, 5th edition, Worth Publishers, 2008 (ISBN-13:978-0-7167-7108-1). http://bcs.whfreeman.com/lehninger5e/default.asp?s=&n=&i=&v=&o=&ns=0&uid=0&rau=0

Required Text: *Biochemistry* by Jeremy M. Berg, John L. Tymoczko and Lubert Stryer, 6th edition, W. H. Freeman and Co., 2007 (ISBN-0-7167-8724-5). http://bcs.whfreeman.com/lehninger5e/default.asp?s=&n=&i=&v=&o=&ns=0&uid=0&rau=0

The electronic version of handouts and study questions for every class are available to download to your PC from the UI Blackboard server:

https://www.blackboard.uidaho.edu/webct/entryPageIns.dowebct

Please pay attention to the text below the slides. In the folder there are also animation files that are very useful to understand more complicated processes. Using handouts during classes and reading relevant material from the textbooks <u>before the class is strongly recommended.</u>

Class Focus: The class will focus on nitrogen and oxygen metabolism in living systems. Students will learn how cells synthesize and degrade small amino acids and large protein biomolecules, and how energy is generated and consumed on the molecular level during these biochemical processes. All of the reactive oxygen species (ROS) and reactive nitrogen species (RNS) will be introduced. We will explore their damaging reactivity towards different biomolecules and how these reactive species are used in different ways to benefit the cells that are generating them. Students will learn the metabolism of small organic molecules in the cell and how they form larger structures. The course will emphasize anabolism and catabolism of amino acids, nucleotides, proteins, and nucleic acids. The trophophasic and idiophasic growth of cells and their biochemical basis and biotechnological application will be introduced. The catalytic strategy employed by enzymes and their structure-function relations will be reviewed. For example, the catalytic mechanism and molecular structures of peroxidases (ligninesse), proteases (chymotrypsin), carbonic anhydrase and pyruvate dehydrogenase will be discussed and analyzed. The class will explore the biochemistry of vision process including signal transduction (the conversion of stimuli detected in receptor cells to electrical impulses that are then transported by the nervous system) in the rod cell and eye. The application of modern analytical techniques such as mass spectrometry, nuclear magnetic resonance, X-ray diffraction spectrometry to biochemical and biological sciences will be discussed with given groups of biomolecules.

Learning Outcomes:

- Upon completion of this course, students should be able to recognize how fundamental
 chemical principles and reactions are utilized in biochemical processes and that these
 reactions are not specific only for living system.
- Student should be able to identify water as essential solvent and reactant in any living system, including understanding how water physical and chemical properties determine biochemical reaction in all living systems.
- Upon completion of this course, students should be able to judge whether a proposed
 or hypothetical reaction is consistent with the general framework of catabolic and
 anabolic processes, particularly related to transformation of amino acids and
 proteins.
- Upon completion of "Amino Acid Oxidation and the Production of Urea" and
 "Biosynthesis of Amino Acids and Related Molecules" sections, students should
 recognize how nitrogen compounds are assimilated, recycled, turned into metabolic
 energy or exerted from the cell and how these processes are related to a particular
 diet or starvation.
- Upon completion of "Reactive oxygen species (ROS) in biological systems" section student will understand free radical chemistry, radical formation and propagation and will be familiar with their influence on metabolism and integrity of the cell.
- Upon completion of "Drugs development" section (Stryer, Biochemistry, chap. 34) students will understand that development of drugs represents one of the most important interface between biochemistry and medicine. They will recognize that, in most cases, drugs act by binding to specific receptors or enzymes and inhibiting, or otherwise modulating, their activities. Student will find out how helpful biochemistry is in the production and understanding of these interactions.
- Upon completion of MMBB 442/542 course, students should be able to use their background knowledge in biochemistry to understand research that led or will lead in the future to key advancements not only in biochemistry but also in biological sciences in general.

Examinations:

Second Thursday of February	Exam I	100 points
Second Thursday of March	Exam II	100 points
Second Thursday of April	Exam III	100 points
Thursday (final week)	Final*	100 points

^{*} Score greater than 90% from exams I, II and III (and the paper) may make the student eligible for exemption from final exam. The attendance in every class will be awarded with +0.5 grade. The classes start at 8: am sharp, I expect that the every student to be on time in the classroom!!

Exams will cover material presented during the lectures and material in the assigned study text. The exam format will consist of five to ten essay questions.

In addition, graduate students will be required to write a detailed review paper or give a presentation on a selected subject, and generate a computer model of the biomolecules covered in their paper (using data deposited in the Protein Data Bank (http://www.rcsb.org/pdb/). The review paper is worth 100 points and is due by the end of March. The course grade will be calculated from the sum of the all exams and the paper (graduate students only), using the following scale: A 90-100%, B 80-89%, C 70-79%, D 50-69%, F below 49%. Unexcused, missed exams will count as 0 points. Excused absences will be granted based on individual cases. Refer to the University of Idaho General Catalog, Requirements and Academic Procedures, Section M. Acts of cheating or/and plagiarism in MMBB 442/542 will result in an automatic 0 for that exam or paper and could result in an automatic F as a final grade for the course. Refer to the Student Code of Conduct (2300) in the Faculty Staff Handbook for more information.

The University of Idaho course evaluation site is located at this URL: http://www.its.uidaho.edu/studentevals. Student evaluations are confidential. As soon as the student submits an evaluation, the data is entered into a table that cannot be linked to the student. I strongly encourage all students to take a time to take time to sincerely evaluate this class. The students' input help to make this better.

American Society for Microbiology (ASM) statement on the scientific basis for evolution (Revised after Council input on May 24, 2006, and subsequent review by the committee)

Knowledge of the microbial world is essential to understanding the evolution of life on Earth. The characteristics of microorganisms—small size, rapid reproduction, mobility, and facility in exchanging genetic information—allow them to adapt rapidly to environmental influences. In microbiology and biochemistry, the validity of evolutionary principles is supported by [1] readily demonstrated mutation, recombination and selection, which are the fundamental mechanisms of evolution; [2] comparisons based on genomic data that support a common ancestry of life; and [3] observable rates of genetic change and the extent of genomic diversity which indicate that divergence has occurred over a very long scale of geologic time, and testify to the great antiquity of life on Earth. Thus, microorganisms illustrate evolution in action, and microbiologists have been able to make use of the microbes' evolutionary capacity in the development of life-improving and life-saving innovations in medicine, agriculture, and for the environment. By contrast, proposed alternatives to evolution, such as intelligent design and other forms of creationism are not scientific, in part because they fail to provide a framework for useful, testable predictions. The use of the supposed "irreducible complexity" of the bacterial flagellum or protist contractile vacuoles an argument to endow nonscientific concepts with what appears to be legitimacy, is spurious and not based on fact. Evolution is not mere conjecture, but a conclusive discovery supported by a coherent body of integrated evidence. Overwhelmingly, the scientific community, regardless of religious belief, accepts evolution as central to an understanding of life and the life sciences. A fundamental aspect of the practice of science is to separate one's personal beliefs from the pursuit of understanding of the natural world. It is important that society and future

generations recognize the legitimacy of testable, verified, fact-based learning about the origins and diversity of life.

University of Idaho Classroom Learning Civility Clause: In any environment in which people gather to learn, it is essential that all members feel as free and safe as possible in their participation. To this end, it is expected that everyone in this course will be treated with mutual respect and civility, with an understanding that all of us (students, instructors, professors, guests, and teaching assistants) will be respectful and civil to one another in discussion, in action, in teaching, and in learning. Should you feel our classroom interactions do not reflect an environment of civility and respect, you are encouraged to meet with your instructor during office hours to discuss your concern. Additional resources for expression of concern or requesting support include the Dean of Students office and staff (5-6757), the UI Counseling & Testing Center's confidential services (5-6716), or the UI Office of Human Rights, Access, & Inclusion (5-4285).

Tentative subjects:

- 1. The foundations of biochemistry: cellular, chemical, physical, genetic, and evolutionary. Biochemical and cellular basis of vision process. Evolution of vision pigments and recombination leading to color blindness. Hydrolytic cleavage of peptide by chymotrypsin, the enzyme structure and reaction mechanism. (*Lehninger*, chapters: 1, 6.4, 12.7 including Box 12.3; *Stryer Biochemistry*, chapter: 1, 2, 3 and 32.3)
- 2. Oxygen and water: the sculptors of life on the Earth. Carbon dioxide, carbonic acid and bicarbonate equilibria and buffer system. Structure and mechanism of carbonic anhydrase reaction (*Lehninger*, chap. 2; *Stryer Biochemistry*, chap 9.2; *Methods in Enzymology* vol. 105 1984).
- 3. Amino acids, peptides, and proteins. Mass spectrometry as a principle analytical tool of proteomic and metabolomic research. (*Lehninger*, chap. 3; *Stryer Biochemistry*, chap. 4.1 and 4.2).
- 4. Drugs development. (Stryer, *Biochemistry*, chap. 34). The development of drugs represents one of the most important interfaces between biochemistry and medicine. In most cases, drugs act by binding to specific receptors or enzymes and inhibiting, or otherwise modulating, their activities. Thus, knowledge of these molecules and the pathways in which they participate is crucial to drug development. An effective drug is much more than a potent modulator of its target, however. Drugs must be readily administered to patients, preferably as small tablets taken orally, and must survive within the body long enough to reach their targets.
- 5. Reactive oxygen species (ROS) in biological systems (*Methods in Enzymology* vol. 105, 1984). Definition of free radicals, cation radicals, anion radicals, radical propagation, radical polymerization, and radical recombination. (*Handbook of*

- *Organic Chemistry*, H. Beyer and W. Walter, T.J. Press Ltd. 1996). Reactive nitrogen species (RNS). Implication of ROS and RNS in aging process: "free radical theory of aging." (Mass Spectrometry Reviews, 2005, 24, 701–718)
- 6. Proteins and amino acids degradation, nitrogen metabolism, urea cycle, ubiquitin-proteasome pathway (*Lehninger*, chap. 18 and 27; and Stryer *Biochemistry*, chap. 23, A. Goldberg et al., The cellular chamber of doom. 2001. Scientific American, Jan 2001 pp. 68-73).
- 7. Biosynthesis of amino acids, nucleotides, and related molecules (*Lehninger Biochemistry*, chap. 22; and Stryer *Biochemistry*, chap. 24).
- 8. Biosignaling: Sensory transduction in vision, olfaction and gustation. The conversion of information into chemical changes (signal transduction) is a universal property of living cell. General features of signal transduction are specificity, cooperativity, amplification, desensitization, integration etc. G protein coupled receptors and second messengers are key players in signal transduction. (*Lehninger Biochemistry* chapt 12)
- 9. Iron homeostasis, iron acquisition, iron storage, iron and redox stress, iron insertion into proteins, life without iron. (*FEMS Microb*. Rev. 27: 215-237, 2003 *Molec*. *Microbiol*. 54:14-22, 2004.)
- 10. The three-dimensional structure of proteins (*Lehninger*, chap. 4).
- 11. Protein synthesis and processing, genetic code (primary and secondary), translation, posttranslational modifications. (*Lehninger*, chap. 27; and Stryer, chap. 29).
- 12. The biochemical evolution of iron and copper proteins. Copper and iron metalloproteins are primary oxidases, oxygenases, and oxygen carriers in all cells. Their evolution will be covered from the early stages of the Earth's history (no oxygen) to the present multimetal containing oxidases (e.g., cytochrome oxides, superoxide dismutases), (from review papers of E. Frieden, including *Metal Ions in Biological Systems*, vol. 13:1-14, 1981).
- 13. Contemporary topics in biochemistry.
- 14. Nobel Price winners in biology and medicine in recent years, their research and the importance of their discoveries.