ASBMB-RCN Meeting at Moravian College – 3 March 2012

*Transcription of group responses to the three afternoon workshop assignments*

**The four Identified concepts from last year’s meetings and groups (4 per group) assigned to them today**

1. Energy: Fundamental Nature, Utilization and Flow (Groups 1 & 5)
2. Core Concepts in Biochemistry and Molecular Biology are Based on: (Groups 2 & 6)  
   a. Objective Measurement  
   b. Quantitative Analysis  
   c. Critical Interpretation  
3. Macromolecular Structure, Function, Regulation, and Storage (Groups 3 & 7)  
4. Transformation and Transfer of Information (Groups 4 & 8)  

**Assigned Task I (45 minutes) Each group transform your assigned core concept into a complete sentence (or two) that would succinctly capture its meaning .**

1. **Energy:**  
   - Group 1: Biochemical systems harvest, store, and use energy to do mechanical work and drive chemical transformations.  
   - Group 5: The basis of life is the making and breaking of chemical bonds in order to do useful work, during which energy is conserved.  

2. **Measurement & Analysis:**  
   - Group 2: A biochemist will, based on the scientific method, critically interpret information derived from quantitative analysis that is informed by objective measurements from rationally designed experiments. *  
     - * this sentence does not represent a core biochemical concept from biochemistry.  
   - Group 6: The core concepts of biochemistry and molecular biology are built on the fundamental principles of chemistry, math and physics, utilizing the scientific method applied in a biological context.  

3. **Macromolecules:**  
   - Group 3: The chemical and physical properties of a biological macromolecule are a direct result of its three-dimensional structure; regulation of this function occurs as the three-dimensional structure is altered.  
   - Group 7: Function, regulation, and compartmentalization (storage) of macromolecules are determined by their 3-D structures.  

4. **Information:**  
   - Group 4: Information in biological systems is transformed and transferred through molecular interactions and changes.  
   - Group 8: The ways in which systems respond to external stimuli.
Assigned Task II – (90 minutes) Working in your groups, write 10 or less learning objectives for your assigned core concept. These would be the 10 most important learning objectives for this core concept. These learning objectives should embrace the breadth of that core concept. Use Blooms Taxonomy (handed out) to choose appropriate verbs for the cognitive levels of the objectives.

1. **Energy**

   **Group 1**
   - Biochemical systems harvest, store, and use energy to do mechanical work and drive chemical transformations.
   - Students will be able to...
     - compare and contrast the ways in which organisms harvest energy
   - (photophosphorylation, substrate-level phosphorylation, oxidative phosphorylation)
     - describe how energy can be stored in a concentration gradient
     - compute the energy stored in an electrochemical gradient
     - characterize how enzymes use ATP to drive reactions
     - contrast the roles of redox chemistry in biosynthesis and energy metabolism
     - describe how ATP hydrolysis drives conformational changes in motor proteins (e.g. myosin, kinesin) and active transporters
     - apply laws of thermodynamics to biological systems
     - recognize group transfer potential in compounds (e.g. glycogen, TAGs, ATP, creatine)

   **Group 5**
   - How is energy harnessed through photosynthesis?
     - Oxidation reduction reactions
     - Show how electrons go from lower to higher energy states (photoexcitation)
     - How does this energy lead to the formation of ATP and reducing power?
     - Can students differentiate between endergonic and exergonic reactions?
   - What is the underlying structural nature of bonds in molecules that allow them to participate in reactions in work is regulated?
   - How are these small molecules synthesized and utilized in these reactions?
   - How is a decrease in entropy compensated for in biosynthetic/anabolic processes?
   - Processes in the cells are organized into units/pathways. These pathways are integrated.
   - The units are controlled.
   - The cell needs to regulate which pathway is utilized
   - Basic free energy calculations/manipulations. Be able to make predictions based on these calculations. What can be changed in the system that would affect predictions.
   - Mass action ratio in relation to the cell and not the test tube.
   - Biological processes are inefficient.
   - What is the result if the system is perturbed at key points.
   - There is conservation of key principles across species.
   - Why does concentration of reagents/substrates/intermediates matter?

2. **Measurement and Analysis**

   **Group 2**
   - Students will be able to interpret quantitative data/values in terms of their effect on
     - Physical/chemical properties
     - Molecular structures
• Students will identify and apply appropriate statistics or qualitative methodologies to meaningfully interpret data sets, relative to the experimental objectives.
• Students will apply appropriate physical processes through the use of appropriate instruments.
• Students will learn to record and store data.

Group 6
Our group felt that more work can be done on identifying a more comprehensive list of core concepts for Biochemistry and Molecular Biology, so we started to discuss possibilities.

Currently identified core concepts:

1. Macromolecules
2. Energy (anabolism, catabolism, thermo)
3. Information (genetic information, systems approach)
A key question became: How do we found the boundaries between the core concepts?

New core concepts:

Homeostasis and Adaptation

• Pathways (anabolism and catabolism)
• Adaptation: repair mechanisms
• Redundancy (cell cycle, more than one way for the cell to do something, multiple receptors responding to the same stimulus)
• Molecular responses to the environment
• Intermediary metabolites
• Understand changes that take place in the cell
• Feedback regulation (coordinating macromolecular syntheses)
• Allosteric mechanism
• Signal transduction (coordinated response)
• Ligand receptor interaction
• pH sensing
• Regulation

3. Macromolecules

Group 3

• Identify constituent monomers of each class of biological macromolecules
• Illustrate the dehydration synthesis (condensation) reactions that join monomers together into a macromolecule
• Compare and contrast the noncovalent interactions that drive the folding, and stabilize the three-dimensional structure, of a biological macromolecule
• Describe the self-assembly of lipids into bilayers.
• Explain how the chemical properties of lipids influence membrane fluidity, permeability, and fusion.
• Describe how a change in the structure of a biological macromolecule potentially leads to a change in the function
Group 7
Students should be able to:

- Identify and characterize the properties of the building blocks of macromolecules
- Recognize and understand the rules of assembly of macromolecules from the basic building blocks.
- Distinguish between the role of covalent and non-covalent interactions in determining the 3-D structure and assembly of biomolecules.
- Understand and predict the role of the physiological environment in determining the structure and function of biomolecules.
- Distinguish between mechanisms of cellular regulation of macromolecular availability and mechanisms of molecular regulations of macromolecular function.
- Explain the mechanisms of compartmentalization of specific macromolecules in relation to cell structure.

4. Transformation and transfer of information

Group 4.

- Explain how structure of nucleic acids allows storage and transfer of genetic information
- Describe processes of replication, transcription and translation.
- Connect physiological responses to the molecular mechanisms that underlie these responses.
- Understand common molecular mechanisms that regulate protein function.
- Compare information transfer through common signaling pathways.
- Understand how information encoded within protein sequences directs interactions and localization.
- Understand how mutations can cause changes in genetic information, and how these processes are critical for evolution to occur.
- Explain how metabolite concentration provides information for regulation of metabolic pathways.

Group 8
Topics that fall under this heading

- Gene regulation: epigenetic modifications, transcriptional and translational regulation
- Transmembrane signaling
- Repair mechanisms/ proofreading
- Posttranslational modifications
- Alternative splicing of RNA
- Signaling cascades/ signal amplification
- The way information is carried. What are the biological signals?
- Metabolic regulation-feedback, allostery
- Degradation pathways for proteins, RNA and DNA
Assigned Task III: Working in your group, consider your core concept and relate it to foundational concepts from chemistry, physics, and math. Select the appropriate ones for the learning objectives that you developed. If there are additional foundational concepts, please identify them, i.e. What do students need to know and use from prerequisite courses to understand your core BMB concepts? (There were two group responses missing from this task and two group responses that were not identified by group. However, the overlap is so great that the needed prerequisite knowledge is pretty much the same for all core concepts.)

1. Energy
   Group 1
   Group 5
   Group ?
   Physics
   - Light (for interpreting photosynthesis) photons
   - Waves and energy
   - Forces
   - Energy-kinetic potential
   - Current and resistance
   Math
   - Algebra
   - Logarithms
   - Equations
   - Curve fitting/ model fitting
   - Graphical interpretation
   - Statistics
   - Proportionality and fractions
   - Rather have firm grounding in logarithms and statistics than calculus and a knowledge of physical chemistry
   Biology
   Chemistry
   - Bond energy
   - Thermodynamics
   - Molecular structure
   - Covalent and non-covalent interactions
   - Electrostatics
   - Resonance
   - Carbonyl and phosphate chemistry
   - Solvations and the chemistry and properties of water
   - pH, pKa
   - Equilibrium constants
   - Le Chatellier’s Principle

2. Measurement and Analysis
   Group 2

   Group 6
Physics
Introductory physics
- opposing forces,
- attracting and repelling forces,
- electromagnetism,
- conduction,
- osmolarity

Math
- Statistics
- Graphing and data analysis
- Correlation
- Unit conversions
- Algebra (equilibrium), fundamental geometry concepts
- Not calculus

Biology
- Cell biology: cell structure, organelles, evolution
- Anatomy and Human physiology before biochemistry??

Chemistry
- Gen Chem (kinetics, thermodynamics, atomic structure, molecular interactions, chemical bonding, classification of types of reactions)
- Organic (functional groups, properties and reactions of biomolecules, stereochemistry, aromaticity, acid-base properties, types of reactions, mechanisms)

In addition
- Interpretation and communications,
- reading technical information,
- problem solving,
- critical thinking
- Instrumentation

3. Macromolecules,
Group 3

Group 7
- Physics
- Electrostatic forces
- Light/spectra
Math
- Unit analysis
- Algebra/calculus
- Basic Math
- Log/ln
- Graphing/interpretation of graphs
Biology
• Cell (basic information, cellular structure)
• Central dogma"

Chemistry
• Bonding (Chemical Bonding)
• Intermolecular interactions
• Ions
• Equilibrium
• Free energy
• Basic kinetics
• Error analysis/significant figures/% error

Group X,

Physics
• Scale and magnitude of time and space
• Temperature
• Electrostatics

Math
• Statistics and probability
• Logarithms and algebra

Biology
• Prokaryote vs eukaryote
• Cellular compartmentalization
• Central dogma
• Membranes

Chemistry
• Atomic structure
• Equilibria
• Intermolecular forces
• Thermodynamics
• Acid-base chemistry
• Oxidation and reduction chemistry
• Electrophilicity and nucleophilicity
• Potential and kinetic energy
• Resonance
• Electronegativity

4. Transformation and Transfer of Information

Group 4
Chemistry
• H bonding and other non-covalent interactions
• acid/base chemistry
• chemical kinetics
• equilibria
• basic thermodynamic principles
• stoichiometry
• electrochemistry
• chemical structure and notation

Physics
• thermodynamics
• electromagnetic radiation
• electricity
• vectoral properties

Math
• mathematical symbolism
• basic algebra
• dimensional analysis
• graphical representation and interpretation
• introduction to calculus

Biology
• Central Dogma
• Introduction to cell structure and organization
• Introduction to classes of biological molecules

Group 8, Assignment 3
Physics
• Basic physical constants
• Coulomb’s Law
• Force, acceleration
• Spectroscopy, UV-vis
Math
• Algebraic manipulation of equations
• Logarithms
• Unit conversion
• Creating and interpreting graphs
• Constructing logical arguments, as exemplified by geometry proofs
• Fundamental statistics – mean, standard deviation, tests for significance
Biology
• Basic genetics
• Cell structure - different cellular compartments
• Classification of cells, e.g. prokaryotes vs eukaryotes
• Evolution- mutation and natural selection
• Basic Molecular biology
• Difference in organ systems/tissues
• Basic physiology – nerve conduction, respiration, homeostasis
Chemistry
• Atomic structure
• Basic thermodynamics
- Basic kinetics
- Molecular structure – Lewis structures/VSEPR/hybridization
- Covalent and ionic interactions
- Stereochemistry
- Electronegativity
- Oxidation and reduction
- Equilibria, Le Chatelier's principle
- Buffers
- Organic nomenclature- functional groups and basic properties of each
- Approximate pKa's of various functional groups
- Valence bond theory
- Stoichiometry
- Concentration
- Structure energy relationships
- Hydrophobicity
- Intermolecular forces