Implementing Vision and Change Using Concept-Driven Teaching Strategies

NSF RCN-UBE Grant #0957205

Designing Scientific Teaching Tools for BMB Education

2013 – 2014 Regional Workshop Series

Planning Guide
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<th>Countdown</th>
<th>Day</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 weeks prior</td>
<td>Fri</td>
<td></td>
<td>Website with workshop info, program, article links</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E-mail invitations and workshop program</td>
</tr>
<tr>
<td>6 weeks prior</td>
<td>Mon</td>
<td></td>
<td>Registration and survey open</td>
</tr>
<tr>
<td>4 weeks prior</td>
<td></td>
<td></td>
<td>Coordinator conference call 1</td>
</tr>
<tr>
<td>2 weeks prior</td>
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<td></td>
<td>Coordinator conference call 2</td>
</tr>
<tr>
<td>1 week prior</td>
<td>Thu</td>
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<td>Registration and survey close</td>
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<tr>
<td>1 week prior</td>
<td>Fri</td>
<td></td>
<td>Disseminate meeting materials</td>
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<tr>
<td></td>
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<td></td>
<td>Dropbox access restricted to registrants</td>
</tr>
<tr>
<td>Workshop Eve</td>
<td>Fri</td>
<td></td>
<td>Coordinator meeting to finalize plans</td>
</tr>
<tr>
<td>Workshop</td>
<td>Sat</td>
<td></td>
<td>Workshop 10 AM - 5 PM</td>
</tr>
<tr>
<td>Post-Workshop</td>
<td>Sat</td>
<td></td>
<td>Coordinator meeting after dinner to reflect</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Discuss general perceptions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Review and discuss evaluation results</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Propose next steps towards sustainability</td>
</tr>
</tbody>
</table>
Workshop Logistics
Contact: Weiyi Zhao, ASBMB
E-Mail: wzhao@asbmb.org        Phone: 240-283-6612

1) A meeting room with capacity for around 40 is ideal. Since these meetings are really workshops where participants are expected to be actively engaged, any more than 40 will lose the interactions we are looking for.

2) Host arranges for audio visual

3) Food – ASBMB can work with on campus and off campus vendors for catering. Typically we want coffee and tea and pastries for breakfast, morning break with tea, coffee, water and soda, lunch and an afternoon break. You can let Weiyi know if your campus catering is willing to do this one day event. Or if you want to recommend a local off campus catering company. ASBMB would be happy to work with them or if it’s just as easy for you to make the arrangements, copy Weiyi in your communications and indicate that ASBMB will be paying for it. If you’d like ASBMB to handle this, please provide contact info to Weiyi.

4) Some workshops have organized a post meeting networking dinner. This is entirely up to host and organizers

5) Budget – Each regional meeting gets around $3,800 from the grant

6) All payments should be routed to ASBMB, this include fees (if any) for facilities rental and A/V. Please use me or Andrea Anastasio, aanastasio@asbmb.org as main contacts.

Workshop Promotion: This portion is entirely handled by ASBMB
1) Blast ASBMB members from the region the workshop will be held with announcements about the workshop based on geography. Please let Weiyi know if there states/schools nearby that are within driving distance to you. This has worked well in the past.

2) We also post announcements on our social media sites, the project website, ASBMB homepage and ASBMB enews. We do not provide funding for participant travel.

Workshop Registration: Also handled by ASBMB
1) Attendees are expected to register online in advance of each meeting. We typically set up the online registration using SurveyMonkey.

2) A pre-workshop survey is included within the online registration.

3) A final registration confirmation will be e-mailed, with a link to Dropbox, and a suggestion to bring a laptop or tablet. The networking dinner will also be mentioned.

Workshop Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Printed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articles – 4 BAMBED and 1 Scientific Teaching</td>
<td>Qty. 3-5 each</td>
</tr>
<tr>
<td>Attendee Directory</td>
<td>Yes</td>
</tr>
<tr>
<td>Workshop Program</td>
<td>Yes</td>
</tr>
<tr>
<td>Example BMB Alignment Table</td>
<td>Colored paper</td>
</tr>
<tr>
<td>Bloom’s Taxonomy</td>
<td>Yes</td>
</tr>
<tr>
<td>Literature Resources</td>
<td>Colored paper</td>
</tr>
<tr>
<td>Sample BMB Goals and Objectives</td>
<td>Colored paper</td>
</tr>
<tr>
<td>Evaluation Form</td>
<td>Yes</td>
</tr>
<tr>
<td>Permission Form</td>
<td>Yes</td>
</tr>
<tr>
<td>Reference – Workshop Alignment Tables</td>
<td>No</td>
</tr>
<tr>
<td>Template – BMB Alignment Table</td>
<td>No</td>
</tr>
</tbody>
</table>

All workshop materials will be made available electronically via Dropbox.com. At least 1 week before the workshop takes place, we gather all the materials and make any necessary copies and ship all meeting materials to the workshop host.
**Invitations**

Invitations are sent via e-mail by ASBMB on behalf of the regional host. An example is below. The targeted audience is BMB educators within driving distance, including:
- Graduate students, post doctoral fellows (e.g., Preparing Future Faculty programs)
- Community college faculty

Greetings Fellow Biochemistry or Molecular Biology Educator,

I am writing to invite you to a local gathering to meet colleagues from regional campuses, and to participate in a workshop to discuss pedagogical issues in biochemistry and molecular biology.

This free workshop is titled, “Designing Scientific Teaching Tools for BMB Education” and will be held on **November 2, 2013 at the University of San Diego.** The full workshop team of speakers and facilitators will include myself and:

- Ellis Bell, PI on ASBMB-RCN grant, Laboratory for Structural Biology, Biophysics & Bioinformatics, Department of Chemistry: Biochemistry & Molecular Biology Program, University of Richmond
- Ben Caldwell, Professor and Dean of Graduate Studies, Missouri Western State University
- Cheryl Sensibaugh, Science Education Ph.D. Candidate, University of New Mexico

This workshop is part of a five year initiative funded by NSF that focuses on network building to create and disseminate validated assessment tools for the foundational core knowledge and skills required for biochemistry and molecular biology degrees, and to promote validated student-centered teaching approaches. The American Society for Biochemistry and Molecular Biology (ASBMB) was awarded a National Science Foundation Research Coordination Network Undergraduate Biology Education grant, and the workshops are being coordinated by the society.

This meeting is a great opportunity for us to forge networks between innovative educators who are interested in effective teaching and learning. The outcomes of meetings like this one will hopefully provide the catalysts for improving student preparation for careers that are solidly grounded in a working knowledge of biochemistry and molecular biology. For all, it is a rare opportunity to engage with colleagues in BMB education, to share stories and receive feedback, and make contacts of value to research, teaching and future collaboration.

I hope you will be able to join us on November 2, 2013 at San Diego University. To learn more about this workshop and to register, visit [http://www.asbmb.org/USD2013/](http://www.asbmb.org/USD2013/).

Sincerely,

Joseph Provost  
Professor of Biochemistry and Molecular Biology  
University of San Diego  
josephprovost@sandiego.edu
Registration and Pre-Workshop Survey

1) Name, institution, address, e-mail address

2) What courses do you teach? (Check all that apply.)
   - General Chemistry
   - Organic Chemistry
   - Biochemistry – single semester course
   - Biochemistry – two semester course
   - General, Organic, Biochem (GOB)
   - Introductory Biology
   - Molecular Biology
   - Genetics
   - Other (please specify)

3) What topic or concept or visual abilities do you find most difficult to assess? Provide one.
   {text box}

4) Which of the following learning strategies have you used in your teaching? (If your answer is yes, please rank your level of comfort from 1-5.)
   - Lecture
   - Laboratory Instruction
   - Undergraduate Research Training
   - Problem-Based Learning (PBL)
   - Process-Oriented Guided Inquiry Learning (POGIL)
   - Peer-Led Team Learning (PLTL)
   - Case Studies
   - Service Learning
   - Portfolios
   - Clickers

5) Which of the following assessment formats have you used in your teaching? Also, to what extent have you used each, and for which do you want more information?
   - Multiple Choice Examinations
   - Essay Examinations
   - Standardized Examinations
   - Concept Inventories
   - Concept Mapping
   - Oral Examinations
   - Group Examinations

6) To what extent do you emphasize the following in your teaching?
   - Facility with mathematics
   - Writing clearly
   - Construction of logical arguments
   - Interpretation of data
   - Creating pictorial visual models by hand
   - One or more molecular modeling programs in class
   - Molecular modeling in lab
   - Molecular modeling take-home/out-of-class
   - Other (please specify)
Overall BMB Learning Goals and Objectives

The most recent advances that have emerged from our project are detailed in three articles, referenced below. These articles present a sample of student learning objectives for three broad areas of the molecular life sciences: foundational disciplinary concepts [1], foundational disciplinary skills [2], and concepts from the allied fields of chemistry, physics, and mathematics [3]. We encourage you to peruse the manuscripts, and we thank you in advance for your thoughts on the following items. Your responses will guide efforts throughout the workshop.

The learning objectives within the remainder of this survey were taken from those works, and in some cases, adapted for formatting purposes. The purpose of the survey items that follow is to distill this large body of sample BMB learning objectives into a manageable starting list of objectives to use in collaborative activities during the workshop. Note that we are not attempting in any way to prioritize learning objectives.

References:


The Foundational Concepts of biochemistry and molecular biology are organized into the following overall learning goals:

• Students should understand the core concept of the theory of evolution, including the process of natural selection and its molecular basis, and evidence supporting the theory of evolution.
• Students should understand the core concept of matter and energy transformation, including thermodynamics, catalysis, the coupling of exergonic and endergonic processes, and the nature of biological energy.
• Students should understand the core concept of homeostasis, including the need for biological balance, linked steady state processes, quantification of homeostasis, the organization of chemical processes, and control mechanisms.
• Students should understand the core concept of biological information, including the genome, the information it contains, its transmission across generations, and maintenance.
• Students should understand the core concept of macromolecular structure and function, including the nature of biological macromolecules, factors that impact structure, the relationship between structure and function, interactions, and regulation of function.

For each of these goals, any number of specific learning objectives may be developed. Please select your single most favorite learning objective from all of the available options.

A) Students should be able to analyze preexisting or novel data and relate the findings in light of the theory of evolution.

B) Students should be able to describe what a mutation is at the molecular level, and how it comes about, be able to predict how changes in a nucleotide sequence can influence the expression of a gene or the amino acid sequence of the gene product (protein) and be able to translate these findings into a conclusion about how said mutation would impact the general fitness of an organism or population.

C) Students should be able to apply their knowledge of basic chemical thermodynamics to biologically catalyzed systems, quantitatively model how these reactions occur, and calculate kinetic parameters from experimental data.

D) Students should be able to discuss the concept of Gibbs free energy and how to apply it to chemical transformations, be able to identify which steps of metabolic pathways are exergonic and which are endergonic and relate the energetics of the reactions.

E) Students should be able to relate the laws of thermodynamics to homeostasis and explain how the cell or organism maintains homeostasis (a system seemingly in equilibrium) using non-equilibrium mechanisms.

F) Students should be able to summarize the different levels of control (including reaction compartmentalization, gene expression, covalent modification of key enzymes, allosteric regulation of key enzymes, substrate availability and proteolytic cleavage), and relate these different levels of control to homeostasis.

G) Students should be able to define what a genome consists of, and how the information in the various genes and other sequence classes within each genome are used to store and express genetic information.

H) Students should be able to illustrate how DNA is replicated and genes are transmitted from one generation to the next in multiple types of organisms including bacteria, eukaryotes, viruses, and retroviruses.

I) Students should be able to discuss the diversity and complexity of various biologically relevant macromolecules and macromolecular assemblies in terms of the basic repeating units of the polymer and the types of linkages between them.

J) Students should be able to compare and contrast the potential ways in which the function of a macromolecule might be affected and be able to discuss examples of allosteric regulation, covalent regulation and gene level alterations of macromolecular structure/function.
8) The Foundational Skills of biochemistry and molecular biology are organized into the following overall learning goals:

- Students should understand the process of science, including hypothesis generation, experimental design, and data analysis and interpretation.
- Students should understand the communication and comprehension of science, including how to access, assess, and use available information, and how to present scientific data.
- Students should understand the community of scientific practice, including ethical dimensions and interdisciplinary collaboration.

For each of these goals, any number of specific learning objectives may be developed. Please select your single most favorite learning objective from all of the available options.

A) Given an experimental observation, students should be able to **develop** a testable and falsifiable hypothesis.
B) Given a hypothesis, students should be able to **identify** the appropriate experimental observations to be measured, as well as appropriate control variables.
C) Students should be able to **use** appropriate equations to **analyze** experimental data and **calculate** parameter estimates.
D) Students should be able to **apply** equations and models to **predict** outcomes of experiments.
E) Students should be able to **find** and **use** the primary literature.
F) Students should be able to **use** databases and bioinformatics tools.
G) Students should be able to **use** visual and verbal tools to **explain** concepts and data.
H) Students should be able to **translate** science into everyday examples.
I) Given a case study, students should be able to **identify** and **evaluate** both scientific and societal ethical aspects.
J) Students should be able to **discuss** cross-disciplinary concepts such as modularity, energy, etc.
9) The foundations from the Allied Fields of biochemistry and molecular biology are organized into the following overall learning goals:
   • Students should understand foundational mechanical concepts from physics, and how they relate to biochemistry and molecular biology.
   • Students should understand foundational energy and thermodynamic concepts from physics and chemistry, and how they relate to biochemistry and molecular biology.
   • Students should understand the foundational concepts of structure from chemistry, and how they relate to biochemistry and molecular biology.
   • Students should understand foundational concepts of reactions from chemistry, and how they relate to biochemistry and molecular biology.
   • Students should understand foundational concepts of mathematics, and how they relate to biochemistry and molecular biology.

For each of these goals, any number of specific learning objectives may be developed. Please select your single most favorite learning objective from all of the available options.

A) Students should be able to recall force laws and apply them in the context of molecular structure and molecular interactions.

B) Students should be able to recall principles and theories regarding waves, light, optics, and imaging, and apply them in the context of biochemical investigations.

C) Students should be able to recall concepts of energetics and order, and apply them in the context of biological macromolecules.

D) Students should be able to recall concepts of thermodynamics, and apply them in the context of thermal processes at the molecular level.

E) Students should be able to recall principles of chemical structure (i.e., covalent bonds, polarity, the hydrophobic effect, hydrogen bonds and other non-covalent interactions), and apply them in the context of the dynamic aspects of molecular structure.

F) Students should be able to recall theories that govern chemical reactions (i.e., collision theory, transition state theory, rate laws and equilibria), and apply them in the context of biomolecular structure and reactivity.

G) Students should be able to recall a range of mathematical functional relationships (i.e., linear, exponential, saturation, and sigmoidal functions), apply them in the context of the molecular life sciences, assess whether the function is appropriate, and predict biomolecular outcomes based on mathematical equations.

10) What do you hope to gain or learn by attending this workshop?
    {text response}

11) Identify those professional societies to which you belong.
    ASBMB
    ACS
    AAAS
    ASCB
    Protein Society
    NSTA
    Other (please specify)

12) Does your school have an ASBMB Undergraduate Affiliate Network (UAN)?
    yes, no, would like more info
Implementing Vision and Change Using Concept-Driven Teaching Strategies

Designing Scientific Teaching Tools for BMB Education

Workshop Program

10:00 AM – 10:30 AM     Welcome
Background and context for the regional workshops will be provided, along with an orientation to roles played by the regional host, group moderators, and group members.

10:30 AM – 11:00 AM     Activity – Decide Your Destiny
Introductions will be made and small groups of three members will be formed based upon attendees’ chosen learning objectives. Group members will self-select roles as literature searcher, electronic submitter, and verbal reporter.

11:00 AM – 11:30 AM     Presentation – BMB Alignment Table
The principles of scientific teaching and backward design will be exemplified using one sample overall learning goal and one sample specific learning objective.

11:30 AM – 12:00 PM     Activity – Goals and Objectives
Small groups will refine their selected overall learning goal and specific learning objective to be sufficiently explicit for purposes of designing an assessment and a learning strategy.

12:00 PM – 1:00 PM     Lunch

1:00 PM – 2:00 PM     Activity – Assessments
Small groups will develop an assessment and associated scoring rubrics to measure student learning of the refined specific learning objective.

2:00 PM – 3:00 PM     Activity – Learning Strategies
Small groups will develop a student-centered strategy to promote learning of the refined specific learning objective, in the context of either a classroom or laboratory setting.

3:00 PM – 3:15 PM     Break

3:15 PM – 3:30 PM     Activity – Finalize Alignment
Small groups finalize and electronically submit their alignment tables.

3:30 PM – 4:30 PM     Activity – Compare and Contrast
Group reporters will summarize their group’s submission. Groups will discuss the similarities and differences in their outcomes. Moderators will report out.

4:30 PM – 5:00 PM     Activity – Reflect and Close
Time will be allowed to complete a short evaluation of the workshop, followed by an unstructured, open discussion.

TBD     Networking Dinner
Workshop Goal I

Foster a networked community to support transformative advances in the teaching and learning of biochemistry and molecular biology (BMB).

<table>
<thead>
<tr>
<th>Objective</th>
<th>Assessment</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendees should be able to relate their participation in a regional workshop to the overall RCN project.</td>
<td>Discussion of any preliminary questions</td>
<td>Welcome</td>
</tr>
<tr>
<td>Attendees should be able to select a type of learning goal and objective upon which to focus.</td>
<td>Formation of small groups with three members</td>
<td>Activity – Decide Your Destiny</td>
</tr>
<tr>
<td>Attendees should be able to collaborate in order to select a particular learning goal and objective.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attendees should be able to divide group work equitably.</td>
<td>Agreed upon group member roles</td>
<td></td>
</tr>
</tbody>
</table>

Welcome – Host and Ellis Bell (or Steering Committee Member) 30 minutes

I. Pre-Workshop Preparation

A. Create directory of attendees → Attendee handout
   1. Name
   2. Institution
   3. E-mail address
   4. Courses taught

B. Summarize survey results
   1. Attendee goals
   2. Top objectives for Concepts
   3. Top objectives for Skills
   4. Top objectives for Allied fields
II. Workshop Presentation

A. What is this all about?
   1. Project overview
   2. BAMBED papers
   3. Summarize Seattle
   4. Vision moving forward

B. Where do I fit?
   1. Summarize attendee goals from pre-workshop survey
      1. Purpose of regional workshops is networking + depth (Seattle was breadth)
      2. Generating pieces of a larger puzzle, products will be available to all

C. What products?
   1. Start with direction from pre-workshop survey
   2. Top objectives for Concepts
   3. Top objectives for Skills
   4. Top objectives for Allied Fields
   5. Upcoming presentation on path from there (BMB Alignment Table)

D. Who is supposed to do what?
   1. Regional host
      Local expert as a resource, local logistics
   2. Group moderators
      Round out group numbers as needed
      Timekeeping, monitor discussions, clarify/coach, let 3 members discuss
      Reporting out only during the Compare and Contrast activity at end
   3. Group members
      Literature searcher (to encourage evidence-based teaching)
      Electronic submitter (to capture products from all workshops)
      Verbal reporter (to communicate products to other attendees)

E. Other preliminary questions attendees may have?
I. Pre-Workshop Preparation

A. Assign group moderators
   1. Concepts moderator
   2. Skills moderator
   3. Allied fields moderator

II. Workshop Activity

A. Create small groups – 20 minutes
   1. Attendees self-select by type of objective they wish to work with
      Move to one of three areas in the room
      Each area should end up with at least six people + one moderator
      a. Concepts
      b. Skills
      c. Allied fields
   2. Six people will start with the same sample goal and objective
   3. Refer to sample goals and objectives in Appendix A
   4. Each set of six people selects their goal and objective
   5. Each set of six people divides into two small groups of three people per group
      Moderators can round out a group if needed, but should not be the reporter
      Moderators will thus be helping at least two small groups

B. Make introductions within small groups – 5 minutes
   1. Name, institution, courses taught

C. Select group member roles – 5 minutes
   1. Moderators hit the highlights of the literature searching resource page
   2. Literature searcher, to encourage evidence-based teaching
   3. Electronic submitter, to capture workshop products
   4. Verbal reporter, to communicate products to other attendees
Literature Resources

Evidence is critical in any endeavor to create scientific teaching tools. What works? How do we know? What assumptions are in place? What are the limitations of the methods?

How to search:

By Journal
Without a subscription, try including the word “free” in your search. Some articles may be freely available, and the search algorithm may cluster the results for you.

PubMed
"Undergraduate science education," filter species for humans → 1522 hits on 10/4/13
"Undergraduate biochemistry education," human filter → 188 hits on 10/4/13
"Clicker training," human filter → 25 hits on 10/4/13

Education Resource Information Center (ERIC)
This literature database contains resources dating back to 1966.
www.ebscohost.com/academic/eric

Commonly cited journals and a few articles of potential interest:

Biochemistry and Molecular Biology Education (IUBMB)

CBE – Life Sciences Education (ASCB)

Journal of Chemical Education (ACS)

Science (AAAS)
Workshop Goal II

Apply the frameworks of scientific teaching and backward design to support transformative advances in the teaching and learning of BMB.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Assessment</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendees should be able to describe the frameworks of scientific teaching and backward design.</td>
<td>Discussion of any post-presentation questions</td>
<td>Presentation – BMB Alignment Table</td>
</tr>
<tr>
<td>Attendees should be able to refine selected goals and objectives to be sufficiently explicit for purposes of designing an assessment and a learning strategy.</td>
<td></td>
<td>Activity – Goals and Objectives</td>
</tr>
<tr>
<td>Attendees should be able to collaboratively develop valid, reliable assessments with accompanying scoring rubrics to measure learning of selected objectives.</td>
<td>Group alignment tables</td>
<td>Activity – Assessments</td>
</tr>
<tr>
<td>Attendees should be able to collaboratively develop student-centered learning strategies to facilitate learning of selected objectives.</td>
<td></td>
<td>Activity – Learning Strategies</td>
</tr>
<tr>
<td>Attendees should be able to collaboratively review, finalize, and electronically submit an alignment table for their selected objective.</td>
<td></td>
<td>Activity – Finalize Alignment</td>
</tr>
<tr>
<td>Attendees should be able to summarize an alignment table.</td>
<td>Group reporter summaries</td>
<td>Activity – Compare and Contrast</td>
</tr>
<tr>
<td>Attendees should be able to compare and contrast multiple alignment tables.</td>
<td>Moderator summaries</td>
<td></td>
</tr>
</tbody>
</table>
A. Speaking points – 20-25 minutes
2. Example BMB alignment table

B. Discussion and questions – 5-10 minutes

**Example BMB Alignment Table of Scientific Teaching Tools**

While an overall goal may imply multiple specific learning objectives, only one objective is exemplified below. Alignment tables typically summarize the assessments and strategies, which are described more fully outside the table, or in a separate document. Attendees should focus on one objective, at one Bloom’s level. See the template on the next page.

**Initial Overall Learning Goal:**
Students should understand the core concept of macromolecular structure and function, including the nature of biological macromolecules, factors that impact structure, the relationship between structure and function, interactions, and regulation of function.

**Initial Specific Learning Objective:**
Students should be able to **discuss** the diversity and complexity of various biologically relevant macromolecules and macromolecular assemblies in terms of the basic repeating units of the polymer and the types of linkages between them.

<table>
<thead>
<tr>
<th>Overall Learning Goal:</th>
<th>Specific Learning Objectives</th>
<th>Learning Assessments</th>
<th>Learning Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students should understand the core concept of macromolecular structure, including the nature of biological macromolecules and factors that impact structure.</td>
<td>Bloom’s Level 1-2: Students should be able to <strong>compare and contrast</strong> various biologically relevant macromolecules and macromolecular assemblies in terms of the basic repeating units of the polymer and the types of linkages between them.</td>
<td>Written Exam Question T/F or Multiple choice (3 pts.)</td>
<td>Pre-class Reading Biomolecular structure (1 participation pt.)</td>
</tr>
<tr>
<td></td>
<td>Bloom’s Level 3-4: Students should be able to <strong>sketch</strong> various biologically relevant macromolecules and macromolecular assemblies in terms of the basic repeating units of the polymer and the types of linkages between them.</td>
<td>Written Exam Question Sketch a polymer (monomers – 2 pts.) (linkage – 1 pts.)</td>
<td>In-class Group Activity Table of biomolecules Turn in one per group (5 participation pts.)</td>
</tr>
<tr>
<td></td>
<td>Bloom’s Level 5-6: Students should be able to <strong>defend</strong> classifications of unfamiliar, biologically relevant macromolecules and macromolecular assemblies in terms of the basic repeating units of the polymer and the types of linkages between them.</td>
<td>Written Exam Question Given a novel structure (classify – 1 pt.) (defend – 2 pts.)</td>
<td>Clicker Question Given a novel structure 1 correct classification Flawed distracters (2 participation pts.)</td>
</tr>
</tbody>
</table>
Designing Scientific Teaching Tools for BMB Education

BMB Alignment Table Template

Please save this template as a separate working document for your group, with the filename as:
Alignment LocationAbbr LastNameA LastNameB LastNameC.docx
(e.g., Alignment USD Garcia Nguyen Smith.docx)

Designed by:
Name of group member
Name of group member
Name of group member

Selected Aspect of BMB:
Foundational Concepts or Foundational Skills or Allied Fields (delete two)

Keywords:
Search terms relevant to your alignment

Initial Overall Learning Goal:
Insert the goal that accompanies your selected objective, in its initial form.

Initial Specific Learning Objective:
Insert your selected objective, in its initial form.

<table>
<thead>
<tr>
<th>Overall Learning Goal:</th>
<th>Insert refined goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Learning Objective</td>
<td>Specific Learning Assessment</td>
</tr>
<tr>
<td>Insert refined objective and Bloom’s level</td>
<td>Summarize assessment</td>
</tr>
</tbody>
</table>

Assessment:
Design your assessment here, and be sure to include the answer or scoring rubrics.

Strategy:
Design your classroom or laboratory strategy here, and be sure to include the time allotted.
Activity – Goals and Objectives – Moderators

A. Small groups (3 members) discuss selected goal and objective
   1. Literature searcher gathers any necessary evidence
   2. Electronic submitter fills in template
   3. Verbal reporter notes any significant discussion points

B. Emerge with a refined overall learning goal and refined specific learning objective
   1. Objective should support development of assessment and strategy
   2. Refined goal and objective should be saved in alignment template

Activity – Assessments – Moderators

A. Small groups discuss any prior experience measuring achievement of objective

B. Group members collaborate to develop one assessment with scoring rubrics
   1. Literature searcher gathers any necessary evidence
   2. Electronic submitter fills in template
   3. Verbal reporter notes any significant discussion points

C. Emerge with an assessment and scoring rubrics
   1. Assessment should measure achievement of the learning objective
   2. Assessment and rubrics should be saved in alignment template

Activity – Learning Strategies – Moderators

A. Small groups discuss prior experience with strategies to facilitate learning of objective

B. Group members collaborate to develop one learning strategy
   1. Literature searcher gathers any necessary evidence
   2. Electronic submitter fills in template
   3. Verbal reporter notes any significant discussion points

C. Emerge with a learning strategy
   1. Strategy should be student-centered and facilitate learning of the objective
   2. Strategy should be saved in alignment template

Activity – Finalize Alignment – Moderators

A. Small groups review and revise alignment table
   1. Overall learning goal
   2. Specific learning objective
   3. Assessment and scoring rubrics
   4. Student-centered learning strategy

B. Electronic submitter submits completed template via Dropbox
Activity – Compare and Contrast – Moderators 60 minutes

We are not judging alignments here. On the contrary, we embrace the diversity of perspectives!

A. Merge small groups that had same starting point – 5 minutes
   Could be two or three small groups (6 or 9 people), but shouldn’t be 4 small groups

B. Verbal reporters summarize each group’s alignment – 15-20 minutes

C. Discuss similarities and differences among alignments – 25-30 minutes

D. Three moderators report out and submit summaries to Dropbox
   1. Concepts moderator – 3 minutes
      a. Summarize one important similarity among alignments
      b. Summarize one important difference among alignments
   2. Skills moderator – 3 minutes
      a. Summarize one important similarity among alignments
      b. Summarize one important difference among alignments
   3. Allied fields moderator – 3 minutes
      a. Summarize one important similarity among alignments
      b. Summarize one important difference among alignments

E. Note: This activity may also inform efforts to implement a peer-review process for submissions to the project’s online educational resources. However, this is not a primary goal. The notation is made only as a tip-off to be alert for what may emerge simultaneously.
Workshop Goal III

Evaluate the workshop in the broader context of the RCN-UBE project, and communicate the impact of this workshop experience.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Assessment</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendees should be able to discuss beneficial aspects of the workshop, and recommend improvements for the benefit of future workshops.</td>
<td>Workshop Evaluation</td>
<td>Activity – Reflect and Close</td>
</tr>
<tr>
<td>Attendees should be able to summarize points of emphasis or clarify any points of confusion.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Activity – Reflect and Close – Facilitator TBD**

In this order, it mimics a “Minute Paper,” or “Think-Write-Share” activity

A. Complete evaluation form and permission form – 15 minutes

B. Open discussion – 15 minutes
Evaluation Form

We thank you for your attendance and thoughtful participation in today’s workshop.

1. Which aspects of the workshop were most beneficial to you?
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

2. What improvements can you recommend for the benefit of future workshops?
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

3. Are there any points that remain confusing to you? If so, please describe.
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

4. How do you plan to apply what you’ve learned to your educational practices?
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

5. What type of follow-up support do you need?
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

6. Please add any additional comments you may have.
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________
Permission Form

Attendee Name: ________________________________

This workshop was part of the ASBMB’s Promoting Concept-Driven Teaching Strategies in Biochemistry and Molecular Biology project. A major goal of this project is to develop a rich, searchable, peer-reviewed database of educational resources for undergraduate biochemistry and molecular biology educators. In the coming year, the ASBMB will be building such a database and uploading materials that have been contributed by educators around the country.

By signing this form, I grant the ASBMB permission to use the alignment table and accompanying assessment and activity developed during today’s workshop. All materials will be housed under the project website at www.asbmb.org/bmbconcept. Please note that we have a large inventory of materials, many of which may be similar, and that by giving us your permission, it does not guarantee that your materials will be added to the repository.

_____________________________________________  ____________
Signature                                                  Date
References


**Sample BMB Learning Goals and Objectives**

**Foundational Concepts**

**Overall Learning Goal 1:**
Students should understand the core concept of the theory of evolution, including the process of natural selection and its molecular basis, and evidence supporting the theory of evolution.

**Learning Objectives for Goal 1:**
A) Students should be able to analyze preexisting or novel data and relate the findings in light of the theory of evolution.

B) Students should be able to describe what a mutation is at the molecular level, and how it comes about, be able to predict how changes in a nucleotide sequence can influence the expression of a gene or the amino acid sequence of the gene product (protein) and be able to translate these findings into a conclusion about how said mutation would impact the general fitness of an organism or population.

**Overall Learning Goal 2:**
Students should understand the core concept of matter and energy transformation, including thermodynamics, catalysis, the coupling of exergonic and endergonic processes, and the nature of biological energy.

**Learning Objectives for Goal 2:**
C) Students should be able to apply their knowledge of basic chemical thermodynamics to biologically catalyzed systems, quantitatively model how these reactions occur, and calculate kinetic parameters from experimental data.

D) Students should be able to discuss the concept of Gibbs free energy, and how to apply it to chemical transformations, be able to identify which steps of metabolic pathways are exergonic and which are endergonic and relate the energetics of the reactions to each other.

**Overall Learning Goal 3:**
Students should understand the core concept of homeostasis, including the need for biological balance, linked study state processes, quantification of homeostasis, the organization of chemical processes, and control mechanisms.

**Learning Objectives for Goal 3:**
E) Students should be able to relate the laws of thermodynamics to homeostasis and explain how the cell or organism maintains homeostasis (a system seemingly in equilibrium) using non-equilibrium mechanisms.

F) Students should be able to summarize the different levels of control (including reaction compartmentalization, gene expression, covalent modification of key enzymes, allosteric regulation of key enzymes, substrate availability and proteolytic cleavage), and relate these different levels of control to homeostasis.
**Overall Learning Goal 4:**
Students should understand the core concept of biological information, including the genome, the information it contains, its transmission across generations, and maintenance.

**Learning Objectives for Goal 4:**
G) Students should be able to **define** what a genome consists of, and how the information in the various genes and other sequence classes within each genome are used to store and express genetic information.

H) Students should be able to **illustrate** how DNA is replicated and genes are transmitted from one generation to the next in multiple types of organisms including bacteria, eukaryotes, viruses, and retroviruses.

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**Overall Learning Goal 5:**
Students should understand the core concept of macromolecular structure and function, including the nature of biological macromolecules, factors that impact structure, the relationship between structure and function, interactions, and regulation of function.

**Learning Objectives for Goal 5:**
I) Students should be able to **discuss** the diversity and complexity of various biologically relevant macromolecules and macromolecular assemblies in terms of the basic repeating units of the polymer and the types of linkages between them.

J) Students should be able to **compare** and **contrast** the potential ways in which the function of a macromolecule might be affected and be able to **discuss** examples of allosteric regulation, covalent regulation and gene level alterations of macromolecular structure/function.
Sample BMB Learning Goals and Objectives

Foundational Skills

**Overall Learning Goal 1:**
Students should understand the process of science, including hypothesis generation, experimental design, and data analysis and interpretation.

**Learning Objectives for Goal 1:**
A) Given an experimental observation, students should be able to develop a testable and falsifiable hypothesis.
B) Given a hypothesis, students should be able to identify the appropriate experimental observations to be measured, as well as appropriate control variables.
C) Students should be able to use appropriate equations to analyze experimental data and calculate parameter estimates.
D) Students should be able to apply equations and models to predict outcomes of experiments.

**Overall Learning Goal 2:**
Students should understand the communication and comprehension of science, including how to access, assess, and use available information, and how to present scientific data.

**Learning Objectives for Goal 2:**
E) Students should be able to find and use the primary literature.
F) Students should be able to use databases and bioinformatics tools.
G) Students should be able to use visual and verbal tools to explain concepts and data.
H) Students should be able to translate science into everyday examples.

**Overall Learning Goal 3:**
Students should understand the community of scientific practice, including ethical dimensions and interdisciplinary collaboration.

**Learning Objectives for Goal 3:**
I) Given a case study, students should be able to identify and evaluate both scientific and societal ethical aspects.
J) Students should be able to discuss cross-disciplinary concepts such as modularity, energy, etc.
**Sample BMB Learning Goals and Objectives**

**Allied Fields**

**Overall Learning Goal 1:**
Students should understand foundational mechanical concepts from physics, and how they relate to biochemistry and molecular biology.

Learning Objectives for Goal 1:
A) Students should be able to **recall** force laws and **apply** them in the context of molecular structure and molecular interactions.

B) Students should be able to **recall** principles and theories regarding waves, light, optics, and imaging, and **apply** them in the context of biochemical investigations.

**Overall Learning Goal 2:**
Students should understand foundational energy and thermodynamic concepts from physics and chemistry, and how they relate to biochemistry and molecular biology.

Learning Objectives for Goal 2:
C) Students should be able to **recall** concepts of energetics and order, and **apply** them in the context of biological macromolecules.

D) Students should be able to **recall** concepts of thermodynamics, and **apply** them in the context of thermal processes at the molecular level.

**Overall Learning Goal 3:**
Students should understand the foundational concepts of structure from chemistry, and how they relate to biochemistry and molecular biology.

Learning Objectives for Goal 3:
E) Students should be able to **recall** principles of chemical structure (*i.e.*, covalent bonds, polarity, the hydrophobic effect, hydrogen bonds and other non-covalent interactions), and **apply** them in the context of the dynamic aspects of molecular structure.

**Overall Learning Goal 4:**
Students should understand foundational concepts of reactions from chemistry, and how they relate to biochemistry and molecular biology.

Learning Objectives for Goal 4:
F) Students should be able to **recall** theories that govern chemical reactions (*i.e.*, collision theory, transition state theory, rate laws and equilibria), and **apply** them in the context of biomolecular structure and reactivity.
Overall Learning Goal 5:
Students should understand foundational concepts of mathematics, and how they relate to biochemistry and molecular biology.

Learning Objectives for Goal 5:
G) Students should be able to recall a range of mathematical functional relationships (i.e., linear, exponential, saturation, and sigmoidal functions), apply them in the context of the molecular life sciences, assess whether the function is appropriate, and predict biomolecular outcomes based on mathematical equations.