



Introduction

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Our consumer-driven society generates a tremendous amount of waste that is threatening the carrying capacity of Planet Earth. The enormous challenge facing us can be summarized in one word: sustainability. "Green chemistry" is a growing field that aims to develop and apply new methods that are more environmentally friendly for the manufacture of products and for recycling of products after they have been used. Important goals of green chemistry are to minimize the waste generated during manufacture of a product and to develop products that are biodegradable or are easy to recycle. There are many common household products for which green chemistry can make an impact, including fuels, plastics, electronics, pharmaceuticals, cleaning products and cosmetics. The aim of this seminar was to illustrate how the principles of green chemistry relate to products that we use every day and how they may lead to a more sustainable society.

My own interest in science stems from my hands-on experiences as a child. Therefore, many demonstrations were included in this seminar — at least one demonstration during each seminar meeting. These demonstrations were chosen so that they could actively involve the participants and at the same time illustrate the scientific principles related to green chemistry.

The book by Paul Anastas and John Warner, entitled *Green Chemistry: Theory and Practice*, was used as the primary text for the seminar. The seminar was greatly enriched during the first meeting in May when Paul Anastas joined our group. Paul is widely regarded as the father of green chemistry and he coined the name "green chemistry." During this first seminar meeting, Paul articulated the need for "green chemistry" and outlined the 12 principles of green chemistry. Several of the Fellows in the seminar took advantage of Dr. Anastas' offer to sign his book. During the Intensive Session in July, a focus of the seminar was on case studies of green chemistry. These were taken from "Real World Cases in Green Chemistry" published by the American Chemical Society, which was used as a supplemental text for the seminar. All of the case studies are examples of projects that have received the prestigious Presidential Green Chemistry Challenge Award. We discussed the principle of atom economy as it was applied to improving the synthesis of ibuprofen (Motrin, Advil, Medipren) so that less waste and fewer byproducts are generated in its production. The different types of plastics, and their recycling, were discussed both from the point of view of consumers and the chemistry for their production and recycling. A demonstration on the synthesis of nylon added to these discussions. We also discussed greener methods for dry cleaning, washing clothes and dishes, and bleaching. Renewable energy is a key aspect of sustainability. With this in mind, the seminar included a discussion of sustainable energy use in the future that included progress in the development of biofuels and processes for solar energy conversion using artificial photosynthesis. A highlight of the seminar was the production of biodiesel fuel from cooking oil that culminated in the combustion of biodiesel fuel in an oil furnace burner.

The curriculum units developed from this seminar are suitable for elementary to middle school to high school students. In all of the units, the science content is integrated with language arts, mathematics and social studies to provide a balanced program that meets the literacy requirements of the school system. The Fellows have prepared extensive lists of materials that can be used in the classroom or as resources. These materials include books that the children can read, textbooks that the teachers can use, demonstration sourcebooks, suppliers of equipment, useful computer software, and addresses of sites on the World Wide Web. Several of the Fellows developed units around a theme or activity related to green chemistry, including an innovative "murder mystery" activity that illustrates the improved "green" method for synthesis of ibuprofen. Other units are related to the impact of our consumer society on our Planet Earth and include topics such as recycling, water use, environmental justice, ecosystems, and use of pesticides and herbicides. The units include a number of excellent activities that will engage the students' interest and teach them about green chemistry and sustainability.

I would encourage all teachers of elementary through high school students to review these curriculum units. These materials provide a valuable resource for incorporating topics of science and society related to "Green Chemistry" into the classroom.

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