LONDON SOUTH BANK UNIVERSITY

(Bio)molecules

SFB-4-101

Faculty of Engineering, Science and the Built Environment

2011-2012

Level 4, Year 1

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1. MODULE DETAILS

Module Title:	(Bio) molecules
Module Level:	Level 4, Year 1
Module Reference Number:	SFB-4-101
Credit Value:	2 Credits = 300 CATS points
Student Study Hours:	300 hours
Contact Hours:	84 hours
Private Study Hours:	216 hours
Pre-requisite Learning (If applicable):	None
Co-requisite Modules (If applicable):	Core Skills (practical skills)
Course(s):	Bioscience, Food all options HND Chemical Engineering (Semester 1 content only)
Year and Semester	Year 1, semesters 1 and 2
Module Coordinator:	Dr Michael Byford
MC Contact Details (Tel, Email, Room)	Room B150, Tel. Ex 7994 email: byfordmf@lsbu.ac.uk
Teaching Team & Contact Details (If applicable):	Dr John Acord Room B140 Tel Ex 7922 Email: acordj@lsbu.ac.uk Dr Nicholas Power (contact details to be announced).
Subject Areas:	Bioscience and Food, Chemical Engineering
Summary of Assessment Method:	MCQ tests in-class (50%) and examination (50%)

2. SHORT DESCRIPTION

An introduction to the chemistry and biochemistry required to underpin science degree courses. Starting from a basic description of the atom, the course leads progressively to cover key aspects of fundamental physical, inorganic and organic chemistry. The unit then looks at various aspects of biochemistry; the structure of nucleic acids, proteins, lipids and carbohydrates. It also includes introductory enzyme kinetics, bioenergetics and basic aspects of metabolism.

3. AIMS OF THE MODULE

The aims of this unit are:

- To equip students with the appropriate scientific background for the study of applied science.
- To encourage a confident, reasoning, disciplined, inquiring and investigative approach to the study of science.
- To provide a body of knowledge of chemical and biochemical science necessary for the study of science-based courses.
- To illustrate some investigative and interdisciplinary approaches that have explained biochemical structures and processes.
- To provide an introduction to the general principles of metabolism in terms of the utilisation of nutrients, based on the fundamentals of bioenergetics and enzyme catalysis.

4. LEARNING OUTCOMES

4.1 Knowledge and Understanding

- Describe in qualitative terms the nature of the interactions between molecules in solids, liquids and gases,

- Carry out simple calculations using the relationships between molarity, relative molecular mass, %w/v, ppm, w/w,
- Describe the electronic structure of elements in the Periodic Table, particularly of those that are biologically important, and explain the structure of the Table,
- Describe the different types of bonding found between atoms and predict the type of bonding to be expected in particular compounds,
- Explain what a radioactive isotope is and what is meant by its 'half-life',
- Predict the approximate equilibrium position of a reaction given the value of the Gibbs free energy change,
- Explain the difference between strong and weak acids and the significance and mechanism of buffering in biological systems and differentiate between oxygen addition and oxidation.
- Recognise the structure and relevance of a number of biologically important carbohydrates, nucleic acids, amino acids, fatty acids and intermediary metabolites.
- Demonstrate an understanding of enzyme kinetics based on the Michaelis-Menten model.
- Describe selected metabolic pathways showing an understanding of the underlying thermodynamics.

4.2 Intellectual Skills

- Learn how to interpret structural or molecular formulae to predict the approximate shapes of simple organic molecules from their formulae.
- Describe the biologically relevant reactions that might be expected of organic substances of given molecular formulae.
- Learning how to learn - there are a wide range of aspects to this skill which will be developed *e.g.* time management, finding and using information.
- Use of information and communication technology - the use of the textbooks and the internet to retrieve information.

4.3 Practical Skills

- Core scientific skills comes from skills unit, which this unit is designed to augment..

4.4 Transferable Skills

- Reasoning skills – through the knowledge of scientific concepts and reasoning.
- Communication skills - written and oral communication will be required during preparation for tutorials especially those involving presentations.
- Numeracy skills - analysis and interpretation of numerical information along with simple algebra.

5. ASSESSMENT OF THE MODULE

There will be a fifty question multiple choice examination at the end of each semester. The coursework component will be a series of 5 in-class tests on alternating weeks if each semester, 12 questions per test. The best 4 of the tests will be averaged to provide the coursework mark.

6. FEEDBACK

Test results will be returned to students the week after the test was set.

7. INTRODUCTION TO STUDYING THE MODULE

7.1 Overview of the Main Content

The nature of matter. This examines the concepts of atoms and molecules, their structure, mass and chemical and physical properties: Electrons in pairs, orbitals and shells. Isotopes (stable and unstable). The formation of ions. The Periodic Table. Bonding; covalent and ionic. The structure of water and hydrogen bonding. Water as a solvent; hydrophobic and hydrophilic effects.

Reactions. This examines chemical reactions, their direction, stoichiometry, catalysis, and energetics: Balancing equations and stoichiometry. Activation energy and the effect of temperature and reactant concentrations on the rates of reaction. Enthalpy, entropy and free energy. Equilibrium, Le Chatelier and the role of 'free energy'. Ionisation, water, strong and weak acids, bases, salts, pH, pK, titrations, buffers, indicators and the Henderson-Hasselbalch equation.

Organic chemistry. This describes simple organic molecules and their reactions: The tetrahedral carbon atoms, double bonds and p electrons. Resonance and conjugation, delocalisation of electrons and aromatic compounds. Electrophilic and nucleophilic groups and reactions. Functional groups: - biologically relevant properties and reactions of alkyl, alkenyl, alcohols, aldehydes, ketones, carboxylic acids, anhydrides, amines, amides and esters. Conformational isomerism, stereoisomerism, optical isomerism and cis/trans isomerism. D-/L- and S-/R- nomenclature.

Structural biochemistry. This will investigate the structures and physical and chemical properties of representative members of the major groups of important biological molecules (polysaccharides, amino acids and proteins, nucleic acids and fatty acids) and relate these to their biological roles.

Enzymology. This looks at the role of enzymes in metabolism and the nature of enzyme catalysed reactions: Reaction components and the molecular basis of enzyme reactions. Reaction rates and factors affecting them, including pH, temperature and inhibition. Basic enzyme kinetics and the Michaelis-Menten equation.

Biochemical equilibria and bioenergetics. This will describe simple thermodynamic relationships in biochemical reactions: The role of ATP and other molecules of high group transfer potential in coupling reactions. Redox systems; NADH and $FADH_2$. An outline of the electron transport chain and the role of proton gradients in the chemiosmotic model.

Basic aspects of metabolism. This will explore the fundamental nature of metabolic reactions by a review of some major catabolic pathways (glycolysis, Krebs cycle, lipid catabolism and the urea cycle) and their interrelationships.

7.2 Overview of Types of Classes

This double credit (30 CATS points) credit unit contains lectures, tutorials and directed student-centred learning. It consists of a total of 300 hours made up of class contact time (84 hrs) and directed learning (216 hrs). Related practical classes form part of the *Core Skills* unit.

The course will be presented in a series of 48 lectures with 24 one-hour tutorials in support. Four reinforcement/revision lectures are also given. Ten one-hour periods will be timetabled every other week starting in week two for the completion of multiple-choice tests. On the weeks following the tests, there will be a one-hour period for going over the answers to the previous week's test and for practising further examples. Practical work (about 18 hours) will support and reinforce the material in the theory sections and develop laboratory skills, safe practice and group participation. This practical work will form part of associated units.

For the six tutorials you will be divided into groups. Your Biological Chemistry tutor will concentrate on the needs of students who have done the least chemistry in the past. A program of guided student-centred activities is provided which includes guided reading, audio-visual aids, computer simulations, molecular modelling and problem solving.

These times are NOT optional. You must invest your time if you are to benefit from University. If you do not use your opportunity then you let us and yourself down.

All lectures, tutorials and multiple-choice test classes must be attended unless you have an excuse acceptable to your course director. All sessions will have attendance monitored.. Attendance is important and absence may cause you to fail. If multiple-choice test sessions are unavoidably missed, it

is not usually possible to do them at an alternative time. Exceptions may be possible if sufficient prior warning is given.

The course has essential textbooks associated with it. One must be purchased to complete the background reading satisfactorily.

7.3 Importance of Student Self-Managed Learning Time

Each one-hour lecture has associated with it two hours for reading your notes and the directed essential reading matter. This should be done on the same day as the lecture. The rest of the unit time is taken up with the problems. For maximum benefit these should also be done as close to their associated lectures as possible and before the following week. For these reasons you should set aside four hours each week on the same day as the Biological Chemistry unit for this work. A further four hours should be set aside at the weekend for the problems and to prepare for the following week. Recognise that this is one of the more demanding Units and invest the time. The investment pays dividends.

7.4 Employability

The unit will develop written and verbal skills (including presentation skills) that are useful in future careers. These include: numeracy, literacy and the ability to reason, along with the ability to retrieve and process information

8. THE PROGRAMME OF TEACHING, LEARNING AND ASSESSMENT

The unit comprises 2 hours of formal lectures per week along with a 1-hour long tutorial.

The weekly programme is given (in the next section) with the following headings:

Problems

Being able to answer these, or similar, problems proves many of the learning outcomes for the unit. The competence to answer them, or similar, will be tested in the fortnightly tests and final examination so practise these problems beforehand. They should be attempted each week. These are in a separate booklet.

Week 1

a) Atomic structure, protons, electrons and neutrons; relative atomic mass; amu; Avogadro's number. (MB)
b) The Periodic Table, metals and non-metals, groups and periods; atomic orbitals, shielding and electronegativity. (MB)

Background reading Timberlake ; Chapters 1, 2 and 3. Atkins and Jones Chapters 1, 2 and 22
Study guide Timberlake ; 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 3.1, 3.2, 3.5. Atkins and Jones pp 1 – 17 (atoms and the Periodic Table), 976 - 981 (radioactive decay);
Related learning aids The Periodic Table, see back cover
Atoms & **Radioactivity** Web pages.

Week 2

d) Ionic and covalent bonding; properties of ionic and covalent compounds; molecules, molecular mass and the mole. (MB)
e) Molecular orbitals, shapes of molecules (MB)

Background reading Timberlake Chapter 4; Atkins and Jones Chapters 7, 8 and 9
Study guide Timberlake 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10; Atkins and Jones pp 18 - 25 (substances), 68 – 71 (molar mass), 322 - 341 (ionic

and covalent bonds), 363 - 372 (shapes of molecules), 388 - 394 (molecular orbitals)

Week 3 **f**) Molarity, calculation of molecular composition, reactions. (NP)
g) Stoichiometry of reactions, balancing equations. (MB)

Background reading	Timberlake Chapters 6 and 7; Atkins and Jones Chapters 3, 4; re-read Chapter 2;
Study guide	Timberlake 6.1, 6.2, 6.3, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6; Atkins and Jones pp 75 - 77 (% composition calculations), 77 - 81 (compound formulae and composition), 92 - 95 (balancing equations), 138 - 151 (stoichiometry), 154 - 158 (molarity)
Related learning aids	**Molarity** & **Stoichiometry** Web pages

Week 4 **h**) States of matter, solids, liquids and gases, the gas laws, polar and non-polar molecules; solutions. (NP)
i) Water, structure, properties and importance; surface energy and entropy; hydrogen bonding. (MB)

Background reading	Timberlake Chapters 5, 8 and 9; Atkins and Jones Chapters 5 and 10
Study guide	Timberlake 5.4, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 9.1; Atkins and Jones 426 - 428 (hydrogen bonding), 428 - 430 (liquids), 178 - 200 (gases and the gas laws)
Related learning aids	**The gas laws** & **Water** Web pages Water Web site: http://www.sbu.ac.uk/water

Week 5 **j**) Water and other solvents, gas solubility; osmosis and other colligative properties; the hydrophobic effect; detergents. (MB)
k) Equilibrium; Le Chatelier's principle, effect of temperature and pressure on equilibria. (NP)

Background reading	Timberlake Chapters 6 and 9; Atkins and Jones Chapters 12 and 13
Study guide	Timberlake 6.8, 9.2, 9.3, 9.5, 9.7, 9.8; Atkins and Jones pp 422 - 426 (forces between molecules), 524 - 543 (solubility), 543 - 559 (osmosis), 620 - 649 (Le Chatelier's principle).
Related learning aids	**'**pH/Titrations' PC program section B, available from Web site **Water** Web page

Week 6 **l**) Introduction to transition metals, ions, electronic configuration of the different valence states, colour, simple redox reactions. (NP)
m) Water, ionisation, acids (strong and weak), bases, salts and pH. (MB)

Background reading	Timberlake Chapter 10; Atkins and Jones Chapters 15 (first part) and 21
Study guide	Timberlake 6.5, 10.1, 10.2, 10.3, 10.4, 10.5, 10.6; Atkins and Jones 660 - 671 (acids, bases and pH), 918 - 922 (transition metals)
Related learning aids	**'**pH/Titrations' PC program section A, available from Web site **Acids** Web page The Periodic Table, back cover

Week 7 **n**) The tetrahedral carbon atom and the projection of three-dimensional structures; alkanes and alkenes; double bonds, pi electrons, aromaticity and resonance; conjugated structures and the optical absorption of dyes (NP)
o) Weak acids, pK_a, the Henderson-Hasselbalch equation and buffers; acid-base titrations and indicators (MB)

Background reading	Timberlake Chapter 10, 11, 12 and 13; Atkins and Jones Chapters 11 (first part), 15 and 16;
Study guide	Timberlake 10.9, 10.10, 10.11, Chapter 11, 12.1, 12.2, 12.3, 13.1, 13.2, 13.3; Atkins and Jones pp 337 - 339 (resonance), 472 - 484 (alkanes, alkenes and aromatics), 671 - 692 (weak acids), 707 - 729 (titrations, buffers and the Henderson-Hasselbalch equation)

Related learning aids **'**pH/Titrations' PC program section C, available from Web site
Acids & **Methane and the alkanes; alkenes** Web pages

Week 8 **p**) Isomers, stereo, cis/trans, optical and conformational; chirality (NP)
q) Reactions, rates of reaction, zero, first and second order rate equations (MB)

Background reading	Timberlake Chapter 6, 11, 12 and 13; Atkins and Jones Chapters 11 and 13 (first part)
Study guide	Timberlake 6.1, 6.2, 6.4, 6.7, 11.6, 13.3, 15.5; Atkins and Jones pp 494 - 498 (isomers), 570 - 586 (rates of reaction),
Related learning aids	Chemistry model kits (in Room J302). Try making models of the compounds shown in Problem 28 **Isomerism** Web page

Week 9 **r**) Organic reactions; introduction to nucleophilic groups; nucleophilic substitution reactions, addition and polymerization of alkenes (NP)
s) Activation energy, effect of temperature, heat of reaction, catalysis (MB)

Background reading	Timberlake Chapter 5, 6 and 14; Atkins and Jones Chapter 13, re-read Chapter 11
Study guide	Timberlake 5.1, 5.2, 6.6, 13.4, 14.1, 14.6; Atkins and Jones pp 498 - 508 (polymers), 586 - 595 (activation energy and effect of temperature), 595 - 598 (catalysis), 603 – 608, 625 - 626 (rates and equilibrium)

Week 10 **t)** Alcohols, dehydration; ethers; phenols, carboxylic acids, pK_a's; anhydrides and esters, formation and hydrolysis (NP)
u) Laws of thermodynamics, Free energy, relationship to equilibrium constant, enthalpy, entropy, spontaneity (MB)

Background reading	Timberlake Chapter 14 and 17; Atkins and Jones Chapter 17; re-read Chapter 11
Study guide	Timberlake 17.1, 17.2, 17.3, 17.4; Atkins and Jones pp 240 - 257 (enthalpy), 756 - 782 (entropy, free energy, spontaneity and the laws of thermodynamics), 485, 488 (alcohols, phenols and ethers), 490 - 491 (carboxylic acids and esters)
Related learning aids	**Thermodynamics** & **Biochemically important groups** Web pages

Week 11 **v**) Aldehydes and ketones, oxidation and reduction, reaction with amines and alcohols (NP)
w) Electrochemistry, half reactions, redox potential (MB)

Background reading	Timberlake Chapter 15; Atkins and Jones Chapter 18, re-read Chapter 11
Study guide	Timberlake 6.5, 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7; Atkins and Jones pp 792 - 797 (electrochemistry), 810 - 815 (redox reactions), 489 (aldehydes and ketones)
Related learning aids	**Redox** & **Biochemically important groups** Web pages

Week 12 **x**) Amines, primary, secondary, tertiary and quaternary, imidazole, pK_a's, redox properties; amides, formation and hydrolysis, (NP)
y) Revision lecture (MB)
z) Revision lecture (NP)

Background reading	Timberlake Chapter 19; Re-read Atkins and Jones Chapter 11
Study guide	Timberlake 19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7; Atkins and Jones 491 - 492 (amines and amides)

This completes the first half of the unit. Bioscience students will continue next semester to use these key chemical concepts in the study of biological molecules and their enzyme catalysed transformations.

You will have revision sessions to check your progress after Christmas.

Semester 2

We now move on to study the chemistry of life in this semester

	Lecture	**Tutorial**
	14.00-16.00	16.00-17.00
Week No.		
19	MB	MB
20	MB	MB
21	JA	JA
22	JA	JA
23	JA	JA
24	JA	JA
25	MB	MB
26	MB	JA
27	MB	JA
28-30	Easter	
29	MB	MB
32	JA	JA
33	MB	MB
34	MB/JA Revision	

Week 19: The structure of nucleic acids and the Genetic Code (Dr. M. Byford)
Base pairing; A-T; C-G; A-U

Week 20: Amino acids and the primary structure of proteins (Dr. M. Byford)
The structures of glycine, lysine, aspartic acid, histidine, proline and cysteine
The primary structure of proteins

Week 21: The secondary and tertiary structures of proteins (Dr. J. Acord)
The secondary structure of proteins
Structures of the α-helix, β-pleated sheet and triple helix in proteins
The tertiary structure of proteins

Week 22: The quaternary structure of proteins, the variety of their structures and functions, and an introduction to the biological chemistry of iron (Dr. J. Acord).
The quaternary structure of proteins, including collagen.
The oxygen dissociation curve of haemoglobin

Week 23: The structure and properties of lipids and cell membranes (Dr. J. Acord)
The structures of palmitic, oleic and linoleic acids, and triacylglycerols
The fluid mosaic model of membranes

Week 24: Structure and physiologically-relevant properties of carbohydrates (Dr. J. Acord)
The structures of glucose, fructose, sucrose, starch and cellulose

Week 25: Bioenergetics. ATP and an introduction to metabolism (Dr. M. Byford)
The laws of thermodynamics
The structure of ATP and the Nernst equation
Overview of metabolic pathways

Week 26: Glycolysis (Dr. M. Byford)

The pathway overview (including molecular structures)

Week 27: The citric acid cycle, electron transport and chemiosmotic theory (Dr. M. Byford)
The pathway overview of the citric acid cycle (including molecular structures).
The meaning of the electron transport pathway and the chemiosmotic theory.

Week 28-30: Easter

Week 31: Introduction to enzymes and their rates of reaction (Dr. M. Byford)
The meaning of the Michaelis-Menten equation: $v = \frac{V_{max} \times [S]}{K_m + [S]}$

Week 32: The urea cycle and lipid catabolism (Dr. J. Acord)
The pathway overviews (including molecular structures)

Week 33: Enzyme mechanisms and their kinetics (Dr. M. Byford)
The effect of heat, pH and inhibitors on enzyme reactions
The active site and mechanism of action of an enzyme

Week 34: Revision lectures (Dr. J. Acord and Dr. M. Byford)
These lectures are provided in order to revise the content of this unit and prepare for the examination.

Tutorial programme: Student led tutorial system, based on in-class test performance.

ASSESSMENT

The assessment will be based on 60% end-of-unit multiple-choice examination and 40% from in-course multiple-choice tests. Five in-course tests will be given. The highest four marks will weighted in forming the in-course test mark. This is to allow for, and encourage, students to improve throughout the unit and should not be used as an excuse for not trying to pass all tests. These tests will be addressed to the learning outcomes of current aspects of the course, as presented in the lectures, guided reading or problems. To encourage note-taking, you are allowed to bring your hand-written notes to the in-class tests, but not to the end-of-unit examination. You will need a simple calculator for these tests. They will concentrate on the specified lectures but may contain material tested previously. The overall pass mark for this Unit is 40% with a minimum mark in the final examination of 30%.

9 STUDENT EVALUATION

In 2010-11, 147 students completed the unit, 87 passed in June and 3 further students passed on referral. The average score on the feedback form was 3.44

10 LEARNING RESOURCES

a. Core Materials

General, Organic & Biological Chemistry Structures of Life, Karen C. Timberlake, Pearson Education, Inc., 2004, ISBN 0-8053-8914-8
It includes an excellent and useful CD-ROM for PCs and links to its Web site,
http://www.chemplace.com/college

Chemistry, Molecules, Matter, and Change, Loretta Jones and Peter Atkins, 4th edition, W. H. Freeman, 1999, ISBN 0-7167-3254-8
It includes two excellent and useful CD-ROMs for PCs and links to its Web site, http://www.whfreeman.com/chemistry/.

Chemistry, 2nd edition, by Catherine E Housecroft and Edwin C Constable, Prentice Hall, 2002, ISBN 0-130-86924-4
This is a comprehensive and more advanced textbook. Students with an 'A' or 'AS' level chemistry background are recommended this. It includes a useful Web site, http://www.booksites.net/housecroft.

Lehninger A. L., Nelson D. L. And Cox M. M. (2008) *Principles of Biochemistry,* 5th edition. Freeman.

Note: The purchase of one of these books should be considered essential for this unit. They contain all of the directed reading. You will find them to be useful for other units in your course and as a reference book in your later careers. Currently, you may use these web sites (except Timberlake's) even if you have not bought the books.

The Unit Web site: http://www.sbu.ac.uk/biology/biolchem/ contains much extra information concerning this unit including: Problems and their worked answers, exam-type questions and their worked answers, the pH/titrations computer program, information sheets and any notices concerning the Unit.

b. Optional Materials

- Horton R. H. et al (2005) *Principles of Biochemistry*, 4th edition. Prentice Hall
- Voet D., Voet J. G. And Pratt W. C. (2008) *Principles of Biochemistry*, 3rd edition. Wiley
  Berg, J. M., Tymoczko J. L., and Stryer L. (2006) *Biochemistry, 6th edition*. Freeman. The fifth edition is also available on line for free and searchable from PubMed at: http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=stryer.TOC&depth=2

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