Photosynthesis

In this example, Ms. M. believes that her understanding of the history of scientific ideas enriches her understanding of the nature of scientific inquiry. She also wants the students to understand how ideas in science develop, change, and are influenced by values, ideas, and resources prevalent in society at any given time. She uses an historical approach to introduce an important concept in life science. She provokes an interest in the topic by purposely showing an overhead beyond what is developmentally appropriate for high-school students. Her lecture is interrupted with questions that encourage discussion among students. The research activity, primarily using print material which she has been collecting for a long time, includes discussion. The questions about factors that might influence contemporary research return the students to issues that are of immediate concern to them.

[This example highlights some elements of Teaching Standards A and B; 9-12 Content Standards A, C, F and G; and Program Standard B.]

Ms.M. was beginning the second round of planning for the high-school biology class. She had set aside three weeks for a unit on green plants. Now it was time to decide what would happen during those three weeks. Students came to the class with some knowledge and understanding about green plants, but they still had many questions. As a way to get students to focus some of their questions, and to highlight the interdependence of science and civilization, she was going to begin the unit with a lecture on photosynthesis. Lecturing was something she seldom did. However, the purpose here was not to lay out the details of the photosynthetic process, but to illustrate how the scientific community's knowledge of photosynthesis had changed over time.

She would begin the lecture by putting a transparency on the overhead projector of that detailed diagram of photosynthesis which had been sent to her free from one of the pharmaceutical companies. One of the high-school textbooks that she kept as a reference said that scientists now had described 80 separate but interdependent reactions that made up photosynthesis. The high-school students would not study these reactions. Rather, she wanted the students to observe the complexity of the current knowledge about photosynthesis, and this diagram was a useful introduction to her lecture. She would ask the students how long the scientific community had known about these many complex reactions; why this knowledge was important; how they had come to know so much; was there still more detail to be described?

Next she would ask the students to tell her what they already knew about photosynthesis. She expected most would recall that carbon dioxide,water, sugar, oxygen and sunlight were important and many would recall growing plants in dark cupboards and under boxes in middle school. The next two questions would have to be worded carefully: Why is photosynthesis so important or, put another way, what is the fundamental question that photosynthesis answers? And how long have scientists known about photosynthesis?

With this introduction, she would lecture about the seventeenth century experiment of van Helmont and his tree and his conclusion that the weight of the plants came from water. Ms.M. would pause. "Was van Helmont wrong?", she would ask the students. She expected them to have difficulty conceiving that van Helmont had conducted an experiment, which they knew was essential to science, but that he had not obtained the answer they knew was correct. Ms.M. would help them analyze the experiment and the conclusions that could legitimately be drawn from it. She would then introduce more of the context of van Helmont's investigation: the prevailing belief about plants as a combination of fire and earth and how van Helmont's study was designed to refute this belief. She would comment that many researchers chose to repeat the tree study, and then she would allow students to discuss how (or whether) van Helmont's study had contributed to the science of photosynthesis.

She would then continue her historical lecture using similar details from several other episodes. She would describe how chemists had learned to collect gases from chemical reactions, how Priestley used these new techniques, and how he then observed the effect that gases from plants produced on burning candles. She would note that Priestley did not know about oxygen, but viewed it as a purer form of air. She would mention how Ingenhousz expanded Priestley's finding by showing that the air was changed only when the plants were kept in sunlight,and how de Saussure confirmed that carbon dioxide was a gas needed for the same effect. She would detail how James Hutton had been involved in industrial debates about the quality of coal and was interested in why coal burned. He had interpreted plant imprints in coal as a clue that something from the sun was being stored in

plants and then fossilized as coal. The "something" would later be released again as light and heat as the coal burned. But Hutton had no concept of chemical or light energy—concepts introduced only decades later by Julius Mayer. Ms. M. would stop her history here. Students would review how various factors had shaped the development of early knowledge about photosynthesis. She would record and organize their views on the chalkboard. From this they would develop a set of questions for continuing the history on their own.

Ms. M. had collected a number of textbooks from different periods in the century. She would introduce them as a resource for sketching the changing status of knowledge about photosynthesis.She would have the students work in groups of five.Each group would prepare a brief presentation on ideas of photosynthesis during a particular historical period. After two days to gather information,each group would share the result of their research and together they would identify or infer what discoveries had been made in each period. Then, using the questions they had formulated earlier, the students would return to their groups to determine how each discovery had occurred. They would identify factors such as new technologies that were relevant to conducting investigations, the sources of funding for various research projects, the personal interests of researchers, occasions of luck or chance, and the theories that had guided research. Finally, each group would share two patterns that they had uncovered and how they had reached their conclusion.

Through this activity, students would come to realize that scientific understanding does not emerge all at once or fully formed. Further, the students recognized that each new concept reflected the personal backgrounds, time, and place of its discoverers. At the very end of the period Ms.M would ask the students to speculate on what scientists might ask about photosynthesis today or in the future, and what factors might shape their research.