INDEX

Thanks to Michelle Withers and the West Virginia University Summer Institute on Undergraduate Science and Math Education, from whom much of this handbook was excerpted and to Jenny Frederick, Rob Lue, and the Northeast Regional Summer Institute on Undergraduate Education in Biology from whom many of the readings were excerpted.

Five Colleges Summer Institute
on Scientific Teaching

Overview

Goal

The goal of the Five Colleges Summer Institute on Scientific Teaching (SI) is to improve undergraduate science and math education at the home institutions of the particpants. This will be achieved by training faculty in effective, evidence-based, teaching strategies. This institute is modeled after the National Academies Summer Institutes on Undergraduate Education in Biology and is meant to extend the influence of that successful professional development workshop.

Specific Outcomes

By the end of the SI, you will have:

- practiced a variety of teaching strategies through workshops, presentations and group work
- worked as a team to create teaching materials that implement these strategies
- begun to shift your focus from content and teaching to outcomes and learning

Themes of the SI

Scientific teaching provides a framework for changing our classrooms to make them more learner-focused and our curricula to make them more richly represent the nature and process of science. Scientific teaching is evidence-based and structured to encompass three core themes: active learning, assessment and diversity. Over the course of the SI, you will implement strategies that address each of these themes into your teachable unit.

Five Colleges Summer Institute
on Scientific Teaching

Agenda

All activities are in the Team-Based Learning Classroom, 25 DuBois Library, UMass, Amherst unless otherwise noted

Monday, May 20, 2013

5:30 Welcome Reception, 10th Floor Campus Center
6:30 Dinner, 10th Floor Campus Center
7:00 Welcome
7:15 Session 1: Scientific Teaching
8:15 Team formation
Reading Assignments for Tuesday, at home

Tuesday, May 21, 2013

8:30 Refreshments, Lower Floor, DuBois Library
9:15 Session 2: Active Learning
10:30 Break & Refreshments, outside TBL
11:00 Session 3: Assessment
12:15 Lunch, Conference Room, 26th Floor DuBois Library
1:30 Team Work: Defining and Outlining Teachable Units
4:20 Team Sharing
5:15 Adjourn
Reading Assignments for Wednesday, at home

Wednesday, May 22, 2013

8:30 Refreshments, Lower Floor, DuBois Library
9:15 Session 4: Inclusive Teaching
10:30 Break & Refreshments, outside TBL
11:00 Session 5: How People Learn
12:15 Lunch, Conference Room, 26th Floor DuBois Library
1:30 Team Work: Refining and Practicing Teachable Units
4:20 Team Sharing
5:15 Adjourn
Reading Assignments for Thursday, at home

Thursday, May 23, 2012

8:30 Refreshments, Lower Floor, DuBois Library
9:15 Session 6: Mentoring & Institutional Change
10:30 Break & Refreshments, outside TBL
11:00 Team preparation for presentations
12:15 Lunch, Conference Room, 26th Floor DuBois Library
1:30 Session 7: Team Presentations
5:30 Reception, 10th Floor Campus Center

Daily Reading Assignments

Day	Topics	Evening Reading
Monday	Scientific Teaching	Chapters 1, 2 & 3 in *Scientific Teaching* *Constructive & Destructive Group Behaviors, 5 Stages in Group Development* (in the Resources section)
Tuesday	Active Learning Assessment	Chapter 4 in *Scientific Teaching*; Key Findings (Chapter 2) in *How People Learn: Bridging Research and Practice.*
Wednesday	Inclusive Teaching How People Learn	Chapter 6 in *Scientific Teaching*, W.A. Anderson et al., *Science* 331 (2011) 152-153 (in the Readings section).
Thursday	Mentoring Institutional Change	

ACTIVITIES

Five Colleges Summer Institute
on Scientific Teaching

Format

Morning Workshops.

The morning sessions are designed to introduce participants to innovations and research on undergraduate education, and to model principles about which they teach. These sessions will be interactive and model the strategies that are being introduced.

Afternoon Team Work Sessions.

Group work carefully designed to model scientific teaching has been found to be one of the most important processes at the Summer Institutes. The team process also encourages cross-fertilization of ideas among colleagues and departments and strengthens the impact of the changes that you make in your classrooms. Therefore, much of the SI is devoted to team work time.

During afternoon group work sessions, your team will collaborate to develop a teachable tidbit that focuses on the three SI themes that will be incorporated into the framework of a teachable unit. By Thursday noon, your team will integrate the three themes into a single, finished teachable unit. Facilitators will be working with teams to keep on task and to help model teaching practices that will help each team meet a common goal. Each team will have an anchor facilitator who will help the team establish and meet common goals. Some facilitators may be moving from team to team during the afternoon sessions. On Tuesday and Wednesday, at the end of the team work session, you will take part in a **team share** where teams pair off and present their progress to one another. This will provide the opportunity to practice the presentation of the teachable tidbit and to gain feedback from others before presenting to the entire collection of SI attendees.

Thursday Afternoon Presentations.

The Thursday afternoon session will consist of team presentations of teachable tidbits that will be peer-reviewed by SI organizers and participants. This will allow teams to practice assessing the effectiveness and student-centeredness of learning activities and to incorporate peer feedback into their teaching modules before using them in their own classes.

Description of Activities

1. Teachable Unit (chapter 5 *Scientific Teaching*)

At the end of the SI, groups will complete a "framework for a teachable unit" (pg 85 of *Scientific Teaching*). The teachable unit provides the context for the teachable tidbits and includes the following:

- **Framework:** The completed "framework" document, including an explanation about how the teachable unit addresses the three themes of the SI, and how the activities help meet the learning goals.
- **Tidbits:** The peer reviewed and revised teachable tidbit[s] in detail.
- **Context:** An explanation about how the tidbit[s] fit into the context of a course or class period, plus an overview of the other aspects of the course or class period in which the tidbit[s] will be taught. (Extensive details, such as complete lecture notes, are not necessary, but the general flow of the class should be clear. For example, include a phrase like "mini-lecture about DNA replication" rather than spending time writing the lecture notes in detail. Remember, this is a framework for a teachable unit!)
- **Resources:** Any supplemental materials that another instructor would need to teach the tidbit, including tips for instructors about how to guide students or student materials - handouts/class materials/websites/images, etc.

An example of a teachable unit is included in the resources section of this binder.

2. Teachable tidbits

During the week, each group will develop one or two teachable tidbits. Teachable tidbits are instructional materials designed to engage students in learning. Generally, they consist of a single activity that can be integrated into a larger context, such as a course or lecture.

3. Action Statement

Each participant will indicate the course/semester that they plan to implement the teachable unit.

Daily Team Activities: Tuesday

Session I - Team Work 1:30-4:20

The goal of the first session is to pick the topic for your teachable unit, write learning goals for teachable unit, and begin to develop a formative assessment activity (assessment tidbit).

0. Review Group Behaviors handout. Have each team member write down her or his constructive and destructive group behaviors. Discuss these among all team members and agree on a strategy to promote group effectiveness. Spend 15 minutes on the task – it is well worth it.

1. Discuss morning workshops. What did you learn? What questions do you still have? How does it apply to the development of tidbits?

2. Identify topic area for teachable unit. You want this to be narrow enough to address with a teachable unit. For example, if your topic is evolution, will you focus on the concept of natural selection, the role of mutation in genetic variation, or another concept altogether?

3. Identify learning goals/outcomes for entire teachable unit. Start with the framework for teachable until on page 85 of *Scientific Teaching*. When stating learning outcomes, use active verbs that will suggest suitable assessments. Bad example of learning outcome: Students will understand equilibrium. What do you mean by understand? How will you assess student understanding? Good example of learning outcome: Students will be able to predict how relative changes in concentrations of reactants or products will affect forward or reverse reaction rates. This lends itself to an easily achieved assessment.

4. Identify group member[s] to compile all work/teachable tidbits into teachable unit framework that will be posted on the course website on Thursday.

5. Develop teachable tidbit: Develop a teachable tidbit that will give feedback to both the students and instructor on the student's progress toward the learning goal (consider using models from today's workshops). You do not have to create activities from scratch. Feel free to use or adapt materials that have already been created.

6. Explain how the teachable tidbit models assessment.

Session II – Team Share 4:20-5:15

The goal of these sessions is to practice teaching your tidbits and to give and receive feedback from your peers.

Exchange and review teachable tidbits with another team. Each group should "teach" their tidbit during this time, while the other group acts as the "students". Spend the remaining time asking questions, discussing the tidbits and offering constructive feedback.

Daily Team Activities: Wednesday

Session I – Team Work 1:30-4:20

The goal of this session is to develop a teachable tidbit for active learning.

1. Discuss morning workshops. What did you learn? What questions do you still have? How does it apply to the development of tidbits?

2. Develop teachable tidbit. Feel free to adapt the assessment exercises you created on Monday, or create a new tidbit.

- Revisit the learning goals in light of what you learned about active learning.
- Create learning activities that will engage students' previous knowledge and help them construct new knowledge.

3. Explain how the tidbit fits into the context of the larger teachable unit. How does each tidbit align with the larger goals of the entire unit? Add your explanation to the "framework for a teachable unit" that you started on Tuesday.

Session II – Team Share 4:20-5:15

The goal of these sessions is to practice teaching your tidbits and to give and receive feedback from your peers.

Exchange and review teachable tidbits with another team. Each team should "teach" their tidbit during this time, while the other group acts as the "students". Spend the remaining time asking questions, discussing the tidbits and offering constructive feedback.

Daily Team Activities: Thursday

Session I – Prepare for Presentations 11:00-12:15

During this session you will finish preparation of the 20-minute presentation on one of your teachable tidbits.

Session II – Group Presentations 1:30-5:00

1. Teach one of your tidbits to everyone at the SI, including a brief overview of the entire teachable unit. You will have 20 minutes for your presentation.

2. Provide feedback on your peers' tidbits. You will be provided with a rubric to review your peers' teachable units/tidbits.

Following Thursday's presentations, each group will:
1. Revise their tidbit/unit based on peer review comments
2. Upload the teachable unit framework to the SI website

Expectations for 2013-2014 Academic Year

Teach a Tidbit

Each participant who will be teaching in the coming year should implement a teachable unit into at least one class.

Attend the Follow-Up Meeting

We will hold a follow-up meeting at during the upcoming academic year to share experiences and get feedback on the implementation process and progress.

ATTENDEES

Team Assignments for Participants

Participants will self-select into teams of about 5-7 in size. Teams will be formed at the end of the evening dinner session on Monday. Individuals should use the time during the opening reception and early dinner to begin to coalesce into teams that can work together on an agreed-upon tidbit theme. Participants should share their goals for the SI and teaching focus to help facilitate team formation. Teams will sit together during the morning sessions and will work together in the afternoon sessions to produce teachable tidbits and a teachable unit for the team.

A key aspect of the SI is group work. Scientific Teaching asks students to work together. The team work session in the SI are meant to reinforce this notion, to provide instructors with the experience of team work from the student viewpoint, and to exemplify the parallel qualities of content-dependent (i.e. unit core content) and content-independent (i.e. communication skills, source verification, group though process) learning that is produced in group work.

Attendees: Alphabetically

Neal Abraham Five Colleges, Inc. Organizer nabraham@fivecolleges.edu	Ernie Alleva Hampshire/Smith Participant ealleva@hampshire.edu	Sarah Bacon Mt. Holyoke Participant sbacon@mtholyoke.edu
Zane Barlow Pearson Education Presenter & facilitator jzanebarlow@gmail.com	Herbert Bernstein Amherst/Hampshire Participant hbernstein@hampshire.edu	Mara Breen Mt. Holyoke Participant mbreen@mtholyoke.edu
Steve Brewer Biology Dept., UMass Amherst Facilitator sbrewer@bio.umass.edu	Renae Brodie Mt. Holyoke Participant rbrodie@mtholyoke.edu	Ashley Carter Amherst Participant acarter@amherst.edu
Xinnian Chen UConn Presenter xinnian.chen@uconn.edu	Michael Ching Amherst Participant mching@amherst.edu	Donald Cotter Mt. Holyoke Participant wdcotter@mtholyoke.edu
Jennifer Frederick Yale Presenter jennifer.frederick@yale.edu	Diane Genereux Westfield State Participant dgenereux@westfield.ma.edu	Anne Gershenson UMass Amherst Participant gershenson@biochem.umass.edu
Mark Graham Yale Assessment mark.graham@yale.edu	Frederick Griffiths Amherst Organizer ftgriffiths@amherst.edu	David Gross UMass Amherst Presenter, facilitator, & organizer dgross@biochem.umass.edu
Frank Guiliano Westfield State Participant fgiuliano@westfield.ma.edu	Buzz Hoagland Westfield State Participant bhoagland@westfield.ma.edu	Andrew McAlpine UMass, Amherst SI support amcalpin@english.umass.edu
Stephanie Moeckel-Cole GCC/HCC/UMass Amherst Participant smcole@kin.umass.edu	Pat O'Hara Amherst Participant pbohara@amherst.edu	Becky Wai-Ling Packard Mt. Holyoke Presenter & facilitator bpackard@mtholyoke.edu
Randall Phillis UMass Amherst Presenter rphillis@bio.umass.edu	Frank Rife UMass Amherst Participant frife@kin.umass.edu	Karen Riska HCC/Smith/UMass Amherst Participant karen.riska@gmail.com
Kevin Shea Smith Organizer kshea@smith.edu	Mary Deane Sorcinelli UMass Amherst Facilitator & organizer msorcinelli@acad.umass.edu	Karsten Theis UMass Amherst/Westfield State Participant ktheis@westfield.ma.edu
Ludmila Tyler UMass Amherst Participant ltyler@biochem.umass.edu	Nicholas Venti UMass Amherst Participant nventi@geo.umass.edu	Anne Walton Westfield State Participant awalton@westfield.ma.edu
Laura Wenk Hampshire Facilitator & organizer lwenk@hampshire.edu	Brian White UMass Boston Presenter brian.white@umb.edu	

RESOURCES

CONSTRUCTIVE AND DESTRUCTIVE GROUP BEHAVIORS

Constructive Group Behaviors

Cooperating: Is interested in the views and perspectives of the other group members and is willing to adapt for the good of the group.

Clarifying: Makes issues clear for the group by listening, summarizing and focusing discussions.

Inspiring: Enlivens the group, encourages participation and progress.

Harmonizing: Encourages group cohesion and collaboration. For example, uses humor as a relief after a particularly difficult discussion.

Risk Taking: Is willing to risk possible personal loss or embarrassment for the group or project success.

Process Checking: Questions the group on process issues such as agenda, time frames, discussion topics, decision methods, use of information, etc.

Destructive Group Behaviors

Dominating: Takes much of meeting time expressing self vies and opinions. Tries to take control by use of power, time, etc.

Rushing: Encourages the group to move on before task is complete. Gets "tired" of listening to others and working as a group.

Withdrawing: Removes self from discussions or decision making. Refuses to participate.

Discounting: Disregards or minimizes group or individual ideas or suggestions. Severe discounting behavior includes insults, which are often in the form of jokes.

Digressing: Rambles, tells stories, and takes group away from primary purpose.

Blocking: Impedes group progress by obstructing all ideas and suggestions. "That will never work because…"

Brunt (1993). Facilitation Skills for Quality Improvement. *Quality Enhancement Strategies*. 1008 Fish Hatchery Road. Madison. WI 53715

5 Stages of Group Development

Stage 1: Forming

In the Forming stage, personal relations are characterized by dependence. Group members rely on safe, patterned behavior and look to the group leader for guidance and direction. Group members have a desire for acceptance by the group and a need to be know that the group is safe. They set about gathering impressions and data about the similarities and differences among them and forming preferences for future subgrouping. Rules of behavior seem to be to keep things simple and to avoid controversy. Serious topics and feelings are avoided.

The major task functions also concern orientation. Members attempt to become oriented to the tasks as well as to one another. Discussion centers around defining the scope of the task, how to approach it, and similar concerns. To grow from this stage to the next, each member must relinquish the comfort of non-threatening topics and risk the possibility of conflict.

Stage 2: Storming

The next stage, which Tuckman calls Storming, is characterized by competition and conflict in the personal-relations dimension an organization in the task-functions dimension. As the group members attempt to organize for the task, conflict inevitably results in their personal relations. Individuals have to bend and mold their feelings, ideas, attitudes, and beliefs to suit the group organization. Because of "fear of exposure" or "fear of failure," there will be an increased desire for structural clarification and commitment. Although conflicts may or may not surface as group issues, they do exist. Questions will arise about who is going to be responsible for what, what the rules are, what the reward system is, and what criteria for evaluation are. These reflect conflicts over leadership, structure, power, and authority. There may be wide swings in members' behavior based on emerging issues of competition and hostilities. Because of the discomfort generated during this stage, some members may remain completely silent while others attempt to dominate.

In order to progress to the next stage, group members must move from a "testing and proving" mentality to a problem-solving mentality. The most important trait in helping groups to move on to the next stage seems to be the ability to listen.

Stage 3: Norming

In Tuckman's Norming stage, interpersonal relations are characterized by cohesion. Group members are engaged in active acknowledgment of all members' contributions, community building and maintenance, and solving of group issues. Members are willing to change their preconceived ideas or opinions on the basis of facts presented by other members, and they actively ask questions of one another. Leadership is shared, and cliques dissolve. When members begin to know-and identify with-one another, the level of trust in their personal relations contributes to the development of group cohesion. It is during this stage of development (assuming the group gets this far) that people begin to experience a sense of group belonging and a feeling of relief as a result of resolving interpersonal conflicts.

The major task function of stage three is the data flow between group members: They share feelings and ideas, solicit and give feedback to one another, and explore actions related to the task. Creativity is high. If this stage of data flow and cohesion is attained by the group members, their interactions are characterized by openness and sharing of information on both a personal and task level. They feel good about being part of an effective group.

The major drawback of the norming stage is that members may begin to fear the inevitable future breakup of the group; they may resist change of any sort.

Stage 4: Performing

The Performing stage is not reached by all groups. If group members are able to evolve to stage four, their capacity, range, and depth of personal relations expand to true interdependence. In this stage, people can work independently, in subgroups, or as a total unit with equal facility. Their roles and authorities dynamically adjust to the changing needs of the group and individuals. Stage four is marked by interdependence in personal relations and problem solving in the realm of task functions. By now, the group should be most productive. Individual members have become self-assuring, and the need for group approval is past. Members are both highly task oriented and highly people oriented. There is unity: group identity is complete, group morale is high, and group loyalty is intense. The task function becomes genuine problem solving, leading toward optimal solutions and optimum group development. There is support for experimentation in solving problems and an emphasis on achievement. The overall goal is productivity through problem solving and work.

Stage 5: Adjourning

Tuckman's final stage, Adjourning, involves the termination of task behaviors and disengagement from relationships. A planned conclusion usually includes recognition for participation and achievement and an opportunity for members to say personal goodbyes. Concluding a group can create some apprehension - in effect, a minor crisis. The termination of the group is a regressive movement from giving up control to giving up inclusion in the group. The most effective interventions in this stage are those that facilitate task termination and the disengagement process.

Adapted from:

Tuckman, B. (1965) Developmental Sequence in Small Groups. Psychological Bulletin, 63, 384-399.

Tuckman, B. & Jensen, M. (1977) Stages of Small Group Development. Group and Organizational Studies, 2, 419-427.

Teachable Unit: Executive Summary

Title: The Case of PKU: From Genes to Proteins

Learning objectives

Science Content

Students will learn that genes influence phenotype by determining amino acid sequence/protein structure.
Students will learn the mechanisms for going from DNA to RNA.
Students will learn the mechanisms for going from RNA to protein.

Science Skills: Students will be able to:
Predict from a nucleotide sequence an appropriate amino acid sequence.
Predict how a change in nucleotide sequence would potentially affect protein structure.
Evaluate the effects of mutations on protein structure.
Evaluate the impact of different alleles on phenotype.
Communicate the relationship between genotype and phenotype.

General Skills

Students will practice acquiring information and knowledge through investigation.

Teaching challenge

Science Content:

Students have difficulty visualizing the role of the key characters in the process of translating nucleotide sequences into amino acid chains.
Students become mired in the details of the mechanisms of transcription and translation and miss the larger concept about how DNA determines phenotype.
Students often see molecular processes of gene expression as separate from classical genetics and thus inheritance. (Evidence for all challenges: Student performance on summative assessment and verbalized frustration during class.)

Brief description of the teachable unit

Context:

The material in this teachable unit is a combination of student-centered activities and inquiry-guided mini-lectures designed to replace traditional professor-centered lectures on gene expression. The Case of PKU would be appropriate for introductory biology courses for either majors or non-majors and could be used in lecture courses of any size. Students are expected to have been exposed to content on DNA structure and replication. This unit will require approximately three hours.

Overall Sequence of Activities

1) Background:At the end of the previous class:
Set-Up: "Why does this diet soda can contain the statement 'Phenylketonurics: Contains Phenylalanine'?"
Assignment: Search the web to answer the question and post their answers to the class website before the next class. Read the assigned reading on gene expression.
2) Class 1:

Prior to class students will post their answers to the question posted in the previous class to a class website (or the low-tech alternative is that they could hand them in at the beginning of class on a 3x5 notecard).
Pre-assessment: Formative assessment of students prior knowledge.
Set Up: Restate original question and initiate class discussion about the students findings on phenylketonuria. If necessary, lead the discussion toward the facts that phenylketonuria is both an inherited disease and a disease caused by a dysfunctional enzyme/protein.
Activity: Deducing the genetic code: "If this is a genetic disease, then why is the function of an enzyme/protein affected?" Give students a sequence of nucleotides from a PKU allele and a section of corresponding amino acids from the protein. Students break up into groups to figure out what would they have to know to go from genes to proteins.
Post-assessment:
Wrap up:
Assignment: Watch the animation on transcription from www.thinkwell.com.
3) Class 2:
Pre-assessment on translation.
Set-up: DNAi animation on translation.
Activity: Students describe and deduce the rationale for the major players in translation using a figure and guiding questions.
Compile student deductions and use a mini-lecture to fill in any gaps in the students' understanding of the process of translation.
Post-assessment: Use the same or analogous questions as pre-assessment to track progress. Use follow-up discussion to address any areas of continuiing confusion.
Wrap-up:
4) Class 3:
Set-up: Video clip of PKU patient and use leading questions to initiate discussion of genetic disease.
Activity: Break students into groups. Each group is given a set of nucleotide sequences from the coding region of normal and mutant PKU alleles. One sequence comes from a normal allele and has the corresponding sequence of amino acids from the normal protein. The other sequence is the same section of nucleotides from a mutant allele. The students must determine the amino acid sequence that would result from the mutant sequence and predict the affect this mutation would have on the structure/function of the protein. Since students must apply the knowledge they have gained during the teachable unit, this activity is also an assessment of student understanding of the process of gene expression.
Wrap up: Return to discussion of PKU. What have students learned about the nature of inherited diseases and the relationship between genotypes and phenotypes.

How does the teachable unit address the following themes?

Diversity

The Case of PKU should be intriguing to the majority of introductory biology students, regardless of major, sex or race, for two main reasons, 1) nutrasweet is an additive in many foods that college students consume, particularly diet sodas, and 2) PKU is an genetic disease that affects all populations. Different mutant alleles have higher incidence in different ethnic populations. We selected our mutants for this student activity to represent multiple races and included that information in the student activity. This activity should also accomodate a broad diversity of learning styles because it utilizes materials/information from a variety of sources, such as web sites, animations, video clips, figures, text, lectures and discussions, in addition to using several teaching techniques, such as collaborative activities, inquiry-driven mini-lectures, teacher-guided discussions, and student-guided web searches.

Active Learning

Student interest will be peaked by the human interest hook of a genetic disease, phenylketonuria, and will be engaged in several collaborative activities to find out how the processes of gene expression explain the relationship between gene mutations and protein dysfunctions that cause genetic diseases.

Assessment

Students will be formatively assessed through:

a) Clicker questions on processes of information flow from DNA to proteins;

b) A strip sequence learning activity on the steps of translation;

c) Class work and homework in which they must determine how changes in a mutated gene sequence change the amino acid sequence of the protein and predict how these changes might affect the protein's function.

Students will be summatively assessed through exam questions in which they must determine what will happen to the amino acid sequence of a protein when its gene is mutated.

Bloom's Levels and Associated Verbs

LOC or HOC	***Bloom's Levels and Associated Verbs***
LOC	***Knowledge***: arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce state
LOC	***Comprehension***: classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate
LOC or HOC	***Application***: apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write
HOC	***Analysis***: analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test
HOC	***Synthesis***: arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write
HOC	***Evaluation***: appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, core, select, support, value, evaluate

Modified from Blooming Biology, Crowe et al., 2008, *CBE*

Bloom's Alignment Table

TU Goals/ Objectives	LOCs HOCs	TU Outcomes	LOCsHOCs	Assessment for Outcome	LOCsHOCs	Learning Activity for Outcomes

Modified from Blooming Biology, Crowe et al., 2008, *CBE*

Student-Centered Learning Publications and Resources

Strategy	Specific Examples	References for specific example or for the general strategy
General Biology Examples of Active Learning: "How To" and Efficacy resources	Resource guides for getting started	Handelsman, J., S. Miller, C. Pfund 2007 *Scientific Teaching*. New York, W. H. Freeman *Pathways to Scientific Teaching* 2008 Eds. Ebert-May, D. and J. Hodder. Sunderland, Sinauer.
	Review article on active learning strategies relating to physiology education	Michael, J. 2006 "Where's the evidence that active learning works?" *Adv Physiol Educ* 30: 159-167
	Article describing a model for implementing active learning in classrooms	Allen, D., and K. Tanner. 2005 Infusing Active Learning into the Large-enrollment biology Class: Seven Strategies, from Simple to Complex. *Cell Biology Education* 4:262-268. McClanahan, E. and L. McClanahan. 2002 Active Learning in a Non-Majors Biology Class. *College Teaching* 50(3): 92-96. Smith, A., R. Stewart, P. Shields, J. Hayes-Klosteridis, P. Robinson and R. Yuan. 2005 "Introductory Biology Courses: A Framework To Support Active Learning in Large Enrollment Introductory Science Courses." *Cell Biology Education* 4:143-156.
	Research article on efficacy of active learning strategies in biology classes	Freeman, S., E. O'Connor, J. Parks, M. Cunningham, D. Hurley, D. Haak, C. Dirks, and M.P. Wenderoth. 2007 "Prescribed Active Learning Increases Performance in Introductory Biology. *CBE – Life Sciences Education* 6:132-139. Knight, J., and W. Wood. 2005 "Teaching More by Lecturing Less" *Cell Biology Education* 4:298-310. Walker, J., S. Cotner, P. Baepler, and M. Decker. 2008 A Delicate Balance: Integrating Active Learning into a Large Lecture Course. *CBE-Life Sciences Education* 7:361-367.
Classroom assessment and immediate response systems	Online resource for clicker articles and other resources	Clicker Bibliography at UMass Amherst http://srri.umass.edu/topics/crs/bibliography
	Research article on efficacy of clickers in large enrollment classrooms	Mayer, RE, et al., "Clickers in College Classrooms: Fostering learning with Questioning Methods in Large Lecture Classes", *Contemporary Educational Psychology*, 34:1 pp51-57 (2009)
	Research article on IF-AT and clicker (perception data)	Cotner, SH, et al., (2008) "Rapid Feedback Assessment Methods: Can We Improve Engagement and Preparation for Exams in Large Enrollment Courses?" *Journal of Science Education and Technology* 15:5 p437-443.
	Comprehensive "How To" resource book	**College Assessment Tools Angelo and Cross**
Case-based learning	"How to" resource book	Herreid, C.F. (ed.) (2007) *Start With a Story*: National Science Teachers Association Press, Arlington, VA.
	Article on how to use clickers to implement case studies in class	Herreid, C.F. (2006) "Clicker Cases," Journal of College Science Teaching 36 (2): 43-47.
	Online resources for Case Studies	Case It! http://caseit.uwrf.edu/ Investigative Case-based Learning http://www.bioquest.org/icbl/cases.php

		National Center for Case Study Teaching in Science http://ublib.buffalo.edu/libraries/projects/cases/case.html
Model-based learning	How To resource for redesigning courses with Model-based instruction	Modeling Instruction: An effective Model for Science Education. Jane Jackson, Larry Dukerich and David Hestenes. *Science Educator* Spring 2008 Vol 17:1
Problem-based learning	How to Guide for PBL	"The Power of Problem-based Learning: A Practical 'How To' For Teaching Undergraduate Courses in Any Discipline" Edited by Barbara Duch, Susan Groh, and Deborah E. Allen
	Article describing specific bioinfomatics example of PBL	Harold B. White, III and Prasad Dhurjati, "Evolution of Protein Lipograms: A Bioinformatics Problem," *Biochem. Molec. Biol. Educ.*, **34**, 262-266 (2006).
Peer-led team learning	Article comparing PBL, POGIL and PLTL	Thomas Eberlein, Jack Kampmeier, Vicky Minderhout, Richard S. Moog, Terry Platt, Pratibha Varma-Nelson, Harold B. White, "Pedagogies of Engagement in Science: A Comparison of PBL, POGIL, and PLTL" *Biochem. Molec. Biol. Educ.*, **36**, 262-273 (2008).
	Articles looking at efficacy of PLTL	Gafney, L & Varma-Nelson, P. Peer-Led Team Learning (PLTL): A Study of Former Workshop Leaders. *Journal of Chemical Education,* (accepted for publication). Gafney, L. and Varma-Nelson, P. (2008) Peer-Led Team Learning: Evaluation, Dissemination and Institutionalization of a College level Initiative, Dordrecht, The Netherlands: Springer. Gosser, Jr. D., J. Kampmeier, P. Varma-Nelson. 2010 Peer-Led Team learning: 2008 James flack Norris Award Address. J *Chemical Education* 87(4):374-380. Preszler, R. 2009 Replacing Lecture with Peer-Led Workshops Improves Student Learning. *CBE- Life Sciences Education* 8:182-192
Team-based learning	"How To" Resources	"Team-Based Learning: A Transformative use of Small Groups in College Teaching" Ed. by Michaelsen, LK, Bauman-Knight, A and Fink, LD (2004), pub. Stylus. Barkley, EF, Cross, KP and Major CH (2005) "Collaborative Learning Techniques: A Handbook for College Faculty" pub Jossey-Bass

From AAAS Vision and Change Report, submitted

TECHNOLOGY RESOURCES

INSTRUCTIONAL RESOURCES

BioSciEdNet - http://www.biosciednet.org/portal/
The National Science Digital Library (NSDL) Pathway for biological sciences education. The BEN Portal provides access to education resources from BEN Collaborators and is managed by the American Association for the Advancement of Science (AAAS). Over 15,319 reviewed resources covering 77 biological sciences topics are available. BEN resources can help you engage student interest, shorten lesson preparation time, provide concept updates, and develop curricula that are in line with national standards for content, use of animals and humans, and student safety.

National Science Digital Library - http://nsdl.org/
NSDL is the Nation's online library for education and research in Science, Technology, Engineering, Mathematics.

American Institute of Biological Sciences Resources for Teaching and Learning Biology - http://www.aibs.org/education/teaching_resources.html
The American Institute of Biological Sciences provides links to a number of resources on biology teaching including evolution.

Action Bioscience - http://www.actionbioscience.org/ ActionBioscience.org examines bioscience issues in biodiversity, environment, genomics, biotechnology, evolution, new frontiers in the sciences, and education.

Project Kaleidoscope - http://www.pkal.org/ Alliance of individuals, institutions, and organizations committed to strengthening undergraduate science, mathematics, engineering, and technology education.

Case Studies - http://ublib.buffalo.edu/libraries/projects/cases/ubcase.htm The case study method of teaching applied to college science teaching, from The National Center for Case Study Teaching in Science.

CBE Life Sciences Education (online journal) - http://www.lifescied.org/
CBE—Life Sciences Education (CBE-LSE), a free, online quarterly journal, is published by the American Society for Cell Biology (ASCB). *CBE-LSE* publishes peer-reviewed articles on life science education at the K–12, undergraduate, and graduate levels. The ASCB believes that learning in biology encompasses diverse fields, including math, chemistry, physics, engineering, computer science, and the interdisciplinary intersections of biology with these fields. Within biology, *CBE-LSE* focuses on how students are introduced to the study of life sciences, as well as approaches in cell biology, developmental biology, neuroscience, biochemistry, molecular biology, genetics, genomics, bioinformatics, and proteomics.

Multimedia Educational Resource for Learning and Online Teaching (MERLOT) - http://www.merlot.org/merlot/index.htm

A free and open resource designed primarily for faculty and students of higher education. MERLOT is a leading edge, user-centered, searchable collection of peer reviewed and selected higher education, online learning materials, catalogued by registered members and a set of faculty development support services.

Problem-Based Learning - http://www.udel.edu/pbl/ These problems are used to engage students' curiosity and initiate learning the subject matter.

Teaching Issues and Experiments in Ecology - http://tiee.ecoed.net/ TIEE: Teaching Issues and Experiments in Ecology - a peer reviewed publication of ecological educational materials by the Ecological Society of America.

FIRST II - http://first2.plantbiology.msu.edu/ Website from national dissemination network that provides long-term professional development for life science faculty in teaching and learning.

Book: How People Learn - http://www.nap.edu/openbook.php?record_id=6160

National Science Teachers Association - http://www.nsta.org/college/?lid=hp

National Association of Biology Teachers - http://www.nabt.org/websites/institution/index.php?p=1

Association of College and University Biology Educators - http://acube.org/

TOOLS:

Google Docs www.docs.google.com - Allows multiple users to created, edit, and share **documents**, **spreadsheets**, and **presentations** from any web browser. You can now **create forms** from the Docs list or from any spreadsheet.

Enhancing Assessment in the Biological Sciences - http://www.bioassess.edu.au/examples/list ideas and resources for university educators (Australian)

Fevatools http://fevatools.wikispaces.com/ - Wiki on online tools for fully online courses - includes many on line assessments, like mid-semester surveys. It's a one-stop portal to formative evaluation tools to help you measure the success of your online courses or modules.

Wordle - http://www.wordle.net/
Resource for generating "word clouds" from text that you provide. Generates word pictures based on frequency of use of words.

Free online graph paper - http://incompetech.com/graphpaper/ Print your own graph paper as you need it.

Free Technology for Teachers Blog - http://www.freetech4teachers.com/

blog reviewing technology resources for education

Free pdf generator for PCs - http://www.cutepdf.com/

SurveyMonkey - http://www.surveymonkey.com/ free online surveys

Delicious - http://delicious.com/ Social bookmarking, online bookmarks. Save your web bookmarks so you can share and access them from any computer, anywhere, anytime.

Jing - http://www.jingproject.com/ Cross-platform screen capture software for taking screenshots and screencasts on Mac and Windows platforms.
Add visuals to your online conversations (create screencasts)

Screencast.com - http://www.screencast.com/ Easy and affordable media hosting for academic professionals who want to share multimedia content on the Web. Allows you to host the screencasts you created with Jing

Screentoaster - http://www.screentoaster.com Free online screen recorder.
Capture video of onscreen action and share them instantly. No download. Windows, Mac OS X, Linux.

Twitter - http://twitter.com/ Social networking and microblogging service that enables its users to send and read messages known as tweets (text-based posts of up to 140 characters).

Twitterfall - http://twitterfall.com/ Twitter client specialising in real-time tweet searches. Designed to allow users of Twitter to view upcoming trends and patterns posted by users in the form of tweets. Can be used as a "cell phone based clicker/polling system."

CLASSROOM COLLABORATION SOFTWARE

Dyknow http://www.dyknow.com/ (in class communication - clickers on steroids) DyKnow Vision is a tool used for collaboration and access to classroom content, including collaborative note taking and student response. [not free]

Netsupport http://www.netsupportschool.com/ (in class communication - clickers on steroids) Similar to DyKnow, but less expensive.

Lecture tools https://www.lecturetools.com/ (in class communication - clickers on steroids) LectureTools is a web-based responder, note-taking and student inquiry system for use in classrooms. LectureTools is FREE for instructors at any university or college.

Classroom Presenter http://classroompresenter.cs.washington.edu/ Classroom Presenter is a Tablet PC-based interaction system that supports the sharing of digital ink on slides between instructors and students. Classroom presenter is FREE.

Ubiquitous Presenter http://up.ucsd.edu/ Ubiquitous Presenter (UP) is an outgrowth of University of Washington's Classroom Presenter (CP), a program that uses Tablet PC ink to allow instructors to annotate pre-prepared slides and students to create submissions for in-class activities. Upiquitous Presenter is FREE.

VIDEOS and SIMULATIONS and DEMONSTRATIONS

Youtube - http://www.youtube.com

PBS Science   http://www.pbs.org/science/   PBS Online hosts interactive content for everyone.
PBS evolution site: http://www.pbs.org/wgbh/evolution/

Annenberg Media - http://www.learner.org/resources/browse.html?discipline=6
videos online, including Minds of Our Own and A Private Universe and others

Climate simulation - http://forio.com/simulation/climate-development/index.htm

Wolfram Demonstrations Project - http://demonstrations.wolfram.com/
"A free resource of interactive visualizations"
Lots of science demonstrations, need the free Mathematica Reader or else Mathematica to run them

MIT OpenCourseware - http://ocw.mit.edu/OcwWeb/web/home/home/index.htm

iTunesU - http://www.apple.com/education/itunes-u/
Free access to learning elements like lectures & interviews from MIT, UC Berkeley, Stanford, UW-Madison, UMinn, and many more - as well as labs from Stanford and more.

COURSE MANAGEMENT SYSTEMS

Blackboard - http://www.blackboard.com/ - a web-based server software platform, including course management services.

WebCT - WebCT - now owned by Blackboard, is an online proprietary virtual learning environment system. It is a combined set of tools for developing and delivering interactive courses and its components over the Web.

Sakai Project - http://sakaiproject.org/ an enterprise teaching, learning, and academic collaboration platform

Moodle - http://moodle.org/
Moodle is a Course Management System (CMS), also known as a Learning Management System (LMS) or a Virtual Learning Environment (VLE). It is a Free web application that educators can use to create effective online learning sites.

COLLABORATIVE WEBSITES:

Wikispaces - http://www.wikispaces.com/ - is a hosting service and is among the largest wiki hosts, competing with
PBworks, Wetpaint, Wikia, and Google Sites (formerly JotSpot).

Blogspot - http://www.blogspot.com   Blogger hosts and publishes blogs for free. Create your own blog, or explore a new or notable blog.

Drupal - http://drupal.org/ - an open source content management platform. Drupal supports a variety of websites ranging from personal weblogs to large community-driven websites.

Simple Team Experience Assessment Measure (STEAM) - peer assessment within groups
http://peereval.okstate.edu/beta/WelcometoSteam.html

READINGS