Promoting Concept-Driven Teaching Strategies in Biochemistry and Molecular Biology through Concept Assessments

Regional ASBMB RCN Meeting

Visualization and Assessment

Purdue University
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Knowing = Understanding?

JUST GO TO www.criticalthinking.com AND CLICK ON "ANSWERS"!
Classification of student knowledge gaps:

- Things students think they know but do not (ignorance masquerading as knowledge).
- Things students do not know they do not know (hidden ignorance).
- Things students know they do not know (overt ignorance).
- Things students think they do not know but really do (lack of awareness masquerading as ignorance).

Modified from Robert Root-Bernstein
What does it mean when a student says, *I understand*?....

Does it mean the same thing to the student that it does to another student or to you?.....

How can students demonstrate their understanding to you and others?
Addressing Student Understanding

Long-Term Memory
Home of Misconceptions

How do we find out what is here?

Long-Term Memory
An “infinite” expandable long-term storage space

How can students correct it, if it is wrong?

Incoming Information

Perception Filter

Working Memory Space
“5 ± 2”

Limited thinking-holding space

Storing
Revision
Retrieving

Feedback Loop for Perception Filter

Teaching = Learning?

I taught Stripe how to whistle.

I don't hear him whistling.

I said I taught him, I didn't say he learned it.
• A large body of evidence shows that humans achieve greater conceptual understanding and retain information longer when they are actively involved—a process that enables them to construct knowledge.

• For a majority of students, lecturing is not the most effective mode of instruction.

So why do we continue to teach the way we do?
5 Core Concepts

Evolution
Structure and Function
Information Flow
Transformation of Energy and Matter
Systems

6 Core Competencies

Apply Science Process
Quantitative Reasoning
Modeling and Simulation
Interdisciplinary Nature of Science
Communicate and Collaborate
Science and Society

www.visionandchange.org
Vision and Change - Recommendations

• Integrate Core Concepts and Competencies throughout the Curriculum

• Focus on Student-Centered Learning

• Promote Campuswide Commitment to Change.

• Engage the Biology Community in the Implementation of Change.
NSF-Funded ASBMB Project: Background and Overview

Preparation: ASBMB Education Committee responds to need for core concept inventories linked to assessment.

Realization that (1) biochemistry core concepts need to vetted by a variety of experts, (2) core concepts of preparatory areas are needed, (3) core concepts need to be integrally linked to pedagogy and assessment.

RCN-UBE Project

Plan the development of Central Resource of core concepts, pedagogical approaches, assessment and network building.

Bring together experts in concept inventories, pedagogy, and education research.

Develop, launch, disseminate and assess effectiveness of central resource.

Provide educators and education researchers with relevant resource to biochemistry education. Increase participation of faculty in new and ongoing projects in education research.
These objectives will be addressed in the following four specific aims of this project:

- **Specific Aim 1**: Identify foundational concepts in terms of core knowledge and foundational principles, research, and skills.

- **Specific Aim 2**: Create a taxonomy of these foundational concepts and skills, and link them to topics outlined in the undergraduate curriculum recommendations of ASBMB.

- **Specific Aim 3**: Develop and evaluate appropriate assessment tools for the topics identified in Specific Aim 1.

- **Specific Aim 4**: Create a toolkit that can be easily accessed by the academic community.
Five Year Schedule for the ASBMB Project

- **March 2010**
  - Rockville
  - CABMB Meeting

- **August 2011**
  - Richmond
  - Core Working Group

- **April 2012**
  - San Diego
  - Core Working Group

- **August 2013**
  - Seattle
  - Core Working Group

Year 1:
- Concordia
- Montclair

Year 2:
- Moravian
- Northeastern
- Norfolk State
- UC Santa Barbara
- UM Dearborn

Year 3:
- Purdue
- Marymount NYC
- St Marys (MD)
- ASBMB-Boston
- Others

Promoting Concept Driven Teaching Strategies in BMB through Concept Assessments
Specific Goals for Regional Workshops Years 1-5

2010-2011: --Definitions of foundational concepts and skills
             --Introduction of the goals of assessment tools: formative vs. summative assessment

2011-2012:  --Taxonomy of concepts and skills- links to potential revisions of ASBMB recommended curriculum
             --Active Learning Strategies

2012-2013:  --Development and testing of Assessment tools

2021-2014:  --Development and testing of Assessment tools

2014-2015:  --Dissemination of results/Toolkit development
What Do Our Students Need to Know?

Chemistry
Provides the methods and molecular perspective

Biology
Provides the relevance

Mathematics
Provides the means to evaluate and predict

Physics
Provides physical models

Biochemistry
Molecular Biology

\[ M = \frac{2RT \ln \frac{C_1}{C_2}}{\omega^2(1-\nu\rho)(x_1^2-x_2^2)} \]
Foundational Concepts from First Two Years


   Energy comes in different forms and can be transformed to other forms to drive biological processes within the laws of thermodynamics.

2. Macromolecular Structure, Function, Regulation, and Storage

   Macromolecules are a diverse assembly of biochemical building blocks held together by covalent and non-covalent interactions resulting in a variety of structural and functional properties. Together, the regulation, storage and spatial organization of these building blocks constitute the chemical pathways in living systems.
3. Transformation and Transfer of Information

Organisms sense changes in their environments and transduce relevant signals into appropriate responses through signal discrimination and amplification. Communication of biomolecules with each other, small molecules, and environment signals leads to cellular and physiological responses or phenomena and to the transfer and modification of genetic information to future generations. Living organisms use molecular machinery to store, express and transmit genetic information from one generation to the next in the form of sequences of long molecules. Changes in the sequences accumulate over generations allowing populations to adapt to their environments. Organisms also respond to information in their environments in the short term.

4. Core Skills in Biochemistry and Molecular Biology are based on:
   a. Objective Measurement   b. Quantitative Analysis  c. Critical Interpretation

Students will develop the ability to design controlled experiments that test specific hypotheses, find relevant data in electronic repositories, and assess the quality of both. Further, they will be able to quantitatively model and interpret data, form conclusions and new hypotheses and clearly communicate their findings to diverse audiences.
Workshop Schedule for Today

9:00 am - Arrival Check-In

9:30 am - Introduction and Overview of the ASBMB-RCN grant - Hal White

10:00 am - Keynote - “Assessment of Students’ Reasoning with Core Concepts and Visualizations in Biochemistry" - Trevor Anderson

10:45 am - Workshop - Training and practice on validation procedures - facilitated by Trevor Anderson and Nancy Pelaez

11:45 am - Lunch (provided)

12:30 pm - Examining Questions Workshop - facilitated by Hal White and Trevor Anderson

2:00 pm - Panel discussion - "Critical friends“ - Ellis Bell, Cheryl Bailey, and Nancy Pelaez

2:30 pm – Coffee and tea break

2:45 – Workshop - “Shredding" Exercise - facilitated by Hal White and Trevor Anderson

4:00 pm - Final Report Out and Discussion - facilitated by Hal White and Ellis Bell

4:40 pm - Planning for the future and Wrap-up, Goals, Net-working, Assignments, Deadlines, Meeting Assessment - facilitated by Cheryl Bailey and Ellis Bell

5:00 pm Workshop Concludes. Participants may continue discussion over dinner.

6:00 pm No-host Dinner