May 2011 Report from the Task Force on Curriculum Guidelines for Undergraduate Microbiology Education

Preamble

In 2010 the Education Board appointed an ASM Task Force on Curriculum Guidelines for Undergraduate Microbiology Education co-chaired by Sue Merkel, Cornell University, Ithaca, NY and Jackie Reynolds, Richland College, Dallas, TX. The Task Force charge is to update the ASM Curriculum Guidelines for Undergraduate Microbiology in light of national reports that urge faculty to refrain from presenting science as a sea of facts and work towards ensuring that students have a foundational understanding in biology. Other Task Force members include Kai “Billy” Hung, Eastern Illinois University, Charleston, IL, Amy Siegesmund, Pacific Lutheran University, Seattle, WA, Ann Smith, University of Maryland, College Park, MD, and Heidi Smith, Front Range Community College, Fort Collins, CO.

The Task Force affirmed five overarching concepts in biology put forth in the 2011 AAAS Report Vision and Change in Undergraduate Biology Education: A Call to Action¹ and added a sixth concept specific to microbiology. The final list of overarching concepts include evolution, structure and function, pathways, information flow, systems, and impact of microorganisms.

The Task Force identified 26 statements related to the six overarching concepts. These statements identify “enduring understandings” – what students should truly understand, not just do rote or memorize, as a result of studying a particular concept. The statements are deliberately framed as declarative statements and present major curricular generalizations and recurrent themes.

In addition to its focus on conceptual understanding of microbiology, the Task Force identified two key skill areas, scientific thinking and microbiology skills, where students’ development of competency would have enduring and lasting value beyond the classroom and laboratories.

Part 1 identifies concepts and statements and Part 2 identifies skill areas and competencies for introductory microbiology.

¹ Report available at http://visionandchange.org/finalreport
Part 1. Concepts and Topics

**Evolution**

1. Cells, organelles and all major metabolic pathways evolved from early prokaryotes.
2. The immense diversity of micro-environments, along with mutations and horizontal gene transfer, have selected for a huge diversity of micro-organisms.
3. Human impact on the environment influences the evolution of microorganisms (for example, emerging diseases and the selection of antibiotic resistance).
4. The biological concept of species is not readily applicable to microbes, due to their rapidly changing genomes and frequent use of asexual reproduction.
5. The evolutionary relatedness of organisms is best reflected in phylogenetic trees.

**Structure and Function**

1. Microorganisms have unique cell structures that can act as targets for antibiotics, immunity and phage infection.
2. Bacteria have unique structures (flagella, endospores, and pili) that often convey critical capabilities.
3. The life cycles of viruses (lytic and lysogenic) are different from living cells and determined by their unique genomes and structures.
4. The structure and function of microorganisms have been revealed by the use of microscopy (including bright field, phase contrast, fluorescent, and electron).

**Metabolic Pathways**

1. Microorganisms exhibit extensive metabolic diversity.
2. The enrichment and growth of a microorganism depends on its metabolic characteristics.
3. The growth of microorganisms can be controlled by physical, chemical, mechanical, and biological methods.
4. Metabolic capabilities determine the interactions of microorganisms among themselves and with their environment.

**Information Flow**

1. Genetic variations impact microbial functions.
2. Although the central dogma is universal in all cells, bacteria, archaea, and eukaryotes are characterized by unique features within the mechanisms of replication, transcription, and translation.
3. Both external and internal cues and/or signals regulate gene expression.
4. The replication of genetic material and cell synthesis in viruses differs from cells and among viruses.

**Systems**

1. Microorganisms are ubiquitous and live in diverse and complex ecosystems.
3. Microorganisms and their environment interact with and modify each other.
4. Interactions between a host and microorganism (cellular or viral) can be neutral, detrimental, or beneficial.
5. Microorganisms, cellular and viral, interact with both human and non-human hosts.

**Impact of Microorganisms**

1. Life on this planet, as we know it, depends on microorganisms.
2. Microorganisms provide essential models that provide scientists with fundamental knowledge about all other life.
3. Humans continue to utilize and harness microorganisms and their products for our own benefit.
4. The potential for microorganisms to improve life is not yet fully explored due to our current limited understanding of the true diversity of microbial life.
Part 2. Skills and Competencies

**Scientific Thinking**

1. Ability to apply the process of science
   a. Demonstrate an understanding of hypothesis testing and experimental design
   b. Analyze and interpret results from a variety of methods used to investigate microbes and apply these methods to other situations

2. Ability to use quantitative reasoning
   a. Apply quantitative reasoning to solving problems in microbiology

3. Ability to communicate and collaborate with other disciplines
   a. Demonstrate interpersonal and collaborative skills
   b. Communicate fundamental concepts of microbiology, both in written and in oral format.
   c. Identify, interpret and evaluate a range of scientific literature

4. Ability to understand the relationship between science and society
   a. Demonstrate an understanding of ethical responsibility as it applies to microbiology

**Microbiology Skills**

1. Properly prepare specimens for examination using phase contrast and bright field microscopy

2. Use aseptic and pure culture techniques

3. Use appropriate microbiological media and test systems to identify microorganisms

4. Estimate the number of microorganisms in a sample

5. Use standard molecular and microbiological equipment

6. Practice safe microbiology, using appropriate protective and emergency procedures