



Foreword

Dear Fellow Teacher,

We have many responsibilities in the classroom, one of which is curriculum. Many of us have a curriculum which is packed with important science content, and we work feverishly to cover all of it. In the process, we sometimes don't get to the scientific thinking skills we would like to spend time developing with our students. I hope these lessons will help you in teaching your curriculum while encouraging the higher level thinking skills which your students need. For me, this has been an adventure in planning lessons which cover important aspects in curriculum (National Science Education Standards and Benchmarks) while addressing the varied levels of thinking. These lessons have helped me to develop those important higher level thinking skills with my students while engaging in fun and exciting activities which meet my curriculum requirements. Here's how:

Bloom's Taxonomy

This module is written to address the various levels of thinking required for challenging students and helping them to advance their scientific thinking. The objectives for each of these lessons are based on Bloom's taxonomy. This will allow you as the teacher to plan lessons which engage students' higher level thinking skills.

Bloom's Taxonomy was developed by Benjamin Bloom. Working at the University of Chicago, he developed three overlapping levels of intellectual behaviors. The Cognitive, Affective, and Psychomotor, these three types of behavior were considered central to learning. Probably the most well known, or at least most used of these types is Cognitive learning. Within Cognitive Learning, Bloom identified six levels of cognitive functioning. These levels are often used to describe the levels of thinking involved in student tasks.

Because these lessons have objectives designed around Bloom's Taxonomy, you will be able to work towards higher level thinking skills with your students. Each lesson has multiple objectives allowing you to build up to the higher level thinking skills. To begin with these skills would be unrealistic as students must learn and understand the basics of a concept before applying that understanding to more complex problems. It is through the use of activities which incorporate a variety of levels of Bloom's Taxonomy that student will excel.

Bloom's Taxonomy

Lower Level	1. Knowledge
	2. Comprehension
	3. Application
	4. Analysis
	5. Synthesis
Higher Level	6. Evaluation

After each of the lessons, there is a section titled "Observations". In it I have recorded my observations from using these lessons in my classroom to help you in using them in your own. Use these observations to help you tailor them to the needs of your students.

Jennifer Lamkie



Introduction

Dear Educator,

The material in this manual is based on a set of demonstrations that I developed for college students at Rutgers, The State University of New Jersey. The activities are meant to help establish the connection between earth and life sciences in students' minds by showing how living things influence the physical environment and vice versa. The concepts behind these activities represent our current understanding of biogeochemical cycles and are the result of the work of many researchers.

These lessons have been adapted for Middle School level students, but we have tried to leave enough flexibility that they can be used in both lower and higher grades. The activities are designed to help students understand how biogeochemical cycles work, how metabolism is related to electrical potential, and how small-scale models can be used to study large-scale systems. These topics can be covered in more or less detail without changing the basic activities. Other important skills that are taught include how to handle quantitative data, lab safety, and computer techniques.

Although the activities are separated into nine lessons, they are all more-or-less linked. Lessons #1-3 are meant as introductions to the topics of microbiology, biocomplexity and biogeochemical cycles. They provide helpful background for students doing the rest of the lessons, but they could also be taught as stand-alone lessons. Lesson #4 leads into the Winogradsky column activities but can be done by the teacher if time is limited. Lessons #5-8 make up the core activities. I believe that the lessons work best if both the electrical potential (#6) and reduced iron (#7) are measured, but one or the other can be used to indicate the bacterial activity. The final lesson (#9) can be used as a "capstone" activity. It incorporates the concepts from all of the earlier lessons and encourages a high level of independent thinking. It is most suitable for advanced students.

I hope that you find these lessons a helpful part of your curriculum.

Craig D. Phelps, Ph.D.