

# FOCUS

## on Microbiology Education



### TABLE OF CONTENTS

#### FEATURES

To Three or Not to Three, That is the Question .....	1
Molecular Phylogeny in the Undergraduate Microbiology Classroom .....	3
Bacterial Taxonomy: Melding Morphology and Molecular Phylogeny .....	4

#### NUTS AND BOLTS

Learning Styles and Microbiology Education: A New Emphasis in a New Millennium .....	5
--	---

#### NEWS AND VIEWS

Journal Watch .....	7
---------------------	---

#### MEETINGS

Seventh Annual ASM Undergraduate Conference .....	8
You are Not Alone! Report from the UK Regional Microbiology Education Conferences .....	9

### Seventh ASM Undergraduate Microbiology Education Conference 2000

#### The Cutting Edge of

#### Microbiology Education

Friday, May 19 - Sunday, May 21

Kellogg West Conference Center  
California Polytechnic State University

Pomona, CA

More information and registration forms available at:  
[www.asmtusa.org/edusrc/edu4c2000.htm](http://www.asmtusa.org/edusrc/edu4c2000.htm)



AMERICAN  
SOCIETY FOR  
MICROBIOLOGY

### Microbial Revolution

Linda Sherwood, Managing Editor  
Montana State University

Back in the 1970s, when I first learned microbiology, Stanier, Adelberg, and Ingraham stated in their textbook, *The Microbial World*, "...it is possible to identify a certain number of specific groups, all the members of which share sufficient common properties to suggest a common origin.... However, the attempt to discern *intergroup* evolutionary relationships...seems doomed to failure." (1) Then came Woese and his colleagues, and the taxonomic world was turned on end. Taxonomists were not the only ones impacted by Woese's discoveries. Every teacher of microbiology faced the same dilemma: what to teach and how to teach it. The discussion continues today, as evidenced by a recent discussion on the Microedu listserv.

We are pleased to present in this issue of *Focus on Microbiology Education* a set of articles that address this pedagogical conundrum. The first article, "To Three or Not to Three", summarizes discussions on the Microedu listserv and on an equivalent biology listserv. As you will see, there is no unanimous approach to teaching microbial taxonomy, but change clearly is occurring. The remaining articles offer some insights and examples of how to incorporate the new phylogeny into a course. We hope these articles stimulate thoughtful consideration of your approach to teaching this topic. We also hope they foster the development of creative teaching approaches on the topic of microbial phylogeny and that you will share them with us via the Microedu listserv or more formally in an article for this newsletter.

#### References

1. Stanier, R. Y., E. A. Adelberg, and J. L. Ingraham. 1976. *The microbial world*, 4th ed. p.152, Prentice-Hall, Inc., Englewood Cliffs, N.J.

### FEATURES

#### To Three or Not to Three, That is the Question

Leslie Lichtenstein  
Massasoit Community College

Teaching classification seemed to be on lots of minds last winter. Whether to teach Whittaker's Five Kingdoms, Woese's Three Domains, or some combination of both generated lots of responses on two listservs: the Biolab listserv from Clemson and the ASM Microedu listserv.

The Biolab listserv was created for those teaching freshman biology, but many of its postings come from those who teach other college level biology courses and from those who teach high school biology. The majority of the Biolab listserv contributors felt that teaching domains is better than teaching kingdoms. However, for a variety of reasons, these teachers said they were still teaching kingdoms. Most high school teachers indicated that they teach kingdoms because that's how their text is written or that's how classification

## Newsletter Editorial Committee

Linda Sherwood, Managing Editor  
Montana State University  
Microbiology Department  
P.O. Box 173520  
Bozeman, MT 59717

Robert Benoit, Feature Editor  
Biology Department  
Virginia Polytechnic Institute and State  
University  
Blacksburg, VA 24061

Pat Johnson  
Science and Engineering Division  
Palm Beach Community College  
Lake Worth, FL 33461  
johnsonp@pbcc.cc.fl.us

Judy Kandel  
Department of Biological Sciences  
California State University, Fullerton  
Los Angeles, CA 92834  
Jkandel@fullerton.edu

Joanna Mott  
Texas A&M University-Corpus Christi  
Physical and Life Sciences  
6300 Ocean Drive  
Corpus Christi, TX 7841  
jmott@falcon.tamuss.edu

Leigh W. Callan  
Division of Science, Math, and Physical  
Education  
Floyd College  
P.O. Box 1864  
Rome, GA 30162-1864

---

Any comments, questions or suggestions  
for the Focus on Microbiology Education  
newsletter? Please e-mail us at:

**EducationResources@asmusa.org**

---

Deadlines for the Focus on Microbiology  
Education newsletter:

Fall Issue: June 15  
Winter Issue: October 1  
Spring Issue: January 1

---

©All Contents Copyright 2000  
American Society for Microbiology  
All Rights Reserved

is covered in their state's curriculum guidelines. Many teachers of college introductory biology stated that they introduce domains but only after first describing kingdoms. (In several cases, the college teachers said they describe six kingdoms, splitting *Monera* into *Bacteria* and *Archaeobacteria*.) They did so because that's what the students were familiar with from high school and that's how it was presented in textbooks. No one was teaching domains exclusively.

The Biolab listserv discussion also yielded some useful references. These included The Tree of Life site from the University of Arizona (<http://phylogeny.arizona.edu/tree/phylogeny.html>), and the book *Five Kingdoms* by Margulis and Schwartz (6). For the "zoologically inclined", Ned Lyke of California State University-Hayward recommended a recent issue of the *American Zoologist* (9), which includes a group of papers presented at a 1998 Society for Integrative and Comparative Biology symposium in Boston titled Evolutionary Relationships of Metazoan Phyla: Advances, Problems, and Approaches. The papers present a number of approaches that challenge the "old way" of looking at metazoan phylogeny. There are a number of discussions on the use of molecular techniques to explore relationships that were previously established on the basis of developmental and morphological information. Lyke wrote that this is "fascinating stuff that will force changes in a lot of lectures/discussions." Since the tree of life seems to branch in ways not anticipated by the kingdom approach, Bob Lansman of the University of Wisconsin-Oshkosh suggested Margulis' latest work, *The Symbiotic Planet* (5), for a discussion of the several different ancestors of the protoctista and metazoans.

Most respondents on the Microedu listserv said that they teach both systems but favor the domain approach. There was some discussion among those teaching kingdoms about what

belonged in each kingdom. Leleng To favors Margulis' kingdom approach over Whittaker's. Only one person reported teaching only the kingdoms approach because that's how it was presented in the text. Mark Gallo from Niagara University noted, "the 5 kingdoms will continue to receive top billing as long as that's what publishers put in books." Gallo recommended the "beautiful tree of three domains" on pages 78 and 79 of the March 1998 *National Geographic* (7) as "required reading for EVERYONE." John Lennox of Pennsylvania State University-Altoona favors teaching kingdoms because it presents many points of reference for students to use as "hooks" to attach new information, making it a better pedagogical tool. Of those teaching both kingdoms and domains, over half reported teaching kingdoms using the historical approach and favoring domains throughout the course. Jim Curran of Wake Forest University wrote that he teaches phylogeny and taxonomy as "related disciplines that serve different purposes. Phylogeny...to understand the evolution of organisms...biochemical and genetic systems. ...Taxonomy has a more practical use...allows for the coherent discussion of organisms based on readily assayable traits." Ben Wise took time out from his leave from Keene State College to contribute a detailed discussion of the kingdoms approach. He felt "the Five Kingdoms system gives a very rough picture of evolutionary relationships which can then be dissected further when the subject of molecular phylogeny is introduced... There need be, and should be, no contradiction between these approaches...all criteria-morphological, developmental, life-cycle, cytogenetic and genetic-need to be included in any complete phylogenetic methodology." A few "microeduers" reported teaching domains exclusively. Jim Herrick of James Madison University felt it "kind of silly to teach...kingdoms as if they were somehow equal in phylogenetic rank, when...plants, animals

and fungi are just the tips of branches of the tree of life while...monera encompasses by far the vast majority of phylogenetic history." Bob Benoit of Virginia Tech doesn't teach either, presenting microbial evolution with trees "of some unknown number." He suggested Gupta's paper in *Molecular Microbiology*" (2) and Gupta's review article in the December 1998 issue of *Microbiology and Molecular Biology Reviews* (3). The Brock (4) and Atlas (1) texts were suggested as background, and Sara Silverstone of SUNY Brockport suggested the 1994 Woese article "There Must be a Prokaryote Somewhere: Microbiology's Search for Itself" (10) and Pace's article in the *ASM News* (8). Sam Fan felt that while we introduce domains in upper level courses we don't always get that chance with nonmajors; "nonmajors... will be the ones making decisions at the voting booth on conservation issues. For them we must get it right the first time."

I urge anyone not already subscribing to the Microedu Listserv to join by contacting Matthew Henneman (mhenneman@asmusa.org). It's a great place to lurk and you might just want to put your two cents in.

#### References

1. **Atlas, R. M.** 1997. Principles of microbiology. Wm. C. Brown Publishers, Dubuque, IA.
2. **Gupta, R. S.** 1998. What are archaeobacteria: life's third domain or monoderm prokaryotes related to gram positive bacteria? A new proposal for the classification of prokaryotic organisms. *Mol. Microbiol.* **29**: 695-707.
3. **Gupta, R. S.** 1998. Protein phylogenies and signature sequences: a reappraisal of evolutionary relationships among archaeobacteria, eubacteria, and eukaryotes. *Microbiol. Mol. Biol. Rev.* **62**:1435-1491.
4. **Madigan, M. T.** et al. 2000. Brock: Biology of Microorganisms. Prentice Hall, East Saddle River, NJ.
5. **Margulis, L.** (1998). The symbiotic planet: a new look at evolution (Science Masters Series). Basic Books.
6. **Margulis, L. and K. V. Schwartz** (1998). Five kingdoms: an illustrated guide to the phyla of life on earth. W.H. Free-

man and Co., New York.

7. **Monastersky, R.** 1998. The rise of life on Earth. *National Geographic March*:78-79.
8. **Pace, N. R.** 1996. New Perspectives on the natural microbial world. *ASM News* **62**(9): 463-470.
9. **Society for Integrative and Comparative Biology.** 1998. Symposium: Evolutionary relationships of metazoan phyla: advances, problems, and approaches. *American Zoologist* **38**(6).
10. **Woese, C. R.** 1994. There must be a prokaryote somewhere: microbiology's search for itself. *Microbiol. Rev.* **58**:1-9

### Molecular Phylogeny in the Undergraduate Microbiology Laboratory

Jeffrey D. Newman  
Lycoming College

Beginning microbiology students often have been exposed to phylogeny through a survey of animal diversity and to taxonomy by studying the various levels of classification in vertebrates. Such examples provide an intuitive understanding of these concepts because the students can readily visualize evolutionary innovations and similarities and differences among organisms. In order for students to relate these concepts to the microbial world, it is necessary to think at a biochemical and molecular level.

Relatively recent discoveries in this area have triggered a paradigm shift in our understanding of microbial diversity, classification, and phylogeny. A driving force behind this revolution has been the use of molecular sequence data, in particular 16S rRNA sequence, to study the evolutionary relationships among different organisms. Furthermore, the rapid accumulation of complete microbial genome sequences underscores the importance of DNA sequencing as a tool for understanding microbes and promises to extend the revolution for the foreseeable future.

A classic approach used to improve learning of specific concepts is to address the concepts from several different perspectives. Most microbiology courses now include a classroom discussion of phylogenetic relationships

among microbes, and textbook coverage is generally quite good. Some courses also include active learning activities in which the students compare sequences that are provided to them or that they obtain from databases such as Genbank (<http://www.ncbi.nlm.nih.gov/Genbank/index.html>) and the Center for Microbial Ecology's Ribosomal Database Project (RDP) (<http://www.cmc.msu.edu/RDP/html/index.html>). The strategy we have used is to have students apply the principles discussed in the classroom to solve a real laboratory problem, the identification of their unknown microbe. The incorporation of rRNA sequencing into the unknown-microbe identification lab and the active process of comparing these sequences has made the concept of using molecular data in microbial phylogeny much more concrete.

In this investigative laboratory exercise, students sample microbes from environments of their choice, isolate a single pure culture, and conduct a series of biochemical tests for comparison to data in Bergey's Manual of Determinative Bacteriology. In addition, students PCR amplify a segment of the 16S rRNA gene using a set of primers to highly conserved regions of the gene. The PCR products are subsequently sequenced using nonradioactive methods (Promega's Silver Sequence kit) and compared to sequences accessible through the GenBank and/or RDP Web sites mentioned above. Sequence alignments, primer sequences, protocols, and student results are available under week 9 on the most recent course web page at <http://lyco.lycoming.edu/~newman/courses/bio32199/index.html>. The spring 2000 version is part of our Molecular Biology and Bioinformatics Project (<http://lyco.lycoming.edu/~newman/models.html>) and will include more detailed sequence comparisons by the students as well as construction of phylogenetic trees from the data.

The primary objective of incorporating rRNA sequencing into the unknown microbe lab was to reinforce a

variety of essential concepts discussed in class, including microbial diversity and the use of molecular sequence data for identification and phylogenetic analysis. This activity also enabled students to be more confident in their unknown microbe identifications and provided a database link to recent research on the students' microbes. This last benefit often proved useful with organisms which had undergone recent name changes, such as *Paenebacillus*. In this case, molecular level examination of species within the genus *Bacillus* has led to the recognition of relationships and the creation of new genera. In several cases, students had misinterpreted early results, such as regular versus irregular nonsporing rods, which were then caught and corrected by the sequence analysis.

The rRNA sequencing component of the experiment is somewhat resource intensive, in both time and money. The DNA sequencing can be done manually for about \$4 per reaction in materials (not counting equipment) or one could send student samples to commercial or in house core sequencing facilities at a cost of \$12 to 18 per reaction. Obviously, the manual sequencing requires a significant investment of time by the instructor and/or skilled assistants.

The experiment was an absolute success during the two trials at Lycoming College, first with 17 students and then with 22 students. The students found the experiment challenging but satisfying when their biochemical and molecular data were in agreement. By comparison, students in previous years were not as engaged and excited by the project when their unknown was one of the common organisms we worked with in the lab. In another instance, we tried to identify environmental unknowns without using rRNA sequencing. However, the students were not able to unambiguously identify their unknowns and became quite frustrated. While rRNA sequencing was extremely demanding, the benefit realized was certainly worth the time and effort expended.

## Bacterial Taxonomy: Melding Morphology and Molecular Phylogeny

Janet Siefert

Rice University

In 1977, Carl Woese and George Fox at the University of Illinois proposed a radical idea in taxonomy. They suggested a classification scheme based on differences in the sequence of nucleotides in small subunit rRNA genes (especially the 16S rRNA genes in prokaryotes and the 18S rRNA genes in eukaryotes)-genes found in all extant life. The resulting tree of life was broadly incongruent with the kingdom classification system then in favor. Their results indicated that all of extant life could be organized into three broad domains. Two domains were composed entirely of prokaryotic organisms. These organisms had previously been united in a single kingdom (*Monera*) and are now known as the *Archaea* and the *Bacteria*. Despite great differences in their 16S rRNAs, these organisms share similar cellular structures. All other life forms, from fungi and protists to plants and animals, occupy the third domain, *Eucarya*.

One of the most striking implications of this research, and the subsequent technical advances of genetic sequencing, was its impact on bacterial taxonomy. Indeed the field was completely revolutionized. Before the molecular era, microbiologists relied upon very simple morphological characters and a battery of biochemical assays to identify and categorize bacteria. It was frustratingly apparent that these characters were insufficient. They did not carry enough detail to invoke a reliable association between similarity of traits and the evolutionary history of those traits or of the organism. At that time, microbiologists despaired of a classification scheme based on phylogenetic history. But once nucleic acid sequence analysis afforded microbiology with a scheme, it was rigorously and enthusiastically applied. Indeed, the 16S rRNA gene was so sensitive to phylogenetic signal that it could be used to identify

genera and even species without cultivating the organism. The microbial world as the unseen majority was quickly becoming a knowable entity.

While molecular phylogeny was quickly replacing classical microbiological techniques for identification, a dilemma brewed. Classical schemes, though known to be insufficient, were not thought to be inherently incorrect. However, certain relationships discovered through molecular phylogeny were proving counter to the logic of classical taxonomy. Specifically, molecular phylogeny began to place certain disparate morphologies together as closely related. The knee jerk reaction was to choose one approach over the other. And generally molecular phylogeny was chosen as the better taxonomic scheme. But intuition forces us to consider whether there should be reconciliation between the molecular data and the morphological and biochemical observations performed by the pre-molecular era taxonomists. After all, the phenotypic and biochemical characters used by classical microbiologists are products of the genetics of the organisms whose phylogenetic history is being reconstructed. They shouldn't be at odds.

George Fox and I conducted a simple study (1) to address the intrinsic value of morphology as an indicator of phylogenetic signal in bacteria. We superimposed classic morphological descriptions of ~250 bacterial species onto the phylogenetic framework provided by 16S rRNA analysis. We chose these organisms from a publicly accessible database, the Ribosomal Database Project (<http://www.cme.msu.edu/RDP>), because they represent all of the major groups of bacteria known to exist. We reasoned that by tracking each branch of the tree from the base to the tips and noting the bacterial shapes along the way, we might detect a pattern that would provide clues about the evolution of bacterial shape. To our surprise a pattern did emerge. As lineages of bacteria begin to diverge, the earliest ones, those

closest to the base of the tree, were all rod shaped. Some lineages were completely homogeneous for novel morphologies (e.g., spirochates and mycoplasmas), some were homogeneous for coccus shape, and several were heterogeneous, containing both rods and cocci. In the heterogeneous clusters, cocci were frequently interspersed with rods, but never the alternative. A cluster of coccus-shaped species never exhibited a rod-shaped species embedded within it. We considered one of the heterogeneous lineages, the low G+C gram-positive cluster in detail, and extracted and compared 160 sequences. The results were robustly in support of the previous results. The coccus morphology had arisen in many lineages, but once it had done so it was never seen to revert to the rod morphology. The results indicated a specific pattern, demonstrating that although bacterial morphology is not useful in defining bacterial phylogeny, it is remarkably consistent with that phylogeny once it is known. Classical systematics had not been wrong in assigning phylogenetic significance to morphology, it only lacked the perspective afforded by molecular phylogeny to assess its significance. For microbiologists, whether classically trained or members of the post molecular movement, there is a distinct satisfaction in these results.

#### References

1. Seifert, J. L. and G. E. Fox. 1998. Phylogenetic mapping of bacterial morphology. *Microbiology* **144**: 2803-2808

### Microbial Discovery Outreach Program

2000

June 21-25  
Florida Atlantic University  
Davie, Florida

July 26-30  
University of Idaho  
Moscow, Idaho

[www.asmtusa.org/edusrc/edumdp.htm](http://www.asmtusa.org/edusrc/edumdp.htm)

## NUTS AND BOLTS

### Learning Styles and Microbiology Education: a New Emphasis in a New Millennium

Beverly L. Smith  
University of Minnesota and  
Concordia University

As educators, we are continually trying to understand the natures of our students and to define what we must do for them if they are to learn our subject. Hippocrates first tried to understand the nature of humans by dividing behavior into four temperaments governed by four body fluids: phlegm, blood, black bile, and yellow bile (4). The study of determining human behavior and personalities continued with Freud, Adler, Spranger, Kretschmer and others in the early 20th century. In 1946, Jung connected personality and learning (3), and since then, learning styles have been further defined and instruments based on Jungian typology have been developed for the determination of learning styles. Through learning style assessment, we as microbiology educators now have an insight into the natures of our students and can design curricula to meet their needs.

The 1999 Gordon Research Conference on Undergraduate Microbiology Education and various sessions of the 1999 ASM General Meeting emphasized many ideas for change in undergraduate, graduate, and medical microbiology education. These meetings are consistent with the ongoing paradigm shift from full-time traditional didactic lecture to a learning environment that engages students by using active-learning strategies (2). This shift is fueled by the observation that when traditional methods of lecture and reading are used, students' retention of information ranges from only 5 to 10% (1). K-12 educators have been using and assessing active learning for years, but as ASM addresses issues concerning microbiology education, another topic must also be considered. This is the challenge of not only incorporating active-learning strategies into mi-

crobiology classrooms and laboratories but also encompassing the diversity of learning styles within the classroom while using multiple instructional strategies.

The need to consider the diversity of learning styles is very clear. Current assessment data indicate that active-learning strategies have been effective in engaging students, enhancing student learning, developing critical thinking skills, and aiding in the retention of information by students. These studies show that retention may be increased from 10%, using lecture and reading, to 90%, using *multiple* strategies (1). However, the use of *only one or two* methods may not reach all students with all learning preferences. It is with this in mind, that I herald a move toward diversification of teaching strategies in order to promote learning by students of all learning styles. Such diversification would allow students to learn within their learning style preferences and to further develop their learning skills by using strategies intended for other learning types.

Several learning style assessment instruments based on Jungian typology have been developed and used over the past 3 decades. The Jungian typology of personality theory is defined as the belief that people exhibit styles of life or personality that predispose them to recognizable patterns of behavior. In other words, personality types can be indicative of learning preferences. Following Jungian typology came the breakthrough development of the Myers-Briggs Type Indicator (MBTI), which reflects, by self-report, preferences for perceiving and reaching conclusions (7). Keirsey and Bates continued studies with the MBTI and subsequently developed the Keirsey-Bates Learning Pattern Assessment (4). This instrument is available, in part, as an on-line learning style assessment, dividing student learning styles into 16 permutations based on four temperaments (<http://www.bates.edu> [to administration, career services]). Other instruments for learning style assess-

ment have also been developed, including the Learning Type Measure, the Canfield Learning Styles Inventory, 4-mat, Felder, and Kolb's Learning Style Inventory (LSI).

Kolb's LSI also founded on the Jungian concept of personality types, proposes four stages of cyclical experiential learning: concrete experience, reflective observation, abstract conceptualization, and active experimentation. The LSI also proposes that learning style is expressed in the degree of preference a person has for a particular stage in the cycle. The model depicts growth and development as the student moves from one stage to another. Different learners start at different places in the cycle; the most effective learning involves all four phases. By answering the LSI questions and plotting the numerical values from the responses on a grid, the individual learns which of the four phases he or she prefers in a learning situation. The closer the numerical values are to the center of the grid, the more balanced the learning style; the farther away, the more heavily the individual relies on one of the four learning styles. According to Kolb's terminology, these four groups of learners are the Convergers, Assimilators, Divergers, and Accomodators (5).

Each student within a class-with his or her unique personality, learning style, and background-forms a relationship with the instructor through the course design. As the instructor identifies the learning styles in a class, a curriculum can be designed to address the differences among students and the relationship between each student and the material presented in the course. Some educational theories suggest that each student may be responsive to one educational program but not to another. Because of this, these theories also suggest that students be taught individually or grouped according to learning style type. Each group of like learners can then be taught using the instructional program appropriate for that group. Conversely, keeping in mind

### Learning Preferences of Kolb's Four Groups of Learners

**Convergers:** solving problems, making decisions, reasoning deductively, defining problems, and being logical.

**Assimilators:** planning, creating models, defining problems, developing theories, being patient.

**Divergers:** being imaginative, understanding people, recognizing problems, brain-storming, being open-minded.

**Accomodators:** getting things done, leading, taking risks, initiating, being adaptable and practical

Kolb's assumptions that the best learning involves all four learning preferences, groups may comprise a diversity of learners and multiple instruction strategies may be used to address all learning types.

As a graduate teaching assistant and as a new instructor, I have observed several difficulties that often plague microbiology teaching laboratories. For instance, students are often unprepared for lab. They rush to complete the lab without thinking critically and synthesizing key concepts, and they may leave the course without understanding microbiological techniques, media, and cultures. In addition, a diversity of students' backgrounds, majors, and learning styles are found in each class. Here I briefly describe how I used the LSI to assess student learning styles; developed an inquiry-based curriculum, which would engage students of diverse learning styles and enhance learning in a general microbiology laboratory; and evaluated the effectiveness of the inquiry-based curriculum.

In the inquiry-based labs, students used the LSI on the first day of class to evaluate their own learning styles. Groups containing a diversity of learning styles were formed so that mem-

bers of each group would work together and would assume particular roles which capitalized on their strengths and covered each other members' weaknesses. In addition, students occasionally were challenged to step outside of their learning preferences and develop new strategies for learning. The lab incorporated active learning strategies specific for all four learning preferences. Technology was also included by using the CD-ROM *Identibacter interactus* (McGraw-Hill).

To reach the diverse needs and learning styles of students and to promote development of learning outside the individual's learning preference, each student belonged to two groups in the lab: an experimental group and a teaching group. Experimental groups, preferably composed of four students, represented a diversity of majors and learning styles. Each week, experimental groups were given an inquiry-based problem. Beginning with a set of questions and a list of strategies for problem solving, experimental groups first brainstormed, then eliminated possibilities, solved problems, formulated hypotheses, made media, and gathered reagents to test their various hypotheses. For example, given chicken broth, heat, and flasks, the students were asked to design an experiment to test the theory of spontaneous generation. Since this was before the discussion of spontaneous generation, students brainstormed and problem solved, came up with controls and variables, and ultimately designed Pasteur's swan-necked flask experiment.

In other labs later in the semester, each experimental group isolated an unknown from an environmental source (soil, rectum, throat, food, or water) and was given an unknown by the instructor. Then, members of each group determined what they knew about their unknowns; referred to the CD-ROM *Identibacter interactus*, their lab manual, and their text book; decided how they could test their unknowns; made media specific for their chosen tests; and ultimately identified their un-

knowns using *Bergey's Manual*. During these interactions, it was not uncommon for particular students to perform particular tasks. Occasionally, they were asked to step outside their comfortable learning preferences and perform a different task. Admittedly, they did not "prefer" doing this, but in talking with the instructor, they grew to understand their learning style's strengths and weaknesses and to appreciate the goal of developing other learning skills, which could transfer to learning in other classrooms. In addition, after the lab "experiments" were completed, each group had to ensure that all members understood and could report on that day's lab exercise before going into their teaching groups.

The teaching groups were composed of students from each experimental group. Generally, students in a teaching group had similar learning preferences. At the end of each lab exercise, the experimental groups broke into teaching groups, and since the members of the teaching groups came from different experimental groups, they shared and compared approaches and solutions to that day's problem. In this manner, students could learn about other methods to solve a problem and other problem solving skills, types of media, microbial techniques, and bacteria from their peers. They also used critical thinking skills to evaluate and choose relevant procedures for their experiments.

At the end of the semester, a Likert scale was used to survey the students. The results were quite pleasing. The students indicated that they thought the lab contained components for all learning styles and that they learned from several different strategies. However, although student surveys are useful indicators of student learning, additional methods of assessment are needed in the future. As educators, we teach our students using a variety of methods; we must also evaluate our students using various levels of assessment. Several other forms of assessment could be valuable, including portfolios, to assess

critical thinking and creativity, and performance on examinations and standardized tests. In future studies of curriculum design, a larger collaborative effort among microbiology educators may be facilitated by the design of an assessment specific for active learning in microbiology education. For more discussion and collaboration on this topic, I encourage questions and comments on the ASM Division W listserv at [UGCONF@mail.asmusa.org](mailto:UGCONF@mail.asmusa.org).

For those who do not have the time or resources to assess learning styles in your classroom, I encourage you to assume that you have a diverse class. Based on that assumption, use multiple active-learning strategies, if not within a single classroom period, at least within each learning unit per examination. In doing so, keep in mind a few of the strengths from each of Kolb's learning groups (5) or from other similar Jungian-based inventories, with parallel characteristics.

In conclusion, learning style assessments can be useful to us as microbiology educators in understanding the natures of our students and in promoting their greatest learning potential, not only in our classrooms but in all their learning endeavors. We can help them understand how they learn best and how they can challenge themselves to broaden their learning skills. Several assessment instruments are available and can be useful in the design and implementation of curricula, in the formation of cooperative groups, and in understanding a specific student's strengths and weaknesses. By using a variety of strategies for each learning preference in our course, we can hope that each strategy will greatly benefit individuals with certain learning preferences while also encouraging students with other learning preferences to develop additional skills for optimal learning. (This paper is presented in part at: [www.microbiology.med.umn.edu/~bcv](http://www.microbiology.med.umn.edu/~bcv))

*Acknowledgment:* Special thanks and acknowledgment are due to Doris K. Smith, Ph.D. for her expertise in learn-

ing styles and education and for her ideas and collaboration on the curriculum design.

#### References

1. Angelo, T. A. and Cross, K.P. 1983. Classroom assessment techniques. Jossey-Bass, San Francisco.
2. Campbell, W. E. and Smith, K.A. 1997. New paradigms for college teaching. Interaction Book Company, Edina, MN.
3. Jung, C. G. 1946. Psychological types: or the psychology of individuation. Harcourt, Brace, and Co., New York.
4. Keirse, D. M. Bates. 1984. Please understand me. Prometheus Nemesis, Del Mar, CA.
5. Kolb, D. A. 1984. Experiential learning: experience as the source of learning and development. Prentice Hall, Englewood Cliffs, N.J.
6. Kolb, D. A. 1999. Learning style inventory, version 3. Hay/McBer Training Resources Group Prentice-Hall, Englewood Cliffs, N.J.
7. Myers, I. B. 1980. Gifts differing. Consulting Psychologists Press, Palo Alto, CA.

#### NEWS AND VIEWS

##### Journal Watch

Linda M. Sherwood, Managing Editor  
Montana State University

If you are like me, you subscribe to one or more scientific journals, but you do not subscribe to education journals or have the time to routinely review them at the library. With this issue of *Focus on Microbiology Education* we begin what we hope will become a regular item in the newsletter: announcements regarding recently published articles of interest to microbiology educators. However, *we need your help*. If you have recently published an article in a journal such as *The American Biology Teacher* or if you have recently read an article you found interesting, please contact me at [umbls@gemini.oscs.montana.edu](mailto:umbls@gemini.oscs.montana.edu) so that we can share these finds with others. What follows is the first installment of this service:

**Use of Veterinary Records to Teach Laboratory Thinking Skills in Biology** by C. J. Woolverton. *The American Biology Teacher* 61(6):444-

447.

**The Winogradsky Column and Biofilms - Models for Teaching Nutrient Cycling and Succession in an Ecosystem** by D. C. Anderson and R.V. Hairston. *The American Biology Teacher* 61(6):453-459.

**Rediscovering Teacher Education - School Renewal and Educating Educators** by John Goodlad. *Change Magazine*, Sept/Oct 1999, p. 29-33.

**The Scholarship of Teaching - New Elaborations, New Developments** by Pat Hutchings and Lee Schulman. *Change Magazine*, Sept/Oct 1999, p. 1-15.

**Taking Learning Seriously** by Lee Schulman. *Change Magazine*, Jul/Aug 1999, p 11-17.

## MEETINGS

### **Seventh Annual ASM Undergraduate Microbiology Conference**

Erica Suchman  
Colorado State University

The Seventh Annual ASM Undergraduate Microbiology Education Conference, generously supported by the American Society for Microbiology, will be held 19 to 21 May 2000 at the California Polytechnic State University in Pomona. This year the meeting will once again immediately precede the general meeting (22 to 25 May). The planning committee and ASM staff have worked hard all summer to put together what we feel will be an exciting and informative program entitled "The Cutting Edge of Microbiology Education." This meeting is designed to prepare you for the new millennium with the latest information about both microbiology and education. The plenary topics include:

HIV and the Immune System: Emerging Concepts in Pathogenesis of AIDs (Mark Goldsmith, Gladstone Institute)

In Search of Previously Unrecognized Microbial Pathogens (David

Relman, Stanford)

· Bioinformatics in the Classroom: DNA to Digital (Mark Gallo, Niagara University and Chris Woolverton, Kent State University)

· Assessment: The Teaching and Learning Bonding Site (Virginia Anderson, Towson State University).

In addition, there will be concurrent sessions on

· Publishing Education Oriented Articles

· The Scholarship of Teaching Undergraduate Microbiology,

· Biotechnology Workforce: Who is the Industry Seeking

· More on Bioinformatics

· Active Learning in Microbiology

In the last session, participants will break into groups consisting of people teaching similar subjects, student audiences, and class sizes. These groups will attain two objectives. One is to develop active learning strategies and assessment instruments for teaching either immunology or bioinformatics. The other is to develop curricular guidelines for the following: undergraduate programs leading to degrees in microbiology, inclusion of microbiology in undergraduate programs in biology, and microbiology courses for non-science majors. All groups will ultimately share their outcomes with the entire conference.

For more information on the conference, please see our Web page at <http://www.asmtusa.org/edusrc/edu42000/htm>.

### **You are not Alone! Report from the UK**

Joanna Verran

Manchester Metropolitan University

Having attended a couple of the ASM Undergraduate Microbiology Education conferences and the recent Gordon Conference, I thought members might like to know a little about how other microbiologists active in education disseminate some of their work. The Society for General Microbiology (SGM) has an Education Group, which organizes meetings twice

yearly, concurrent with the society's Scientific Symposia. This is a brief report on our most recent meeting.

The Education Group of the SGM recently held a half-day meeting within the 4-day society symposium at Leeds University. The topic was "Microbiology for the Nonmicrobiologist," a somewhat bemusing topic for United Kingdom lecturers who are less accustomed than our American colleagues to teaching microbiology to a diverse student body. As always for the SGM Education group, the meeting facilitated dissemination of examples of good practice, provided mutual support, and allowed the discussion of general issues of concern. The group sessions, as always, attracted modest numbers of voluble participants, usually divided equally between the "old" (research-oriented) and "new" (comparable with 4-year colleges, with considerable post-18 teaching contact, including postgraduate qualifications, as well as commendable research activity) universities. The speakers were similarly split on this occasion.

The premise behind this year's meeting was that increasing modularity in undergraduate degrees would inevitably encompass more "non-majors," whose academic requirements would differ from those of the dedicated microbiology major. How could we cater to those differences?

In general, nonmajors tend to take part of a general biology degree, with microbiology courses being taken early in the program. The nonmajors are usually in the same classes taken by students having more microbiologically oriented aspirations, and these classes tend to be large. The large class sizes usually require that instructors work in teams to design a curriculum that ensures students have comparable experiences, whichever lecturer is teaching. This formalization does not necessarily preclude innovative or student-centered assignments—for example group work is often of value—but such assignments need to be built into the course at the beginning, when

there is more flexibility. In later years of the program for nonmajors, students may take microbiology courses specific to their degrees. For instance, Materials Technology students take courses on Biomaterials, and Environmental Health students take courses in Epidemiology. These classes are smaller, usually under the control of one lecturer, and there is more flexibility in the content, design of the teaching program, and assessment schedule.

With these aspects of teaching the nonmajor in mind, six speakers described specific successful classroom strategies and courses. These are summarized below.

- **Problem-based learning:** One speaker described how members of an academic staff have the opportunity to obtain and modify real data (and make it anonymous where necessary) so that the work is appropriate for a particular group of students and real-life problems are provided for student assignments. This approach enables students to take on professional roles in data analysis, report writing, oral presentations, and group work.
- **Successful modification of a laboratory course in response to reduced contact hours.** In a laboratory course on biological diversity, students were placed in groups of 10 and then subdivided into pairs. Each pair in the group was given a "spectacular" specimen from a particular phylum. Having prepared prior to class, they examined the specimen and then reported back to the other four pairs in their group. Of the five practical exercises in the course, the final three were formally assessed. Formative assessment was made if the earlier assignments and the presentations. Each group of 10 students had a tutor, usually a postgraduate, who had been trained to facilitate the finding of solutions rather than to reveal them. The developer of the course approached its modification in this way because he held a firm belief that the stimulation of learning is more successful than the vain attempt to cram a mass of taxonomic criteria into reluctant brains-his experi-

ence with this exercise reinforced that belief.

- **Student-centered instruction.** Two student-centered units were described, where students from any department in the university could enroll in a general elective unit addressing different aspects of microbiology. The unit called "Plagues, Pestilences, and People" focused on epidemiology, while "Man and Microbes" covered more general topical issues. With minimal formal contact, the lectures were general and entertaining, often using external speakers. Videos were used as teaching support, and each student eventually produced a 2,000-word case study of a topic of their choosing.
- **Practical microbiology courses for hospital technicians and nurses.** Hospital technicians and nurses are not trained microbiologists but generally are required to take some microbiology as part of their part-time program. Their program involves attendance for 1 day a week for 2 years. The award, an HNC (Higher National Certificate) in Biological Sciences or in Physiological Measurement, is equivalent to the first year of a full-time 3-year honor degree. Successful HNC students may transfer to year 2 of a part-time honors degree for an additional 3 years. This also involves attendance for 1 day each week. Success in teaching this audience has been achieved by focusing on such basic principles as cross-contamination, disinfection, and hygiene rather than by attempting to cover all aspects of microbiology in the mere seven lectures allocated to the topic. Two 2-h lab classes enabled students to discover the ubiquity of microorganisms and to learn about their growth and death. The assignment accompanying this short experience was a group project addressing some aspect of hygiene. The presentations were made to the class and included a play revealing general misconceptions about food hygiene, a microbiological survey of the cardiac technician laboratory, collation of hand washing information provided to hospital staff, and a "forfeits" game involving question and an-

swer sessions. Other, more traditional presentations were also made. Evaluation of the unit was good, since the applied nature of the content enhanced the retention of knowledge and also stimulated interest in the area.

- **Tutorial assignment:** In a course similar to that described above for hospital technicians and nurses, students picked a disease, made a one-side hand-out on the causative agent, and presented their findings to the rest of the tutorial group (usually 8 to 12 students). The presentations emphasized a particular fascinating fact about the microbe. Nurses and hospital technicians in courses such as these are often mature and are usually parents. Their choices of disease for this assignment were strongly influenced by their life experiences; thus, their findings were of personal value and interest. Evaluation of this assignment was good, and the work done by the students received high grades.

Based on the examples presented above, it would be easy to think that innovative teaching approaches are applicable primarily to teaching nonmajors. But as the attendees at this year's SGM meeting recognized, the teaching goals are the same for both majors and nonmajors. Clearly, the generation of interest, the use of assignments requiring critical thinking, and the focus on topical and relevant material is appropriate for all students. Content, no matter what the course, should always be stimulating, activities appropriate, and assignments relevant to the audience, whatever their origin.

### **Regional Microbiology Education Conferences**

Barbara Hyde and Amy Chang  
ASM

The fourth Mid-Atlantic Conference was held in May 1999 at Goucher College in Baltimore and was organized by Goucher's Leleng To. "Based on verbal and written feedback, the participants found this conference very helpful and stimulating, especially since many of them do not have an opportu-

nity to attend ASM's General Meeting," she said. "Every single respondent said they wanted to continue these yearly conferences; the breakout sessions and seminars were on topics that people indicated as the most interesting, according to a survey conducted in January 1999."

The Mid-Atlantic conference began with a presentation by Dr. G. William Claus of Virginia Tech on using the Internet to teach a large microbiology class. He offers a Web-based microbiology course and described how electronic media can be used in active distance learning. He communicates electronically with all his distance-learning students. Claus also discussed how he uses teamwork to enhance active learning through class participation, which represents a significant portion of the students' grades. Team members represent their teams in class participation, and all members of the same team earn the same grade. Interested in earning the best possible grades, team members usually prepare each other so that learning is enhanced by collaborative work. The theme of active learning in large classes was continued by Dr. Philip Sokolove of the University of Maryland-Baltimore. He modeled active learning in large classes by having participants work in groups to solve problems, such as labeling a single virus with P<sup>32</sup> and determining how many of the progeny will be labeled, assuming a semiconservative model of DNA replication.

Workshop topics at the Mid-Atlantic Conference included Western blot analysis, use of the green fluorescent protein in teaching labs, and the Foundation for Microbiology workshop on programs that enhance science teaching from K-12. Some of the breakout session topics were promoting critical thinking in the laboratory; designing examinations to foster analytical thinking, synthesis, and creativity; and teaching science as a process in the microbiology laboratory. "Many participants mentioned that they now plan to include teamwork, group projects, and

more active learning in the classroom," To said.

Sara Silverstone organized the first New York State Regional Undergraduate Microbiology Education Conference at SUNY-Brockport, where she is a faculty member. The keynote speaker for the conference was Dr. Charles Bonwell of Active Learning Workshops, an education consulting company. The topics emphasized in the conference were empowering students through student projects, using computers in teaching, identifying teaching and learning styles, and assessing student learning.

The agenda for the conference consisted of numerous presentations, workshops, and other activities. Donald Buckley, Quinnipiac College (Connecticut), demonstrated features of multimedia learning and assessment tools customized for microbiology education. His examples included a program that allows students to design and conduct experiments to understand the phenomenon of genetic transformation. Bonwell led a workshop on active learning and learning styles. "Active learning is used more often in the humanities than in science," Silverstone noted. "Because there is so much content in science, it's quite a challenge to get away from the lecture mode." Bonwell presented strategies that can be used in large classrooms and described visual, aural, and kinesthetic learning styles. He also discussed differences in learning styles between students and teachers. "Most students are multimodal," Silverstone said, "so a variety of styles are needed in teaching to reach all different students." Another session focused on case-based learning and the excellent Hantavirus case study developed by Janet Yagoda Shagam, Janet Decker, and Ethyl Stanley. This case study is currently available on ASM's Web site as "Souvenirs: A Case Study for the 90s" (<http://www.asmusa.org/edusrc/souvenir/index.html>). Other sessions included a scientific update by Stephen Olmstead of Wyeth-Lederle on vaccine

development and an informal evening networking session, which featured ASM and vendor displays, a poster session, demonstrations of educational CD-ROMs, and a syllabus exchange. "This session was so popular that the group had to be forced out of the building at the evening's end," Silverstone said.

The success of the First Annual New York State Conference was repeated August 1999 at Genesee Community College, but in a smaller, 1 day conference. Silverstone reported that they "plan to repeat the small, 1 day format for the Third Annual Conference in 2000 and then organize another weekend conference at Brockport, N.Y. for the Fourth Annual Conference in 2001."

If you would like to organize an undergraduate microbiology educators' conference or attend a nearby regional conference, visit ASM's Web site (<http://www.asmusa.org/edusrc/edu37.htm>). This site provides helpful hints on organizing a workshop, information about the support available to do so, and information about upcoming conferences. Announcements of upcoming conferences can also be found in *Focus on Microbiology Education*.

**Seventh ASM Undergraduate  
Microbiology Education  
Conference  
Important Dates**

Abstract Deadline	March 1
Faculty Enhancement Program Application	March 15
Faculty Travel Grant Application	March 15
Early Registration	March 17
Late Registration	April 15

**More information and  
registration forms available at:**

**[www.asmusa.org/edusrc/  
edu4c2000.htm](http://www.asmusa.org/edusrc/edu4c2000.htm)**