Monarchs in the Classroom:
A K-12 ecology education program

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Abstract
Monarchs in the Classroom is a K-12 ecology education program designed around an in-depth study of the monarch butterfly. The program involves a cooperative network of scientists, teachers, graduate students and pre-college students, with connections to the Monarch Watch program and monarch-based education throughout North America. Program components include providing live monarchs to classroom teachers; development and dissemination of grade-specific curriculum materials; teacher training; and research partnerships between students, scientists, and pre-college teachers.

Introduction
Picture a classroom of eight-year-olds silently gathered around a table, watching with their mouths wide open as a monarch butterfly emerges from its pupa. Each day for almost two weeks, these students fed, observed, measured and cared for their own caterpillars and then waited another 10 days for this moment. In the process, these students became experts on a fascinating organism, both through their own observations and inquiries, and through the instruction of their teacher who integrated monarchs into science, math, reading, social studies, and art lessons. Later in the day, the students tag and release their monarch as part of an international research project on migration, thus contributing to the body of knowledge about monarch biology as they learn about research. As they follow their monarch’s amazing migration south to another country, they learn about a culture very different from their own and begin to think about how eastern North American monarchs depend on the actions of an international citizenry. In the spring, they will check Internet sources for monarch sightings, search the ground for milkweed shoots, and anxiously await the return of monarchs to their area. This is Monarchs in the Classroom.

More formally, Monarchs in the Classroom is a science outreach program from the University of Minnesota, Department of Ecology, Evolution & Behavior. The program has four primary goals: 1) to help make science more accessible and purposeful for students by bringing science to life in the classroom, 2) to increase students’ understanding of biological and ecological principles, 3) to promote research collaboration between students, researchers and educators, and 4) to promote understanding of conservation issues through student connections with monarchs.

The first two of these goals relate directly to current US science education objectives. In recent years, an increased focus on K-12 (kindergarten to grade 12) science instruction has resulted in the development of Benchmarks for Science Literacy (AAAS 1993), National Science Education Standards (National Research Council of the National Academy of Science 1996), and individual state science standards. While these efforts vary in their foci, each stresses the importance of teaching science as a process—promoting a scientific literacy in which students are able to “ask, find, or determine answers to questions derived from curiosity about everyday experiences,” and “describe, explain, and predict natural phenomena” (National Research Council of the National Academy of Science 1996, p. 22). Another objective of these standards is reducing the breadth of coverage in science education and covering the core material more thoroughly; in other words, replacing the mile-wide, inch-deep approach typical of science textbooks with an inquiry-based approach. The overriding objective is to teach students to think and discover for themselves—to promote the process of inquiry and discovery used by scientists to understand natural phenomena.

Students involved with Monarchs in the Classroom are afforded the opportunity to study one organism in depth, learning enough about monarchs to generate their own ideas and questions. While an extensive
science education program centered around a single insect may seem a bit narrow, this focus has proven to be extremely successful and popular with teachers and students. Monarchs are familiar, well-loved insects that provide a fascinating, non-threatening experience with living organisms. Their easily-observed life cycle brings exciting science concepts to life, and their large size makes it easy for students to handle all life stages. Since monarch larvae feed on milkweed, common even in urban settings, students can collect their food from the surroundings, enabling important connections with the environment. Working with living organisms in the classroom engages students, and allows them to conduct simple investigations, thus practicing observation, hypothesis testing, data collection and analysis. Finally, studying monarchs is especially appealing because it captures the interest and attention of all students, not just those with an aptitude for science. All students become equally involved with this program.

When science is taught as a process rather than a body of knowledge, it is important that teachers have experience with the process of science. Unfortunately, few pre-college teachers have themselves been taught in the way they are being asked to teach their students (Druger and Allen 1998). Our third goal of promoting collaborations between students, teachers and scientists aims at improving this situation. Working scientists have a great deal to offer during this transition in science teaching, and can work in partnership with K-12 educators. Partnerships can take many forms: scientists may help with special projects in their children’s schools (science fairs, career days, classroom visits); scientists may partner with teachers to co-develop curriculum and outreach programs for K-12 classrooms; and scientists can involve educators in research, extending the range of the research while affording teachers invaluable experience. Monarchs in the Classroom, along with Monarch Watch (Taylor this volume), has explored each of these avenues (see below) and has evolved into a true K-12/University partnership.

Our fourth goal of promoting an understanding of conservation issues is relevant to environmental education objectives. The development of standards for environmental education at both national and state levels (e.g., State of Minnesota 1993) is an indication of the growing importance of this area in the eyes of education policy makers. While scientific knowledge, particularly an understanding of ecological systems, is integral to environmental education programs, other important components include: 1) an understanding of how social systems interface with environmental issues, and 2) the need for individual stewardship. Both the capacity and the commitment to engage in pro-active stewardship must be developed in students, and commitment is much more likely to result from programs that instill a sense of connection between students and the natural world. Students rearing monarchs make these connections and the monarch’s conservation story naturally unfolds for them, giving meaning to these complex and often distant issues.

**Program components**

**Instructional materials**

Monarchs in the Classroom began six years ago when we gave extra monarch larvae to a local elementary school, larvae left over from our summer research on monarch reproduction. Today, providing monarch larvae and eggs to teachers is still an important component of the program. In the fall of 1997 we distributed over 7,500 larvae, with most teachers receiving 10 to 20. Most teachers receive the larvae at the beginning of school, use wild milkweed to feed them, and release the adults back into the environment soon after they emerge.

Key to our program is a comprehensive written curriculum that leads teachers and students through an inquiry-based study of monarch butterflies (Monarchs in the Classroom 1997). This curriculum is the result of a three-year collaboration with several Minnesota teachers, who piloted most of the lessons in their classrooms. Our second edition consists of three separate guides (for K-2, 3–6, and Middle School teachers), each of which is over 180 pages long. With its foundation in life science, the curriculum also incorporates concepts and skills in math, reading, writing, art and social studies. Lessons are congruent with pre-college concept and process standards as outlined in the National Research Council of the National Academy of Science’s *National Science Education Standards* (1996). The Minnesota Framework for Math and Science Standards (SciMath 1997) showcases the program as an exemplary way of covering life science standards in grades 5–8. Each curriculum guide includes an extensive background section on monarch biology and suggestions for raising monarchs in classrooms, six subject sections of classroom lessons (life cycle, migration
& overwintering, ecology, systematics, experimentation, and conservation), an extensive bibliography, and many student handouts. Lessons range from outdoor observations and class discussions to art projects and games. Table 1 lists the lessons in the Middle School ecology section, as a sample of the breadth of topics covered.

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<thead>
<tr>
<th>Table 1</th>
<th>Middle School ecology curriculum: Lesson index topic*</th>
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<tbody>
<tr>
<td><strong>Topic</strong></td>
<td><strong>Lesson</strong></td>
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<tr>
<td>Habitat</td>
<td>1. Butterfly habitat survey</td>
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<td>2. Make a plant field guide</td>
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<td>3. Make a butterfly and moth field guide</td>
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<td>5. Why isn’t the world overrun with monarchs?</td>
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<td>6. Mortality in classroom and wild monarch larvae</td>
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<td>7. Monarch Mishaps: A game of survival</td>
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<td>Defenses</td>
<td>8. How living things protect themselves</td>
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<td></td>
<td>9. Plant defenses</td>
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<td>10. Butterfly coloration, Camouflage</td>
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<td></td>
<td>– 1: Hide a butterfly</td>
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<td></td>
<td>11. Butterfly coloration, Camouflage</td>
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<td>– 2: Toothpick prey</td>
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<td>12. Butterfly coloration: Warning coloration</td>
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<td>13. Butterfly coloration: Startle Coloration</td>
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<td>15. Monarch protection</td>
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* from Monarchs in the classroom: an inquiry-based curriculum for Middle School (1997): 115

We have developed additional support materials, including a monarch caterpillar field guide (Oberhauser & Kuda 1997), which shows readers how to distinguish the five larval instars; two scripted classroom slide sets, one on the monarch’s yearly life cycle and one on overwintering biology and conservation; and a board game. The slide sets each consist of 23 separate images, most of which were taken from our research on monarch butterflies.

**Teacher workshops**
For over three years, we have offered a variety of workshops and courses for teachers. Our most intensive course is a ten day (six hours per day) summer course. This offering is structured to meet over the course of a month to enable teachers to rear larvae and practice their own investigations between the weeks we are in session. The first week is a crash course in monarch biology and research with field and lab experience. The emphasis is to make teachers comfortable with the body of scientific information on monarchs as well as with the process of scientific investigations. During the second week, we focus on translating this knowledge to the classroom. Teachers work in grade level groups (K-2, 3–6 and Middle School) and practice lessons they will use with students. Throughout the course, we model scientific inquiry methods and emphasize the importance of involving students in inquiry activities. Our own research projects illustrate the processes of science—observation, question asking, hypothesis formation, and experimental design. We also teach basic ecological techniques such as population censusing. Each teacher designs and carries out a simple individual or small group experiment, and takes part in class research projects. In addition to the increase in science
knowledge and skills gained by teachers, an important outcome of this intensive course is the science education partnerships that develop between educators and researchers. These relationships are maintained after the course ends with formal and informal contacts.

For teachers who can not make the time commitment of the summer course, we offer short (one to seven hour) workshops for individual schools or school districts. In these shorter format workshops, we provide instructions on successfully rearing monarchs in the classroom and guide teachers through the curriculum. In most cases, each participant receives a curriculum guide and ten larvae. Many of the workshops are co-taught with teachers who have taken the longer summer course. The short workshops also provide an important means of disseminating our program.

Finally, we offer a mid-winter one-day teacher reunion for all workshop participants. This meeting affords teachers the opportunity to share experiences from their classrooms as well as hear updates on monarch migration, research and conservation efforts. A true sense of collegiality is fostered through these reunions.

**Student/teacher/scientist research**

Promoting student and teacher research is a central component of our program. We do this in two ways, by helping teachers to facilitate research projects with their students, and by developing and promoting research projects in which the public can participate.

In workshops and in the written curriculum, we stress the importance of student research and provide instruction on conducting scientific investigations. The curriculum includes step-by-step directions for taking students through the process of designing and carrying out independent research projects. In 1997, we offered a special teacher workshop on developing independent student research projects, which were then carried out in the fall. Participating students were invited to a Monarch Fair held at the Science Museum of Minnesota. They presented posters describing their work to monarch scientists and then left their posters on display for general museum visitors. Research projects were diverse in topic and quality, and included both observational studies (e.g., *When do monarch butterflies emerge most often over a 24-hour period?*) and experiments (e.g., *Does the condition of milkweed affect larval growth?*). Students, teachers, parents, and other museum guests were enthusiastic about the Monarch Fair, and this program provides a model for future single-topic research fairs for students.

Several large-scale, collaborative research efforts have been developed on monarch butterflies, and the educational potential of these projects is immense. The monarch monitoring project (Pryshby & Oberhauser this volume), the Monarch Watch tagging and other research programs (Taylor this volume; Calvert and Wagner this volume), and tracking the spring migration with Journey North (Donnelly this volume) involve students, teachers, and other interested individuals in important research efforts that add to our understanding of basic monarch biology as they teach science. We encourage all of our teachers to participate in as many of these exemplary collaborative research programs as possible.

**Project maintenance**

Monarchs in the Classroom is disseminated in several ways: electronically on the Monarch Watch website (Taylor this volume), through presentations at state and national meetings for educators, and by word-of-mouth through teacher networks. Although we limit distribution of living materials to teachers in Minnesota and Wisconsin (see Brower et al. 1995), our curriculum and other materials reach teachers throughout the country. We have distributed over 2,000 hard copies of the curriculum, and many more have been downloaded from the Monarch Watch website.

The program is under formal evaluation to assess teacher and student improvement in science education, and preliminary feedback from participants is overwhelming. We are told that it is *inspiring* for students and teachers to witness monarch development, *empowering* to learn so much about a single topic that they feel that they are true experts, *challenging* to be involved with real research, and *involving*, particularly with regard to the conservation issues. The program rewards everyone involved—scientists, teachers, pre-college students, and family and community members. Another positive outcome stems from the involvement of graduate students, who are future scientists and educators. Graduate students have been involved in
a variety of capacities, from co-director of the project (L. Goehr), to designing the monitoring effort (Pryshy & Oberhauser this volume), to sharing their research with workshop teachers (Goehring & Oberhauser this volume, Altizer et al. this volume). These students may approach scientific or other careers with a different attitude than those who have no involvement with pre-college educators and students, and can thus play important roles in shaping the changing focus of science education.

Financial support is key to the development of outreach programs, and our fund-raising strategy may provide a model for other ecology education programs. The pairing of scientists and teachers, in essence, the pairing of scientific experience with its delivery to the pre-college community, has been instrumental in attracting funders. The National Science Foundation provided initial funds for both Monarch Watch and Monarchs in the Classroom in a three-year grant from their instructional materials development program. We have received funds over multiple years from the Eisenhower Professional Development Program and the University of Minnesota Department of Continuing Education and Extension for summer workshops, and the Medtronic STAR Foundation for short workshops and the Monarch Fair. Finally, as the program has developed, product sales (larvae, curriculum and larval identification guides, slide sets, T-shirts and posters) and workshop fees provide an increasingly important source of support, and we expect one day may support the entire program.

Summary
The monarch butterfly is an ideal organism on which to center a program that promotes skills-based science education. With its rich and fascinating history of research and discovery, studying monarchs results in an increase in student understanding of basic scientific knowledge, develops scientist/teacher/student collaboration, and promotes awareness of environmental issues as well as the motivation to act on these issues. This entire Proceedings, and the North American Conference on the Monarch Butterfly attest to this. While the monarch is a unique and special example, any one of a myriad of organisms could form the basis of a pre-college program that does all of these things. There are incredible opportunities for scientist/educator partnerships in the changing face of pre-college science education.

Acknowledgments
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References


