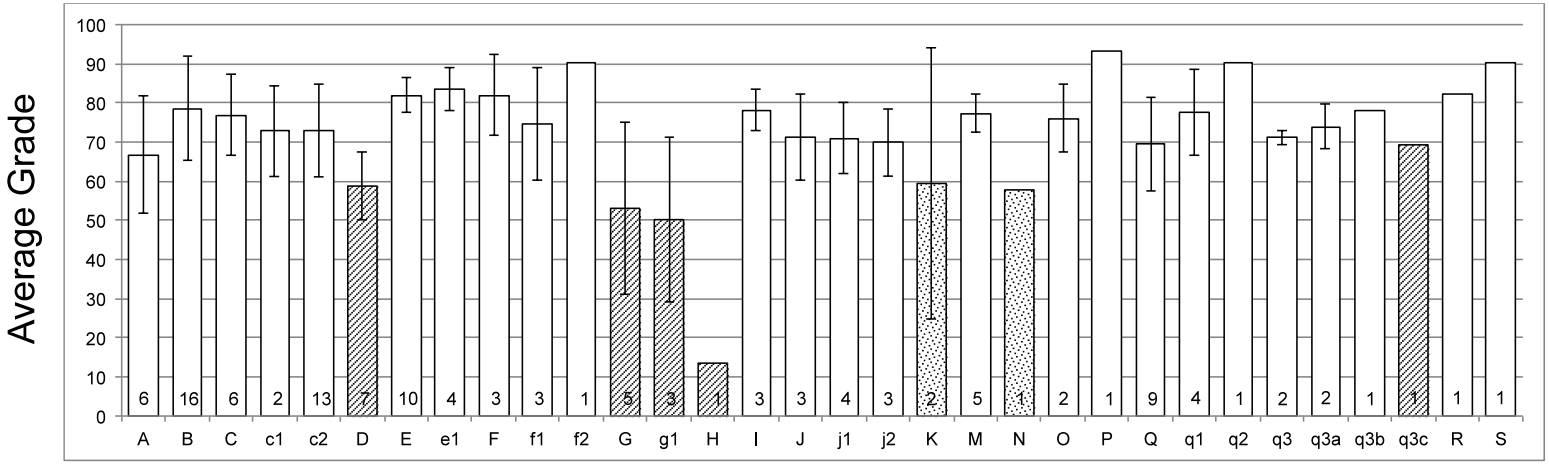
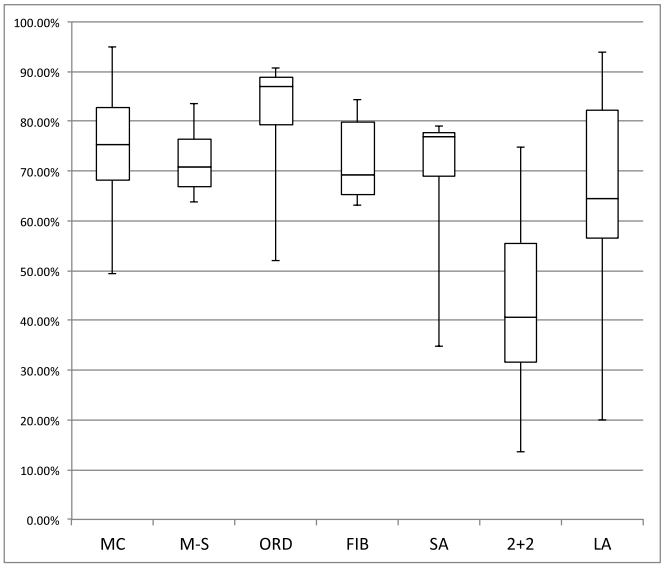
Student performance by LO. Grades on online quiz questions are reported as an average of all questions on all quizzes according to their LO code along the x-axis (See Table 1 for the full description of each LO code). The number of questions asked for each LO is indicated at the bottom of each bar. LOs possessing the verb "calculate" are highlighted with a cross shading; LOs with the verb "predict" are speckled.





Box plot of student performance by question type. The whiskers of these plots show the minima and maxima of the data, with the top and bottom of the boxes indicating the first and third quartiles, and the line inside the boxes representing the median for each. Average grades on all online quiz questions are reported according to the type of question. MC: multiple choice; M-S: multiple select; ORD: ordering; FIB: fill-in-the-blanks; SA: short answer (typically a one-word answer); 2+2: Calculation question using computer-generated variables; LA: long answer (4 sentence responses).

Table 1: LO coding for BIOC*2580

Learning Outcome	**Code**
THEME I: The principles of Physics and Chemistry can explain Biology	
Identify different **functional groups** found in biological molecules. Describe how functional groups (-OH, -COOH, -NH_2, etc.) affect the properties of biological molecules.	A
Identify the major **biological molecules** in living cells (protein, lipids, nucleic acids, and sugars)	B
Describe how **electronegativity** of atoms affects bond polarity, hydrogen bonding, hydrophobicity, and reaction mechanisms of biological molecules.	C
Describe the roles of **non-covalent interactions** (hydrogen bonds, van der Waals forces, and hydrophobic forces) in the structure, reactions and interactions of biological molecules.	c1
Differentiate between electrical, charge and structural **polarity**. Apply concepts of polarity to the separation, analysis and description of biological molecules. Categorize the amino acids according to their polarity.	c2
Apply the principles of **ionization** (pH, acid/base) to the structure and function of proteins. Predict the ionization state of amino acids and peptides.	D
Discriminate between different types of **chemical reactions**: nucleophilic attack, general acid/base catalysis, redox reactions.	E
Describe the **movement of electrons** and the impact of **valence** in these different types of chemical reactions facilitated by biological molecules	e1
Apply fundamental principles of **thermodynamics** (entropy, enthalpy, ΔE, ΔG) to biological molecule structure and function.	F
Calculate ΔE and determine the direction of **redox reactions** facilitated by biological molecules. Calculate the ΔG of redox reactions.	f1
Explain the **chemical basis** of thermodynamically favourable reactions (in particular, ATP hydrolysis).	f2
Derive and apply the **Michaelis-Menten** equation explaining enzyme reaction rates and their biological implications. Define and calculate K_M, V_{max}, or the rate (v) of enzyme reactions in the absence or presence of inhibitors.	G
Differentiate between enzyme **inactivation**, and competitive or non-competitive **inhibition**. Define and calculate Ki for different types of inhibitors.	g1
Discriminate between enzyme reaction rate, enzyme activity, specific activity and molar activity. Calculate the **activity of enzymes**.	H
Apply the **Beer-Lambert law** to calculate the concentration of molecules	h1
THEME II: The Structure and Function of biological molecules are inextricably connected	
Explain how the properties of biological molecules are dictated by their **building blocks**	I
Describe the first three levels of **protein structure**.	J
Describe the major **secondary structure** elements of proteins	j1
Describe the major protein **tertiary structure** families	j2
Predict the secondary structure of peptides based on the properties of peptide bonds.	K
Describe the role of **resonance** on the structure of peptide bonds.	k1
Describe how **chirality** impacts protein structure and function and leads to the formation of different sugar isomers.	M
Predict how biological molecule **function** is impacted by **changes** in structure.	N
Describe the role of **cofactors** in biological processes.	O
THEME III: Biochemistry is the link between biological Metabolism and its underlying Chemistry	
Differentiate between **catabolism** and **anabolism**.	P
Recall that **ATP** is the biochemical link between catabolism and anabolism	p1
Explain that **acetyl-CoA** is the central intermediate of metabolism	Q
Describe how carbohydrates and lipids are **catabolized** into acetyl-CoA	q1
Describe how acetyl-CoA is oxidized via the **citric acid cycle**	q2
Describe how **oxidative phosphorylation** converts the energy of reduced cofactors produced in catabolism into ATP	q3
Describe the reactions of the **electron transport chain**	q3a
Explain how ATP synthase uses the energy of the **proton motive force** to synthesize ATP	q3b
Calculate the total **yield** of ATP from oxidation of a given molecule	q3c
Explain how the electron transport chain, citric acid cycle, and carbohydrates and lipid catabolism are **interconnected**	q4c
Describe **anaerobic** metabolism of sugars	q5c
Name the **enzymes, intermediate metabolites and cofactors** involved in the catabolism of carbohydrates and lipids	R
Describe the role of **subcellular compartmentalization** in the complete catabolism of carbohydrates and lipids	S