

## **IBS601/BCH607: Biochemistry & Metabolism/General Biochemistry**

Course ID: IBS601-001-20056

This is the first half of a two semester course introducing graduate students to the molecules that comprise biological systems, the principles governing their behavior, and the methods used in their study. It is intended for doctoral students planning to enter a career in research in one of the biomedical sciences. Basic aspects of the carbohydrates and lipids are covered but the emphasis is on protein structure and function and metabolic control. Nucleic acid structure and function are covered in the second semester of the sequence.

### *Course content*

The course will start with a series of lectures that should mostly review undergraduate chemistry and introduce major biomolecular classes. The lecture on amino acids will begin an extended section on the structure and function of proteins. This section will first explore elements of protein structure. Basic aspects of protein function will follow, beginning with basic principles of binding interactions interweaved by mechanisms of regulation occurring at the protein level. We will begin with simple concepts and show how more complex behavior is built on these simpler beginnings with a focus on receptor/ligand and antibody/antigen interactions. Elements of chemical and biochemical catalysis will then be introduced, once again building on prior course topics. Throughout this section, quantitative treatments of biological phenomena will be emphasized, as will the chemical and thermodynamic bases of these behaviors.

After completing the section on enzymology, there are seven lectures on experimental methodologies used in the study of protein function and structure. After these methods lectures, the emphasis of the course will be on metabolism and how it is integrated. Three lectures will focus on chemical aspects of metabolic reactions, followed by three lectures covering aspects of biomembranes and subcellular compartmentalization and transport. The thermodynamics and regulation of key pathways for energy production (glycolysis, citric acid cycle, oxidative phosphorylation and photosynthesis) will then be presented. The course will conclude with a three lecture overview of human metabolic control.

### *Meeting time*

Class meets every MWF (except University holidays) from 12 noon to 12:50 pm in MN563 of the Medical Center. In addition, there are three required exams from 6:00-8:00 pm in the evening on Tuesday, 27 Sept.; Tuesday, 25 Oct., and Thursday, 17 Nov. and three voluntary evening review sessions in B202A BBSRB. See the schedule for detailed listings.

### *Prerequisites*

Students taking this course should have at least a bachelor's degree from an accredited university and have taken 1 yr of introductory ("freshman") chemistry, 1 yr. of organic chemistry, and have advanced knowledge in general biology.

More specifically, the student is expected to have a working knowledge of:

- general algebraic principles in the solution of “word problems”, including knowledge of:
  - the properties of logarithms and exponentials
  - solution of simultaneous equations in multiple variables
  - solution of quadratic equations
  - pre-calculus (primarily limits and rates)
- general concepts in thermodynamics such as free energy, enthalpy, entropy, work and their relationship to equilibrium
- different types of chemical bonding (covalent, ionic, polar)
- rates of reaction and their relationship to energies of activation
- the chemical structures and physical properties of major classes of organic compounds, including alkanes, alkenes, aromatic compounds, alcohols, aldehydes, ketones, carboxylic acids, ethers, esters, amines, and amides
- stereochemistry
- the “central dogma” of molecular biology (DNA → RNA → protein)
- evolutionary principles
- chromosomal theory of inheritance and basic principles of Mendelian genetics
- subcellular components (nucleus, chromosome, ribosomes, mitochondria, chloroplasts, endoplasmic reticulum, plasma membrane, Golgi apparatus, lysosomes, cytoskeleton)

### *Text*

Most of the assigned readings will be in Voet & Voet, *Biochemistry 3<sup>rd</sup> Edition*, Wiley Press, but additional readings may be assigned for some topics not adequately covered by the text.

The text contains far too much information; it is a very useful reference and, although expensive, you should really own your own copy. I still have (and use) the text with which I studied introductory biochemistry. Use the lectures and what the instructors tell you as guides as to what to pay particular attention to in the text. There is a fair amount of detailed information that you will be required to memorize, there is a lot more information with which you should have passing familiarity. The lectures will be more effective if the assigned reading is done prior to lecture.

### *Blackboard (course website)*

IBS601 uses the University Blackboard system extensively. Announcements, this syllabus, the class lecture and exam schedule, lecture notes, reading assignments, homework assignments, answer keys, old exams, and instructor contact information are posted on this site (<http://www.uky.edu/Blackboard>). In addition, some of the faculty will make use of the “Discussion Boards” function (under the “email” tab) to answer questions about course material outside of class.

### *eQuestions*

Students are encouraged to contact faculty electronically concerning questions that might best be answered in an impersonal way. The email addresses of all faculty members participating in this course are appended at the end of this syllabus.

In addition, some of the faculty will make use of the Discussion Board function on Blackboard to handle questions of this nature. Any questions can be posted, *anonymously if desired*, and the participating faculty will provide written answers within one or two working days. This approach has the benefit that all students have access to the same answers and are able to see the kinds of questions their classmates are asking. Students are also able to make comments on the responses or add follow-up questions. **When posting questions by this method, please identify the faculty member that you would like to get the response from in the header to the question.**

The faculty choosing to use the discussion board are Mendenhall & Woodward. These faculty request that you do **not** email them directly with questions about course material, although direct emails are encouraged for personal matters (questions about individual grades, absences, etc.) The faculty not participating in the Discussion Board are Hersh, Schwarze, LeVine & Whiteheart; please contact them directly at their email addresses. Those faculty that have not indicated a preference are Moncman & Murphy.

### *Exams*

There are 4 exams this semester. Three of the exams occur during the semester and are held on Tuesday or Thursday evenings from 6:00-8:00—check the class schedule and be sure to keep these evenings open. The last exam is during finals week. Each exam is worth 100 points. The exams are technically not cumulative—they only cover the lectures as listed in the syllabus—but the information in class builds on prior lectures, so concepts introduced earlier in the course could show up on later exams if they pertain to the newer material. The exams are closed book. No notes, calculators or devices other than a pen or pencil will be permitted during the exam.

If it appears that you will miss an exam, contact the course director at your earliest opportunity prior to the exam. Unexcused absences will result in a zero grade unless there was a consequential reason for the absence **and** concrete evidence that prior notification was unavoidable (emergency room report, arresting officer's report, public statement by Gonzalez that you were held incommunicado due to suspicion of Patriot Act violations or other leftist leanings). Acceptable reasons for **excused** absences are: serious illness, illness or death of a family member, University-related trips, major religious holidays, or other circumstances agreed to by the course director. The student should be prepared to provide appropriate verification for an excused absence to the course director.

### *Homework assignments*

There are 4 homework assignments. The homework assignments will be due as indicated in the syllabus. Each assignment is worth 25 points. All together they equal one exam in weight. Late assignments will be given a grade of zero. The homework assignments will cover roughly the

same material as will be covered by the exams, but will frequently require more elaborate calculations or involve more complex structures than will be typical for the examinations. The purpose of the homework is to expose students to practical aspects of biochemistry and to test ability and material understanding that is not feasibly done by an in-class examination. *It is not meant to be used as a means of preparing for exams*, although it may have that function as a side-effect. The homework should represent your own work. Plagiarism or copying could result in a substantially reduced grade.

### *Code names*

To help preserve confidentiality of test scores and grades, we will use code names instead of real names on all exams and homework assignments. Early in the semester, you will be asked to provide a 5 letter or digit “code name” to the course director. You will use that name all semester on exams and homework assignments instead of your real name. Except for the course director, faculty and graders will not have knowledge of the real identity of the code names. This will allow the faculty to return exams and homework assignments without students being able to see each others’ grades.

### *Grading*

Grades are based on the four exams and four homework assignments. The final class grade is based on your combined performance on tests and take-homes relative to the class as a whole at the end of the semester.

Grades will be calculated by two different grading systems; each student will receive the **higher** of the grades calculated by the two systems as their final grade for the course.

In the first grading system, and the one most likely to be in effect, students with total scores one standard deviation or more above the class average will receive an “A” grade, scores less than one standard deviation above or more than one standard deviation below will receive a “B”. Students with total scores more than one standard deviation below the average, but less than two standard deviations below the average, will receive a “C”. Students with scores more than two standard deviations below the average will receive an “E”. There is no “D” for graduate students. On this scale, about 20% of the class will receive A’s, 60% B’s, 20% C’s.

In the second grading system, any student obtaining final scores of 450 or more (>90% of the total) will receive an “A”, between 400 and 449 will receive a “B”, between 350 and 399 will receive a “C” with scores below that receiving an “E”.

In 2003, there were no failing grades; in 2004, there was one. Interim grades based on completed homework assignments and examinations will be available throughout the semester, but these grades should be regarded only as estimates.

The course director also has the discretion to raise individual students’ grades on the basis of superior exam scores.

Keys to exams and take-homes will be posted on the class website after the last excused make-up exam or home-work has been turned in. If you question the grading of any exam or take-home, attach a written explanation as to why you think the grading was in error to the original exam or home-work assignment and return it to the course director within 1 week of the posting of the key for possible regrading. Requests for regrading after this one week period will not be considered.

### *Academic Integrity, Cheating and Plagiarism*

Plagiarism (willful, unattributed copying of another's work) and other forms of cheating are considered unacceptable behavior for any student attending this University. The minimum penalty for either of these academic offenses is an "E" grade, with suspension or dismissal from the University also possible.

### *Classroom Behavior, Decorum and Civility*

Students and faculty have the right to expect that all class activities will occur in a spirit of mutual respect for the opinions and rights of all participants. While all participants have the right to take reasoned exception and to voice alternative opinions, the accepted level of civility would not include attacks of a personal nature or statements denigrating another on the basis of race, sex, religion, sexual orientation, age, national/regional origin or other such irrelevant factors.

### *Writing Skills*

Regardless of discipline, instructors have the right—and the obligation—to expect that students use English properly in all aspects of the course. (S.R.5.2.4.3). Instructors can ask students to rewrite papers, make writing style one of the grading criteria, and report a seriously deficient student to his/her college for remedial work. *Lecturers (in order of appearance):*

### *Contact Information*

Michael Mendenhall, course director, Department of Molecular & Cellular Biochemistry, B163 BBSRB, 7-5379, [mendenh@uky.edu](mailto:mendenh@uky.edu)

Lou Hersh, Chair, Department of Molecular & Cellular Biochemistry, B283 BBSRB, 3-5549, [lhersh@uky.edu](mailto:lhersh@uky.edu)

Carole Moncman, Department of Molecular & Cellular Biochemistry, B117 BBSRB, 3-3732, [cmonc2@uky.edu](mailto:cmonc2@uky.edu)

Jerry Woodward, Department of Microbiology, Immunology and Molecular Genetics, MN426 Med. Sci., 3-5538, [jwood1@uky.edu](mailto:jwood1@uky.edu)

Paul Murphy, Department of Molecular & Cellular Biochemistry, 211 Sanders-Brown Center on Aging, 7-1412 ext 490, [mpaulmurphy@uky.edu](mailto:mpaulmurphy@uky.edu)

Steven Schwarze, Department of Molecular & Cellular Biochemistry, 307 Combs Cancer Research Building, 3-2648, [steve.schwarze@uky.edu](mailto:steve.schwarze@uky.edu)

Harry LeVine, course co-director, Center on Aging and Department of Molecular & Cellular Biochemistry, 209 Sanders-Brown Center on Aging, [hlevine@uky.edu](mailto:hlevine@uky.edu)

Wally Whiteheart, Department of Molecular & Cellular Biochemistry, B261 BBSRB, 7-4882,  
[whitehe@uky.edu](mailto:whitehe@uky.edu)

*Other useful telephone numbers:*

IBS office: 323-0004

Molecular & Cellular Biochemistry Office: 323-5549

*Office hours:*

Mendenhall: Aug25-Oct4: MWF 1-2 B163 BBSRB *or by appointment*. After Oct 4, *by appointment only*. Email [mendenh@uky.edu](mailto:mendenh@uky.edu) or phone 7-5379 to schedule an appointment.

Hersh: *By appointment only*. Email [lhersh@uky.edu](mailto:lhersh@uky.edu) or phone 3-5549 to schedule an appointment.

Moncman: *By appointment only*. Email [cmonc2@uky.edu](mailto:cmonc2@uky.edu) or phone 3-3732 to schedule an appointment.

Woodward: *By appointment only*. Email [jwood1@uky.edu](mailto:jwood1@uky.edu) to schedule an appointment.

Murphy: *By appointment only*. Email [mpaulmurphy@uky.edu](mailto:mpaulmurphy@uky.edu) or call 7-1412 ext 490 to schedule an appointment.

Schwarze: *By appointment only*. Email [steve.schwarze@uky.edu](mailto:steve.schwarze@uky.edu) or call 3-2648 to schedule an appointment.

LeVine: *By appointment only, Nov. 2 to Dec. 2*. Email [hlevine@uky.edu](mailto:hlevine@uky.edu) to schedule an appointment.

Whiteheart: ThF 5-6, B261 BBSRB

Date	Topic	Reading	Lecturer
Aug 24	Introduction	1	Mendenhall
26	Thermodynamics & Equilibrium	3	Mendenhall
29	Aqueous Solutions, pH	2	Mendenhall
31	Carbohydrates	11.1-11.2	Mendenhall
Sep 2	Lipids and Lipid Aggregates	12.1-12.2	Mendenhall
5	☺ Labor Day		
7	Amino Acids	4.1-2B	Mendenhall
9	Peptides and Protein Structure (part I)	4.1B, 8.1A-B	Mendenhall
12	Protein Structure (part II)	8.1C-D, 8.3B, 8.4	Mendenhall
14	Protein Folding	9.1-9.3	Mendenhall
16	Dynamics, Structure Prediction, Conformational Diseases	9.4-9.5	Mendenhall
19	Myoglobin: Simple Hyperbolic Binding	10	Mendenhall
21	Hemoglobin: Cooperative Binding (homework 1 due)	10	Mendenhall
23	Hemoglobin: Allosteric Regulation	10	Mendenhall
26	Ligand/Receptor Interactions: Hyperbolic Binding Revisited (evening review session)	19.1.A & notes	Mendenhall
27	<b>Exam I, Tuesday, 6-8 p.m., MN and MN (covers Aug 24 to Sept 21)</b>		
28	Ligand/Receptor Interactions: Competition	19.1.A & notes	Mendenhall
30	Chemical Kinetics: Rates	14.1	Hersh
Oct 3	Enzyme Kinetics I	14.2-14.5	Hersh
5	Enzyme Kinetics II	14.2-14.5	Hersh
7	☺ Fall Break		
10	Enzyme Catalysis	13	Hersh
12	Enzyme Mechanisms	15	Hersh
14	Protein Methods: Concentration, Spectroscopy, Centrifugation	6	Moncman
17	Protein Methods: Chromatography (homework 2 due)	6	Moncman
19	Protein Methods: Electrophoresis	6	Moncman
21	Protein Primary Structure Determination: Peptide Sequencing & Mass Spectrometry	7.1	Murphy
24	Immunoglobulins: Structure, Multivalent Interactions		Woodward
25	<b>Exam II, Tuesday 6-8 p.m., MN and MN (covers Sept 23 to Oct 19)</b>		
26	Protein Methods: Antibodies as Reagents, Immunoprecipitation (evening review session)		Woodward
28	Protein Methods: RIA, ELISA, Immunoblotting	6	Woodward
31	Protein Tertiary Structure Determination: Crystallography & NMR	8.3A-B	Schwarze
Nov 2	Metabolism: Group Transfer Reactions	16.2	LeVine
4	Metabolism: Thermodynamics of Phosphate Compounds	16.4, 16.6	LeVine
7	Metabolism: Redox Reactions	16.5	LeVine
9	Biomembranes	12.3	LeVine
11	Permeability Barrier (homework 3 due)	20.1-20.2	LeVine
14	Transporters	20.2-20.5	LeVine
16	Glycolysis: Chemistry & Energetics (evening review session)	17	Moncman
17	<b>Exam III, Thursday 6-8 pm MN and MN (covers Oct 21 to Nov 14)</b>		
18	Glycolysis: Regulation	17	Moncman
21	Citric Acid Cycle	21	Moncman
23	Oxidative Phosphorylation I	Chap. 22 pp 797-827	Whiteheart

25	☺ Thanksgiving		
28	Oxidative Phosphorylation II	Chap. 22 pp 827-839	Whiteheart
30	Photosynthesis: Light Reaction	Chap. 24 pp 871-896	Whiteheart
Dec 2	Photosynthesis: Dark Reaction	Chap. 24 pp 896-906	Whiteheart
5	Intermediate Metabolism	Chap. 27 pp 1054-68	Whiteheart
7	Intermediate Metabolism	pp 930-1, 940-2, 995-6	Whiteheart
9	Intermediate Metabolism (homework 4 due)	pp 836-9, 766, 651-4, 864-4	Whiteheart
16	<b><i>Exam IV Friday 1-2:50 MN463 and MN563 (covers Nov 16 to Dec 9)</i></b>		