21st Century Afterschool Science Project

Model, Guide to Incorporating Science in Afterschool and "Exploring Water Science in Afterschool" Curriculum

The 21st Century Afterschool Science Project is a collaborative effort between the New Jersey Department of Education, Liberty Science Center and the New Jersey School-Age Care Coalition. This cooperative alliance uses the technology, health and science resources of New Jersey to develop and integrate quality science and health education programs into afterschool programs.

Mission Statements:

The New Jersey Department of Education will provide leadership to prepare all students for their role as citizens and for the career opportunities of the 21st century.

Liberty Science Center is an innovative learning resource for lifelong exploration of nature, humanity and technology, strengthening communities and inspiring global stewardship.

The New Jersey School-Age Care Coalition mission is to promote and support the development, continuity and expansion of quality programs for children and youth during out-of-school time.

This project was funded in its entirety with federal Elementary and Secondary Education Act, as amended by No Child Left Behind, Title IV, Part B, 21st Century Community Learning Center (21st CCLC) grant funds through a cooperative grant agreement with the New Jersey Department of Education.

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Acknowledgments

This afterschool science model, guide and curriculum was developed by the 21st Century Afterschool Science Project (21st CASP) partnership to enrich student learning through inquiry-based, interactive science experiences. The project was funded in its entirety with federal Elementary and Secondary Education Act, as amended by No Child Left Behind, Title IV, Part B, 21st Century Community Learning Center (21st CCLC) grant funds through a cooperative grant agreement with the New Jersey Department of Education.

The 21st Century Afterschool Science Project partnership would like to thank the following members of the 21st CASP team for researching, developing, prototyping and writing the guide and curricular materials:

- Maxie Hollingsworth Latimer, Director of Afterschool Initiatives at Liberty Science Center, Jersey City, NJ
- Elizabeth Kurzawa, Associate Director for Research and Grant Programs, Liberty Science Center, Jersey City, NJ
- Pam Lerner, Afterschool Science Specialist, New Jersey School-Age Care Coalition, Westfield, NJ

Additional thanks to Melissa Wadman, Director, Impact Evaluation at Liberty Science Center, Jersey City, NJ for synthesizing the project outcomes from individual interviews, surveys and focus groups with afterschool program facilitators, students and families.

Special thanks to the following Liberty Science Center staff for their help on this project: Bryan Blaney and Bob Smith for developing the hands-on family science activities used during the pilot project and to Matthew Doering for his assistance with the research and review of materials for the curriculum and facilitator guide.

The 21st Century Afterschool Science Project partnership would also like to thank the following environmental educators whose expertise helped the Project team adapt water science experiments into a hands-on curriculum for afterschool providers:

- Claire Antonucci, New Jersey Marine Sciences Consortium
- Janice McDonnell, Institute of Marine & Coastal Sciences at Rutgers University
- Thomas M. Grothues, Rutgers University Marine Field Station at Tuckerton

We also wish to express our gratitude to the following 21st CCLC afterschool program staff who pilot-tested the curriculum activities and contributed invaluable feedback that helped shape the curriculum, trainings and overall model for delivering science in afterschool environments:

- Cassandra Small, Janet Poinsette and Suzanne Lustberg, Janis E. Dismus Middle School, Englewood, NJ
- Pat Snyder, Maryann Brown and Pam Pelletier, Lakewood Latchkey at Oak Street School, Lakewood, NJ
- Rosalind Norrell-Nance and Dr. Jim McGinn, Atlanticare Uptown Family Center Community School, Atlantic City, NJ

We would also like to recognize the following afterschool programs for providing feedback on the project model, curricular materials and trainings:

- Boys & Girls Club of Hudson County at P.S. 27, Jersey City NJ
- Community Science Workshop, Newark NJ
- Focus Group participants: El Club del Barrio, Inc. Newark NJ; Princeton Family YMCA, Princeton NJ; Trenton Public Schools 21st CCLC, Trenton NJ; School One/ Project Open Door, Linden NJ; Western Monmouth County YMCA, Freehold NJ; Easter Seals New Jersey 21st CCLC, Keansburg NJ; Cherry Hills Public Schools STEP, Cherry Hills NJ; La Casa de Don Pedro, Newark NJ; Focus Hispanic Center for Community Development, Newark NJ; Tri-City People's Corporation, Newark NJ.

Thanks to Paul J. Hurtado, Center for Applied Math at Cornell University for providing amazing photographs of wetland animals.

Additionally, we would like to thank the following staff from the Office of Educational Support Services (OESS) at the New Jersey Department of Education for their collaborative effort and guidance on this project: Haydee Y. Perez-Livingston, Extended Educational Services Unit Coordinator; and Tom Collins, Evaluation Coordinator.

Special Acknowledgments:

We would like to recognize and thank the following people, without whom this project would not have been possible:

- Susan Martz, Director, Office of Educational Support Services (OESS) at the New Jersey Department of Education, Trenton, NJ for supporting the enhancement of quality afterschool programming through informal science education;
- Diane Genco, Executive Director, New Jersey School-Age Care Coalition, Westfield, NJ for her expertise, technical assistance and tireless promotion of afterschool;
- Jeffrey Osowski, Ph.D, Vice President for Learning and Teaching, Liberty Science Center, Jersey City, NJ for helping to expand Liberty Science Center's role in the field of afterschool.

PART ONE: 21ST CENTURY AFTERSCHOOL SCIENCE PROJECT — HISTORY AND GOALS

I. 21st Century Afterschool Science Project (21st CASP)

Background

In 2005, the New Jersey Department of Education (NJDOE), Liberty Science Center (LSC) and the New Jersey School-Age Care Coalition (NJSACC) held a series of meetings to discuss the benefits of science learning in out-of-school time (OST) settings, specifically in 21st Century Community Learning Center (21st CCLC) programs, which serve nearly a million students throughout the country and 15,000 students in New Jersey.

The NJDOE, LSC and NJSACC understand that the demands and expectations for OST programs, including afterschool programs, have expanded from providing a safe-haven and homework help to offering supplemental instruction, enrichment opportunities and physical activities. The 21st Century Afterschool Science Project (21st CASP) was born from these initial meetings. The most important issue: how to support science learning in afterschool and other OST environments.

While afterschool programs are varied in their goals and purposes, all are wrestling with the need to prepare students for the challenges of this new century, the scientific and technological revolution, and achievement in school. Research has demonstrated that participation in afterschool programming has a positive impact on students, decreasing risky behaviors and improving school success and academic achievement. Students involved in meaningful pursuits during out-of-school time hours develop increased self-confidence and a stronger sense of community, particularly for those students deemed 'at risk'.[1] Afterschool programs are an important part of the community-based network and should be equipped to engage those with the least access in the critical fields of math, science, and technology.

Afterschool, extended-day and out-of-school time (OST) programs have tremendous potential to help students develop the knowledge and skills needed for positive social development and academic achievement. As educational policy and attitudes change, afterschool programs must also evolve from the traditional latch-key and homework-help programs. The 21st century child is sophisticated: electronic-media savvy and possessing a heightened awareness about her connection to the world community. However, because U.S. advantages in the global marketplace and in science and technology have begun to erode, our children must be better prepared to enter school and the workforce with advanced knowledge. Afterschool and OSTs can offer experiences—particularly in science and technology—that complement and reinforce school-day learning.

1 Hall et al, 2002; McLaughlin, 2002; Davis et al, 2003; Miller, 2003; Hall et al, 2004

Importance of Science

Science learning in afterschool allows students to learn essential team-building and problem-solving skills, and provides more opportunities for students to participate in hands-on, project-based learning. Afterschool is particularly ideal for the type of informal and experiential learning that children need to balance traditional school education. In afterschool, students are able to learn more than just science content; indeed, they are able to research, discuss, identify and develop their own strategies for the social and environmental issues affecting their communities.

United firmly in the belief that access to intensive, comprehensive, resource-rich educational experiences are vital to removing barriers to improved educational opportunities for students, the 21st CASP partnership moved forward to address the well-documented educational challenges that face students in the areas of science, mathematics and technology. There is a growing body of research documenting the importance of science learning in afterschool. Engaging children in informal science activities is shown to be strongly correlated with the further study of science and the pursuit of science-related careers. Interactive science centers—large or small—are especially effective in fostering this mind-set and motivation among educational institutions, individuals and families. [2] The 21st CASP aims to give students the opportunity to explore science by investigating the biological, social and ecological significance of water in afterschool settings.

The 21st CASP partners recognize the need to find creative ways to engage students in science learning to increase students' success rates in school and in the workforce. Afterschool programs are in a unique position to bring science to life for students whose school-day teachers are limited by time, large class sizes, inadequate facilities and equipment, state educational standards, resistance to new teaching strategies, and discomfort with the subject or content.[3] Effective science learning in afterschool and other OST programs can truly support and complement structured school-day learning, particularly for students who don't do well in traditional classroom settings.

In response to increased receptivity to science programming in afterschool settings, and recognizing the potential of OST programs to enrich student learning through inquiry-based, interactive science experiences, the 21st CASP partners developed, prototyped, implemented and evaluated a model for incorporating science into afterschool settings from October 2005 through September 2007. The 21st CASP goes beyond simply providing services; this collaborative effort has produced a replicable model that will engage adults and children in the joy of exploration and discovery, the satisfaction of thinking critically about the 'why' and the 'how', and the freedom to pursue the questions about the natural world that intrigue and delight us.

The 21st CASP focuses on collaborative efforts designed to integrate science into afterschool programs. The project connects New Jersey's afterschool community to the unique educational experiences provided by Liberty Science Center—exhibits, trained staff, and informal inquiry-based learning and teaching approaches; the extensive network, training and technical assistance provided by the NJ School-Age Care Coalition; and the educational resources and authority of the NJ Department of Education to affect educational policy.

2 *Dimensions Journal.* "Beautiful & Useful: Emphasizing Mathematics in Science Centers". George, M.

3 Abell, S. K.; Roth, M. "Constraints to Teaching Elementary Science: A Case Study of a Science Enthusiast Student Teacher". *Science Education,* volume 76 number 6 pp 581- 595, Nov 1992.

Project Model

The goal of the 21st Century Afterschool Science Project was to create and implement a replicable model to build the capacity of afterschool programs and bring exciting science to the children and youth of New Jersey. The 21st CASP seeks to enrich student learning and engagement through inquiry-based, informal science education experiences. The project combined direct-service and macro-level approaches to ensure that the unique challenges encountered by today's afterschool programs are addressed by producing a model for science enrichment. The project emphasizes and pursues the connections between the essential components of scientific inquiry and the skills of language and mathematical literacy through a multifaceted model. The focus is on children in grades 4–8 and afterschool staff —including professional educators, youth workers and paraprofessionals.

The 21st CASP was designed to:

- Develop rich science experiences and curricular materials appropriate for integration into the OST environment;
- Create hands-on science activities that would promote Language Arts, Math and Science literacy skills for students;
- Use a guided-inquiry approach to encourage student problem-solving and engagement;
- Demonstrate and model how to engage OST program staff and children in experiential science activities;
- Build the capacity of OST programs to make high quality, hands-on science a regular part of their offerings through training, modeling and coaching;
- Involve families in hands-on science learning using family science events as a venue to support their children's learning; and to
- Develop curricular materials and a facilitator guide to support and sustain the integration of science experiences into OST programs.

Specifically, the project model is composed of multiple components:

1) An informal, hands-on science curriculum that infuses language arts and math skills and is appropriate for the OST setting;
2) Use of a guided-inquiry approach to encourage student problem-solving and engagement and effective facilitation of science learning;
3) Training and capacity-building through modeling of effective science learning and delivery, and on-site technical assistance that capitalizes on the strengths of OST staff and environments; and,
4) Strategies for the involvement of families that are integral to students' academic success.

Development of the Project

The first step in the project was to develop a hands-on water science curriculum and a student journal specific for use in the OST setting. The New Jersey Core Curriculum Content Standards were used to guide the development of the curriculum activities and learning objectives. The inquiry-based methodology infused throughout the curriculum and student journals aims to help students hone their skills of observation, documentation, formulating and refining questions, articulating ideas and reasoning, identifying and debating evidence, moving from evidence to explanation, and communicating ideas and findings. Mathematical skills such as pattern recognition, data-recording and analysis, proportion, measuring and comparison were incorporated into the curricula. Literacy was integrated through guided and open discussion, listening skills during the science investigations, and writing in the student journals.

The topic selected for the curriculum is water: water as a compound with wondrous properties; water's centrality to life on earth; and the waterways, harbors and estuaries of New Jersey. The curriculum consists of two units of hands-on science investigations: Unit 1 focuses on the properties of water, and Unit 2 focuses on the ecological impacts of water. The activities were designed specifically for use in OST settings, and for students in grades 4 through 8. The experiences were designed to help children probe the fundamental concepts of science and nature; to get them to see the science all around them; and to put them in powerful roles as active learners. The activities were meant to be introduced sequentially as research suggests is best to achieve student learning outcomes[4]; however, they can be completed individually or out of order according to individual program needs. The curriculum was developed and prototyped at Liberty Science Center's Community Science Workshop prior to dissemination to the pilot sites. Additionally, the lessons were reviewed by scientists from the New Jersey Marine Sciences Consortium, the Institute of Marine & Coastal Sciences at Rutgers University, and Rutgers University Marine Field Station at Tuckerton.

A student journal was created to correspond to lessons in each curriculum unit and contains *Science at Home* activities which students could conduct at home with their families using common household items.

Trainings and a facilitator guide were developed to prepare OST staff to guide the activities in the curriculum using a guided-inquiry approach, which staff can generalize to other interdisciplinary activities in their afterschool programs. Inquiry-based questions infused throughout the curriculum and student journals promote critical-thinking and problem-solving which will support youth development as well as science learning. On-site technical assistance was provided by NJSACC and Liberty Science Center trainers to reinforce the concepts provided in the trainings, to demonstrate and model inquiry-based facilitation, and to provide additional support to the pilot sites as needed.

Implementation and Pilot Testing

The 21st CASP partners tested the model in three pilot sites to ensure that the curriculum could be replicated in afterschool programs, using available resources and attending to the practical realities facing afterschool programs. The original intent was to pilot the model in afterschool programs which demonstrated a strong interest in collaborating on the development and integration of science into OST settings, with a population of students in grades 4 through 8, and whose staff lacked formal teaching experience. The pilot sites would be expected to test the water science activities and student journals, attend curriculum and informal science education trainings, receive technical assistance, provide feedback and participate in the project evaluation.

The pilot project was open to New Jersey 21st Century Community Learning Center (21st CCLC) program grantees. 21st CCLC afterschool programs were encouraged to complete a Request for Application (RFA) at the beginning of the project in 2005. Pilot sites were chosen based on their ability to effectively implement the project, dedicate appropriate staff and time, participate in trainings and project evaluation, and their good standing with the NJDOE.

The 21st CCLC sites chosen to participate in the pilot project were: Janis E. Dismus Middle School in Englewood, Lakewood Latchkey at Oak Street School in Lakewood, and Atlanticare Uptown Family

4 Durlak & Weissberg, 2007

Complex Community School in Atlantic City. Over an eighteen-month period, Liberty Science Center developed and pilot-tested 22 hands-on science activities at each of the pilot sites. In Year One, the Unit 1 curriculum was pilot-tested, and in Year Two, a revised Unit 1 curriculum and a Unit 2 curriculum were piloted. Each pilot site had participating staff members who were certified teachers, all of whom taught science.

Liberty Science Center and NJ School-Age Care Coalition staff conducted four technical assistance visits at each pilot site in addition to ongoing telephone, email and web blog communication to assess pilot site needs, provide additional guidance on the model and informal science education teaching techniques, and to solicit input for revisions to the curriculum, student journal and facilitator guide. The technical assistance site visits focused on assessing the pilot sites' readiness for participation in the pilot project, providing additional facilitation and logistical support, including reviewing how each site would accommodate the pilot project into its schedule, allocate staff time for planning and evaluation, and involve students in the process of reflecting on the 21st CASP model components and contributing to the evaluation.

Each pilot site received approximately three (3) full-day training sessions on the curricular activities and on the use of guided-inquiry within the eighteen-month period. Science Educators from Liberty Science Center's Traveling Science Program visited each pilot site six times to model activities related to the core themes of the curriculum units, and to demonstrate how to engage OST program staff and children in experiential science learning.

Liberty Science Center also helped each pilot site coordinate and host a Family Science event featuring hands-on activities that mirrored the curriculum's water theme and science concepts. The Family Science activities were developed and facilitated by LSC staff and provided science activities which families could easily replicate at home using common household materials. Children and their caregivers were able to participate in various water-based activities, including creating the stages of the water cycle in a food storage bag, making rainbows to learn how water distorts light and images, and learning about density and buoyancy by floating hard-boiled eggs.

II. Project Evaluation and Outcomes Summary

The project evaluation documented and analyzed the individual components of the model (afterschool science curriculum, use of guided-inquiry, training and capacity-building, and family involvement strategies), implementation of the model, and student engagement with the science activities at the three pilot sites.

The 21st Century Afterschool Science Project was successful on many fronts including:

- Creating a replicable model designed for afterschool, OST and extended-day programs to implement science programming;
- Increasing OST staff capacity to facilitate science learning in the afterschool setting;
- Increased student engagement, skill and knowledge related to science;
- Developing and piloting curricular materials tailored for the OST setting, which imbed math and language arts components, and which are grounded in the New Jersey Core Curriculum Content Standards and inquiry-based learning; and

- Involving families in hands-on science, math and language arts activities in support of their children's learning.

Overall, the evaluation found the 21st CASP model—with modifications adopted based on participant feedback—to be appropriately structured, its implementation to be adaptive, student engagement as assessed primarily through observations to be strong, and the potential of the model to make science learning an integral part of academic enrichment in afterschool programs to be attainable.

NOTE: Appendix A contains the full project evaluation and outcomes report.

PART II: GUIDE TO INCORPORATING SCIENCE IN AFTERSCHOOL

I. Science is Everywhere: An Introduction for Afterschool Providers

Science is everywhere. As you look around, you may or may not recognize how ever-present science is in your life. You're probably sitting on a chair made of plastics, epoxies, metals and resins—a marriage of physics and chemistry largely unnoticed by the average person. Or, perhaps you used a body wash, cologne or lotion as part of your daily grooming routine? Science has a hand in each of these products—even the paper that this guide is printed on is a common example of the important and seemingly mundane role that science plays in our daily lives. Ordinary? Yes. And, extraordinary, too! Science is common, mainstream, ubiquitous, ever-present and pervasive.

We developed this guide to help afterschool and other out-of-school (OST) providers meet their goals of engaging youth in fun, educational and stimulating activities. The guide is for afterschool providers who recognize how important science learning is for youth in afterschool programs; but who may feel uncomfortable, incapable or ill-equipped to explore science in their afterschool programs. The information and materials were developed specifically for afterschool and other OST staff who have little or no background in science, or with no formal teaching experience. Users of this guide will find information about how to incorporate science in afterschool settings; engaging, interdisciplinary hands-on science activities designed for the afterschool environment; learning and teaching methods to guide you through the informal, hands-on approach uniquely fitting for afterschool and for students of multiple learning abilities; and, additional resources and information to help afterschool staff readily approach hands-on science learning with less apprehension and anxiety.

Science is about exploration. Your understanding, comfort-level and discovery skills will improve as you and your students explore the scientific concepts highlighted in the hands-on activities in this guide.

Through these activities, your students will discover the unique properties of water, the vital role that water plays in our lives, and how vulnerable Earth's aquatic ecosystems are to human impact. They will also gain an understanding and an appreciation for how critical water is for survival.

Accessibility lies at the heart of this guide. Our mission is to help afterschool providers make important connections for their students by making science more accessible. We hope the information in this guide will illuminate some of the mysteries of the world and encourage you to see the world with a different set of eyes. This guide is designed to help non-science educators and afterschool providers feel comfortable with the dynamic world of science. We encourage you to use these materials as a tool to integrate science learning into your afterschool program.

We value your suggestions and invite you to share your experience using this resource. Please be sure to complete the feedback form at the end of this guide and send it to us at Liberty Science Center, 222 Jersey City Boulevard, Jersey City, NJ 07305. Your feedback will help us improve this guide over time.

II. How to Use this Guide: Format & Overview

This guide consists of 21 hands-on, water science lessons with an emphasis on the development of inquiry skills that will enable students to continue the quest for knowledge. The lessons were developed and prototyped by Liberty Science Center staff at the Community Science Workshop, pilot-tested over a two-year period in three 21st CCLC afterschool programs, and reviewed by scientists from the New Jersey Marine Sciences Consortium, the Institute of Marine & Coastal Sciences at Rutgers University, and Rutgers University Marine Field Station at Tuckerton. The lessons can also be found on the CD-ROM enclosed with this guide, as well as online at http://www.lsc.org, at http://www.njsacc.org and through the New Jersey Department of Education, 21st Century Community Learning Centers website at http://www.state.nj.us/education/21cclc.

The lessons are divided into units—*Unit 1: Properties of Water* contains 11 lessons and *Unit 2: Aquatic Ecosystems* contains 10 lessons. A student journal with corresponding lessons accompanies each unit. Each lesson is aligned with the New Jersey Core Curriculum Content Standards. The standards and integrated skills are identified in each lesson and can be found in Appendix C of this guide. The lessons are appropriate for students from 4th through 8th grades.

We use the term "facilitator" for any member of your afterschool staff who will conduct these activities with students in your program. The facilitator(s) should review the section of this guide entitled, "Inquiry-Based Learning and Instruction" for guidance on how to create an informal learning environment that supports hands-on, experiential learning. This section also contains information on the types of questions to ask to encourage participation from students of all abilities and educational backgrounds. The lessons in this guide are experience-focused and project-based, not chaotic and unstructured. It is important to keep in mind that these lessons are designed for the informal environment of afterschool—both in structure and tone.

Lesson Format

The lessons are broken down into themed investigations that can be lead in one session, or over several days with students. Each investigation is divided into "parts" to help the facilitator easily navigate each lesson. Learning objectives identify the important science concepts as well as the specific and observable tasks that your students will accomplish by the end of each lesson.

The lesson titles contain the scientific concept, such as "Cohesion", that is highlighted in the activity. The materials lists break down the supplies by parts, listing everything the facilitator will need to lead each part of the lesson. The materials include common household or office supplies, as well as other supplies that may need to be purchased from an online, craft or science supply store. A list of online and storefront retailers is provided in Appendix E of this guide to help you locate and order supplies. Some materials will need to be gathered and prepared in advance—these items are clearly outlined in the materials list. Be sure to review the lessons and materials lists in advance.

Each lesson provides step-by-step instructions, as well as inquiry-based questions and prompts to help the facilitator guide students through the activity. Procedural steps, predictions, observations, and various tips and notes for the facilitator are also placed throughout the lessons. A "Brainstorm" heading and symbol indicate that the facilitator can use a chalkboard or flipchart to record students' responses to specific questions in this section. Vocabulary words are defined throughout the lessons, and a full glossary of these words can be found in Appendix B of this guide.

For clean-up, we recommend using plastic tablecloths and sponges to avoid unnecessary use and waste of paper and other consumable products.

Lesson Format for Unit 1 and Unit 2:

Page 1: Introduction to the science concept or theme of the lesson

Learning Objectives: What students will learn during the lesson

Time Needed to Conduct the Investigations: estimate of the time needed to do the activity, any advance preparation for materials or procedures, and time needed for student reflection using the student journals

Group size: Recommended number of students per group for each investigation

Vocabulary words

Page 2: Materials list

Investigation begins, including procedural steps, predictions, tips and observations

Page 3: Continuation of the Investigation

Page 4: Wrap-Up of the Investigation

Group Discussion: specific questions outlined for the facilitator

The "Why" and the "How": an explanation of the lesson results and further explanation of the science concept

Curriculum Match-Up: additional ways to enhance the lessons

References

Student Journals

The use of student journals for each lesson is critical to the full implementation of the 21st CASP model. Student journals are an excellent tool to encourage writing, documentation, diagramming and critical-thinking skills. The student journals can capture the in-depth thinking that may occur on a more subtle level for many students and can help you identify the learning successes that are often overlooked in more traditional settings. The student journal and writing tools are included in the materials list of each lesson.

Student Journal Format:

Table of Contents

The Scientific Method

Student Lab Safety Agreement

Lesson Objectives

Questions, procedural steps, observations from the Lesson

Space for recording ideas, responses to questions, diagrams, charts and explanations

Wrap-Up: includes the Group Discussion and time for reflection to allow students time to revisit the group's ideas and their own ideas about the lessons

Curriculum Match-Up: additional activities to enhance the lessons

Science At Home: activities for students to conduct at home with an adult helper

Various science-related quotes and jokes throughout the journal

III. Science Learning in Afterschool

The importance of integrating science into afterschool is clear. According to Nicole Yohalem of the Forum for Youth Investment and Andrew Shouse of the National Research Council:

> *"The potential for after-school programs to help (students) become scientifically engaged clearly exists. A growing number of studies and evaluations of science-focused after-school programs show promising results in terms of students' science knowledge, identity, interest, and career trajectories.... Lucy Friedman and Jane Quinn put it well when they stated in Ed Week, 'Afterschool programs offer an ideal setting for nurturing the potential scientist in every student... Compared to the school day, these programs' smaller groups, longer time slots, and less-formal settings provide opportunities for young people to visit museums, study neighborhood environments, cultivate gardens, perform laboratory experiments, and have their love of discovery awakened in countless other ways.'"* [5]

Typically, afterschool and OST programs are less constrained by the bureaucracy of traditional school environments. They provide more opportunities for expanded and enriching activities without the burden of test scores and measuring student achievement. Afterschool programs can often function more creatively than schools, providing more interactive learning and teaching strategies. In fact, the support needed to work with youth is sometimes more readily available in afterschool environments; for example, afterschool staff are able to develop more meaningful relationships with children and their families, often serving several children from the same family, and thus gaining a better understanding of how to serve the 'whole' child.

Science learning in afterschool environments:

- Gives girls and students of color more opportunities for science learning in a more supportive learning environment;
- Creates opportunities for children to see science as part of their everyday experience;
- Encourages family involvement in their child's learning;
- Provides continuity of science learning and opportunities for in-depth science learning experiences;
- Provides space, time and support for the formation of afterschool science clubs.

IV. Science, Math and Language Arts Literacy

Scientific Literacy

According to the National Science Education Standards, helping students achieve scientific literacy means equipping them with the science knowledge and skills necessary to: read, understand and

5 Linking After-School Programs and STEM Learning: Proceed with Caution, by Nicole Yohalem and Andrew Shouse, Ph.D.

discuss science; describe, predict and explain scientific phenomena; develop informed opinions and make informed decisions on science topics; find the answers to personal science questions; and evaluate the quality or validity of science information in politics and in the media (NSES, 22, 23). Science literacy involves providing students with the tools necessary to make sense of the abundance of often conflicting science information they encounter in everyday life.

Science as an Active Process

When attempting to understand how students learn science it is important to acknowledge that science learning is an active process. In formal education, most of us have probably had the experience of being taught science through facts and formulas strictly from a textbook in a lecture format. However, learning is much more effective when students are actively engaged and at the center of the learning. When facilitating science, it is not necessary to deliver presentations to students, or to cover every single topic in science. It is not even necessary to have all of the answers. Students' engagement with science needs to be both hands-on and minds-on. Science investigations should be constructed so that students interact with both their facilitator and their peers. They should also have time to reflect about what they have observed and what additional questions they may have developed from a particular investigation. To achieve science literacy, students should be asking questions, making observations, making predictions, exploring, experimenting, documenting and reflecting (NSES, 20).

Math Literacy

Math is instrumental in science, not optional. To be a good scientist, one needs to be able to understand and apply the appropriate mathematical concepts. Math should be presented to students as a valuable tool in science inquiry. Math can be used during scientific investigations to collect information and analyze data. Using math in science may involve skills such as computation, applying equations, weighing, measuring, converting and estimating. Using science to reinforce mathematical concepts can be an extremely valuable teaching tool because it allows students to apply math in practical, real-world applications. Using math within a scientific context can help students see the importance of mathematics and have a better sense of the purpose of various mathematical concepts.

Don't be anxious about using math in your afterschool science program. A major misconception is that there is only one way to solve a problem involving math—not true! As in science, there are a variety of ways to solve math problems and lots of tools to assist with the process. Use your fingers, a ruler, graph paper, objects found in nature—whatever helps your students learn and feel comfortable with the way they absorb and retain information.

Language Arts Literacy

Although language arts literacy and science are often viewed as completely separate disciplines, each is necessary for the study and practice of the other. An effective scientist is able to communicate and write fluently about science using appropriate vocabulary. They should also be able to communicate and defend the findings of their investigations to others. Scientists often write up the results of their studies to be published in scientific journals or books.

Just as scientists need to possess good communication skills, students should also be able to communicate effectively about science both verbally and in writing. Students should respond verbally to questions posed by the facilitator and their peers, share questions that they might have and engage in small group and whole-class discussions regarding scientific investigations. Students should also practice describing what happened during investigations and presenting their findings. To practice written communication, students can write down what they do and observe during investigations, as well as compose conclusion statements based on their findings.

V. What is Science?

There are many definitions for science, and almost all of those definitions identify two important themes: curiosity and exploration. As humans, we are innately curious about the history of the natural world and how the natural world works. We seek to understand and explain our natural environment through observation, investigation, and experimentation. Therefore, in a nutshell, science is the study of the natural world.

Science is a diverse field, and there are a number of different branches of study. You may be familiar with some of the more commonly known areas such as biology, chemistry, physics, environmental science and medicine; however, there are some less well-known branches, including zoology, oceanography, neurology, seismology, and genetics. While the various branches of science examine different phenomena in the natural world, they are all interconnected and their relationship should be noted to gain a better understanding of each.

The diverse branches of science developed over time for different reasons—primarily because different people studied different things of interest to them. Ultimately, the various branches of science became more distinct and organized as the need to examine things in different ways, and using different tools became more obvious.

A. Attitudes and Myths about Science

When you hear the word "science," or "scientist," what comes to mind? Is your head filled with thoughts of complicated formulas and equations? Do you imagine a person who resembles Albert Einstein? There are many myths about science that make it intimidating and inaccessible to students and the general public. One common myth is that science knowledge is a special, superior kind of knowledge that is difficult to obtain (Halwes, 2000). In reality, science is about trying to understand the world around us, and solve the problems that we encounter every day. Scientists rely on the same curiosity, thought processes, and communication skills that are used by all people.

Another myth is that science knowledge can only be obtained by professional scientists (Halwes, 2000). Again, this is also a falsehood, as science is done by real people every day. Even an activity as ordinary as cooking involves science! Another common belief is that science knowledge is exact and always accurate (Halwes, 2000). In fact, science is always evolving and scientists are learning new things every day. Science will never be finished. And, many times scientists get things wrong! For example, at one time it was believed that the Earth was at the center of our solar system. Only later was it discovered that the planets orbit around the sun. This also illustrates the point that scientists don't always agree with one another on a particular subject. Just turn on the television and you will see how much conflicting research there is about what constitutes a healthy diet.

B. Definition of a Scientist

What is a scientist? A scientist is a person who uses the scientific process to understand an area of science such as biology, physics or environmental science. Scientists are knowledge-seekers who observe, test theories, and try to provide explanations for what they've observed. Examples of scientists include geologists, paleontologists, microbiologists, botanists and physiologists. Scientists are both men and women, and individuals of many different ages, cultures, socioeconomic backgrounds, religions, ethnicities and abilities. However, there is growing concern within the scientific community about the shortage of women scientists and scientists of color. By engaging students in science in afterschool and other out-of-school time programs, it is our goal to expose them to the wide range of career possibilities in the science field, and open students up to the possibility of pursuing science as a career.

Professionals who pursue science as a career are known as scientists. However, it is important to keep in mind that one does not need to be a professional scientist to learn, love and practice science. What's more important are a curious mind and a willingness to explore.

C. Scientific Method

The scientific community has not formally agreed upon a format for the scientific process, and there is no magic formula to doing science, but there are generally accepted guidelines that help eliminate bias and prejudice in experiments and research.

Science is examined through a process known as the scientific method. The scientific method involves:

- Developing questions about something that is interesting, puzzling or problematic in the natural world;
- Gathering information about those questions;
- Forming hypotheses (proposed explanations) and making predictions based on the information gathered;
- Performing experiments to test the hypotheses;
- Making observations and analyzing findings of the experiments; and,
- Making and sharing conclusions of the analysis.

Good scientists use their senses (in a safe manner) to investigate ideas and concepts. Scientists also record their observations, questions, predictions, findings and diagrams in a field journal similar to the student journals provided in this guide so they may refer back to them at a later time. Keep in mind that scientists seek answers by investigating and exploring possible solutions to questions they have about the natural world. The beauty of science is that the answers aren't needed in order to get started!

Scientific Tools

There are many different types of tools which are valuable to the scientific method. Scientific tools can be used to collect, organize and store information and analyze data. Tools help scientists work faster, more safely, with more ease, and with greater accuracy than without them. Tools used in science can range from calculators to microscopes to computers. Scientific tools do not necessarily have to be high-tech or costly, but they should make sense within the context of the scientific investigation that you are conducting. It is important for you as a facilitator to model the use of appropriate tools during scientific investigations (NSTA, 2004). Students should be instructed on why various tools are used and how to use them properly and safely within the scientific investigation. It is also important that both you and your students not use scientific tools such as calculators blindly, but also understand the scientific and mathematical concepts behind the tools.

D. Equity in Science

Science Equity

All students have the right to quality science instruction. As a facilitator, it is very important for you to provide each and every student with the support they need to explore and gain scientific literacy.

It is also important to be aware of your own beliefs and work to ensure that your personal biases and attitudes do not affect how you manage science in your afterschool program. Facilitators should be able to use a variety of instructional strategies to meet the differing needs and learning styles of students. Facilitators should set high, yet realistic expectations for all students in the afterschool program. It is also necessary to encourage the participation of all students in science activities. Curriculum materials should be inclusive of different genders, cultures and abilities; and should also expose students to diverse role models working in science. Assessment techniques should also be fair and equitable towards all students. Science in afterschool presents opportunities to expose students to a world of exiting career and educational opportunities. It is important to encourage all students to consider pursuing one of the many diverse careers in the science field (NSTA, 2003).

Science for All Students

Although many students are unfamiliar, unmotivated or intimidated by science, all students can achieve scientific literacy, or know-how, if given the opportunity. In your afterschool program, it is necessary to create a learning environment in which all students can learn, regardless of their gender, ability, religion, culture, ethnic background, socioeconomic status or experience with science. It is important to keep in mind that different students may gain scientific knowledge in different ways. They may also learn at different rates and show their scientific literacy differently. Some students may possess a greater degree of scientific understanding in one area than another. All students should have the opportunity to participate in multiple science experiences over the years to achieve scientific literacy (NSES, 22). In addition to formal classroom education, afterschool settings are wonderful places for students to gain additional exposure to and practice with science.

Underrepresentation of Women and Minorities in Science

STEM (Science, Technology, Engineering and Mathematics) disciplines are critical in the 21st century. Innovation in these important areas influences the global economy, standards of living and our quality of life. Historically, women and minorities have been discouraged subtly and overtly from participating in STEM educational programs and careers. Afterschool and other OST environments are in a unique position to reduce the impact of these accessibility barriers, keeping girls and students of color in the STEM educational and workforce pipeline.

Research shows that children respond positively in learning environments that recognize and celebrate the diverse cultures and abilities of all students. One particularly critical factor to note is that educators must believe that all students can succeed. Teacher attitudes about race, gender and ability have a significant impact on overall student engagement. Research also suggests that students achieve when learning tools including books, posters, toys and other materials reflect the diversity of the students in the educational environment, and represent both men and women from a range of backgrounds in science careers.

The National Science Board found that American students are among the lowest performers internationally in STEM disciplines. As the need for educated professionals in these areas increases, many critics charge that schools do not adequately prepare students for STEM careers and that communities need to embrace strategies to change students' competitiveness and attitudes about science and math. [6]

6 National Science Board, *Science and Engineering Indicators 2006*

Having scientists with diverse experiences, thought processes, and opinions is vital to the scientific community. However, there is a significant underrepresentation of women and minorities in the sciences today. As of 2003, only 27% of employed scientists in all science and engineering occupations (at all degree levels) were women. Fourteen percent were Asian, 4.4 % were Black, 4.3 % were Hispanic, and .36% were Native American/Alaska Native (NSF, 2003). Getting more female students and students of color engaged in science and on the science educational and career track is an important goal; and the afterschool community can help. Afterschool science programs can expose children to the basic skills and concepts needed for the 21st century educational and workforce opportunities; provide greater exposure to STEM disciplines to K-12 students; and expose families to science learning in a familiar and supportive setting.

Later in this guide, you will find biographies of the pioneering women and minority scientists who have contributed to the diverse scientific field.

VI. Inquiry-Based Learning & Instruction: Exploration vs. Explanation

You may have heard about a teaching and learning method known as "science by inquiry." Your afterschool program may or may not practice inquiry-based science. According to the National Science Teachers Association, scientific inquiry is "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (NSTA, 2004). There are many different levels of inquiry ranging from open-ended student-led exploration to much more structured teacher-driven learning experiences.

Science by inquiry is a powerful tool to facilitate students' science learning. Science by inquiry involves asking questions and using evidence to answer those questions. In scientific inquiry, students review previous science research and then conduct investigations. During investigations, students make observations and predictions, examine different variables and use tools to collect and analyze information. Students then develop possible explanations for what they have investigated, and communicate and defend the results of their investigations to others. Inquiry intends to reflect the way in which scientists gather information and study our world (NSES, 23; NSTA, 2004).

Inquiry-based learning enhances content knowledge and thinking skills by leaving behind an impression on students. Students learn how to question, gain the mental discipline needed for critical and sequential thought, and learn the "how" and the "why" more readily than if they received a lecture or read a chapter on a particular subject.

A. Why Inquiry?

1) Inquiry helps build self-confidence, motivation to learn, and collective learning among students.
2) Inquiry creates opportunities for teachers to learn how their students' minds work. Facilitators can apply these insights to set up appropriate learning situations and facilitate students' pursuit of knowledge.

Some of the skills that facilitators learn when using inquiry include:

- Knowing when to provide a nudge;
- Knowing how to provide direction to each particular student;
- Knowing what not to tell students;
- Knowing how to read student behaviors as they work through challenges;
- Knowing how to design meaningful learning situations that take specific student behaviors into consideration;
- Knowing how to help students collaborate in solving problems together;
- Knowing when observations, hypotheses, or experiments are meaningful;
- Knowing how to tolerate ambiguity and the unknowns;
- Knowing how to use mistakes constructively;
- Knowing how to guide students so that giving them control of their explorations does not mean losing control of the classroom.

(Adapted from the Center for Inquiry-Based Learning at Duke University)

B. Questioning

Questioning is key when facilitating scientific inquiry. Through inquiry instruction, students learn that science is about developing questions and trying to discover the answers to those questions. Questioning is important because it helps access what students already know and enables them to build on this previous knowledge. Questions can get students to think critically, reflect on and apply what they have learned, and make connections between different concepts (Painter, J., 1996). Questioning also provides the facilitator with feedback about students' learning. Variety in the types of questions will lead to different kinds of scientific exploration. When facilitating inquiry-based science, consider the importance of not only asking questions and encouraging students to ask questions, but also how to answer questions and how to respond to questions posed by students (NSTA, 2004; Painter, J. 1996).

Asking Appropriate Questions

It is important for you, as the facilitator, to ask a variety of different types of questions at different levels, and to teach students to develop questions of their own. However, how does one ask appropriate questions?

Different Levels of Questions

There are a number of different types of questions that you can pose to students, and there are many different levels of learning that can be addressed by these questions. An educational psychologist named Benjamin Bloom developed taxonomy (an organization system) to classify how students learn in the educational process. Bloom's Taxonomy is helpful in identifying the types of questions to ask based on the level of learning you are looking to elicit. Lower-order questions tap into students' knowledge, comprehension and application of concepts that they have learned—their ability to recall information. Higher-order questions encourage students to synthesize and evaluate the content of their learning. These questions help to develop students' critical thinking and problem solving abilities, as well as their ability to develop personal opinions and judgments. When asking questions during investigations it is helpful to contemplate what you would like students to think about, learn and understand; and the type of skills you want them to develop. Keeping these learning objectives in mind can help guide your questioning techniques. The following chart illustrates some examples of how to apply Bloom's Taxonomy through questioning:

Types of Questions Based on Bloom's Taxonomy

Knowledge

- remembering
- memorizing
- recognizing
- recalling identification
- recalling information
- who, what, when, where, how...?
- describe

Comprehension

- interpreting
- translating from one medium to another
- describing in one's own words
- organization and selection of facts and ideas
- retelling

Application

- problem solving
- applying information to produce a result
- use of facts, rules and principles
- how is ... an example of...?
- how is... related to...?
- why is ... significant?

Analysis

- subdividing something to show how it is put together
- finding the underlying structure of a communication
- identifying motives
- separation of a whole into component parts
- what are the parts or features of...?
- classify ... according to ...
- outline/diagram ...
- how does ... compare/contrast with...?
- what evidence can you list for...?

Synthesis

- creating a unique, original product that may be in verbal form or may be a physical object
- combining ideas to form a new whole
- what would you predict/infer from...?
- what ideas can you add to...?
- how would you create/design a new...?
- what might happen if you combined...?
- what solutions would you suggest for...?

Evaluation

- making value decisions about issues
- resolving controversies or differences of opinion
- developing opinions, judgments or decisions
- do you agree that...?
- what do you think about...?
- what is the most important...?
- place the following in order of priority ...
- how would you decide about...?
- what criteria would you use to assess...?

(Bloom et al, 1956)

Open-Ended vs. Closed-Ended Questions

Two types of questions that can be used during scientific investigations are closed-ended questions and open-ended questions. Closed-ended questions possess a limited number of possible responses from which students can select. These would include questions such as:

- How many pennies did you use?
- Did the boat float?
- What color is the water?
- Do you agree or disagree?

Sometimes it is necessary to use closed-ended questions to move investigations along. However, once a student answers a closed-ended question there is not much left to discuss.

Open-ended questions are those that enable students to answer questions in detail in their own words. Open-ended questions are extremely important in scientific inquiry because they get students to think critically about science and respond in their own voices. They can also lead to many interesting discussions with students. Some examples of open-ended questions include:

- What do you think will happen?
- What is your opinion?
- Why did you choose that tool?
- How did you conduct the experiment?
- Tell me about…

It is important to try to use open-ended questioning often throughout the investigations. These types of questions get right to the heart of what science inquiry is all about.

Follow-up or Probing Questions

Follow-up questions, also known as probing questions, are another type of question that can be used with students during investigations. Follow-up questions can be used after a response to get students to elaborate, provide more details, clarify their response or to elicit a deeper explanation. Follow-up questions can help students look at a problem in another way. They can also help you as the facilitator transition into new questions or content areas. Some examples of follow-up questions are:

- Why do you think that?
- How did you come up with that conclusion?
- Tell me more about…
- What do you think would happen if we tried your idea?

Assessment Questions — Are the Students Getting It?

Questions can be an effective means of determining how well students understand the material. Asking students questions can help identify where students could use additional support and where they are ready to receive additional challenges. These types of questions can assess both the progress of individual students and of the group as a whole. Assessment questions can help you tailor the content and the pace of instruction to the needs of your students.

These types of questions should be implemented in a sensitive manner and as a tool to enhancing teaching and learning. Examples of assessment questions include:

- What did you observe?
- What did you do during the experiment?
- Why do you think that occurred?
- What conclusions can you draw from the evidence?

- What did you learn from this investigation?
- What else you want to know?

Students' Responses — Wait Time

When students answer questions posed by you during curriculum instruction, there are a few considerations to keep in mind. Imagine that you have just posed a question to students relating to the science investigation, but seem to be receiving nothing but silence and blank stares. Time for you to jump in and provide the correct answer, right? Well, maybe not. Sometimes students require a little bit of time to digest and process what is being asked. Although the bit of silence when students are thinking can be uncomfortable for you as the facilitator, it is important to allow them the time they need. According to NSTA (1999), students should be provided at least 3 – 5 seconds after each question. Another potential reason for the silence is that the students did not quite understand the question. It may be helpful to try rephrasing the question, or asking some additional questions to help guide students.

Students Responses' — Misconceptions vs. Preconceptions

When students respond to your questions, sometimes they will arrive at answers that are on target and other times their answers will be off the mark. However, just because a student does not give the answer that is technically "correct" does not mean that it is not an integral part of the learning process. As students explore the world around them, they develop theories to explain what they observe and experience. They find ways to organize and understand their environment by building schemes, structures and conceptions. Regardless of whether they are "right" or "wrong" students' conceptions are based on their own experiences and available evidence (Worth, 2000).

When a student possesses what is typically known as a "misconception," it is often viewed negatively because the student does not know the "right" answer. However, these "misconceptions" should not be viewed in a negative light because they are simply the student's way of figuring out the world. When a student presents a "misconception", simply telling the student that s/he is wrong can sometimes make it difficult for the student to move past the incorrect assumption. "Misconceptions," more positively referred to as "preconceptions," "naïve conceptions," or "alternative conceptions," are important building blocks to learning. It is important for you as a facilitator to observe and listen carefully to student's ideas regardless of whether they are "correct" or "incorrect" and work with students where they are having difficulty. If students possess "preconceptions" it is helpful to ask follow up questions, have discussions with students and provide opportunities for them to test out their ideas when possible (Worth, 2000).

Responding to Students' Questions

Answering questions posed by students is also an important part of the scientific inquiry process. Imagine it is your first day facilitating a new curriculum and one of your students, whose father happens to be an environmental scientist, asks you. "How much water is on the entire planet?" Unaware of the correct answer you start to sweat as 30 pairs of inquisitive eyes bore into you. What do you do? Do you brush off the student's question? Make up an answer even if you are unsure if it is the right one? Or, is there a better solution? Not knowing the answer to a question asked by a student is a fear held by many educators. In reality, scientists do not have all the answers, so why should you?

An important part of learning and of science inquiry is that students should be aware that scientists (and adults) don't always have all the answers. Many students feel that science is impossible for them to understand because scientists "know everything." Helping students realize that science is not only about answers, but also about questions, may make this discipline more accessible and less intimidating. Not knowing the answer to a question is also an opportunity to explore and find out the answer together with students. These experiences can help equip students with the tools to conduct research and gather information independently. These skills are not only beneficial in science exploration, but in other content areas and in one's daily life.

Encouraging Students to Develop their Own Questions

When facilitating science in your afterschool program, it is important to encourage students to explore and develop their own questions about science. These skills can also be modeled by you during scientific investigations. It should be stressed to students that there is no magic formula for every scientific investigation. Sometimes science requires "messing around" and exploring ideas and materials to get on the right track. During scientific inquiry it is important to create an environment where students are free to explore materials (safely, of course) because exploration is an extremely valuable part of the learning process. Exploration helps to create enjoyable, risk-free learning environments where students can make choices and find ownership in scientific investigation. In fact, many inventions, technologies and treatments for disease have been discovered by accident while scientists were exploring something else!

Evidence, Critical Thinking and Explanation

It is important that students are able to gather evidence pertaining to science questions, think critically about that evidence and explain their conclusions. Students should be aware that the scientific community seeks explanations that are "empirically based and logically consistent" (NSTA, 2004). The scientific community values these types of explanations because they are grounded in sound scientific methodology. During scientific investigations, you should encourage students to be "science detectives" and gather all of the evidence related to what they are studying. They then should evaluate the evidence and arrive at conclusions based on that evidence. The importance of skepticism when evaluating scientific works should be stressed to students. Students should also be able to explain their findings in their own words both verbally and in writing.

VII. Managing Time, Materials and Space in the Afterschool Setting

It is important to manage your time, space and materials effectively to provide the best possible science-learning experience in your afterschool program.

A. Preparation and Time Management

Afterschool programs must manage multiple logistical issues, from student arrival to snacks to activity schedules. Consider these issues carefully as you plan to incorporate hand-on science learning into your afterschool program. Organize staff schedules to ensure that facilitators have time to review the lessons, and to organize and set up the materials needed for the activities in advance. Advance preparation will save time and enables staff to better manage the time needed to facilitate and wrap-up lessons with students at an unhurried pace. Students should be encouraged to help facilitators with the set up of materials.

Prior to each lesson, review the lesson and materials list thoroughly. Identify which supplies you need, what advance preparation is required for the lesson, how much time is needed for each part of the lesson, and places throughout each investigation where you can pause if you run out of time. Advance review and preparation will help you determine how to best facilitate each lesson, especially if you find that you need to break down the lesson and conduct it over the course of a few days instead of one day.

Each lesson in the 21st CASP Curriculum includes a breakdown of the estimated time as follows:

Estimated Length of Time for Investigation
This investigation has four parts.
Organize and set up materials: 10 minutes
Introduce the lesson: 10 minutes
Conduct the investigation: 30 – 40 minutes
Student journaling/Group reflection: 10 minutes
Total estimated time: 60 – 70 minutes

It is also important to allow time at the end of the lessons for students to write in their journals and for clean-up. Students should participate fully in the clean-up process.

Effective preparation and organization will help you successfully integrate science into your regular program offerings.

B. Materials

Review the curriculum in advance to determine which supplies you will need. You may already have many of the materials needed for some of the lessons, such as modeling clay or paperclips. Manage your program supply budget to ensure that facilitators have access to suitable science materials and tools. Good science materials do not need to be expensive or sophisticated, but they should be appropriate for the investigations that students will be conducting

Gather, organize, prepare and set up materials in advance. The majority of materials in these lessons require common household and office supplies that can be re-used and recycled. Some of the lessons require live plants and animals or other materials that will need to be purchased from a specialty science retailer and prepped in advance. A careful review of the curriculum will help you plan when materials should be purchased, received and prepared for the lessons. You may find yourself creating your own scientific tools using basic materials as you go through the curriculum.

Carefully consider your storage resources and needs. Use large, clear plastic food storage bags and containers to organize and store materials. Make labels with masking tape and permanent markers. Rolling carts are also useful in storing and transporting supplies and equipment if you don't have access to the same room on a regular basis in your afterschool program. Remember to involve students in the organizing, cleaning and storing of science supplies.

C. Space

Space is also very important to the effective integration of science learning in your afterschool program. Facilitators and students need an appropriate space in which to conduct the investigations (preferably in a room with tables where students can work), as well as access to sinks for clean-up and for activities that require water. If your afterschool program has access to a science lab, this is the ideal place in which to facilitate the activities. If possible, it is helpful to have a room designated solely for science afterschool, where distractions and interruptions can be limited.

VIII. Getting Staff and Students Excited About Science

Getting staff and students excited about science is integral to achieving true engagement and science literacy. Students are naturally curious about the world around them. Facilitating science in OST settings provides unique opportunities to capitalize on students' enthusiasm and to tap into their interests. The less-structured and informal nature of the OST environment is ideal because it offers more flexibility than a traditional classroom setting. It is important to provide students with activities in a wide variety of science disciplines and to enable them to explore their own questions. Allowing students to investigate what interests them increases the likelihood that they will be excited about what they are learning.

Never underestimate the power of staff enthusiasm as a way to ignite students' excitement. Program administrators can support science learning by providing ample training opportunities for staff to gain experience and comfort-level with the new materials. In this way, you will garner their support and maintain their investment and interest in the program.

Tips for Generating Excitement about Science in Afterschool:

1) Be enthusiastic anytime you talk about science in afterschool!
2) Allow and encourage staff to attend 21st CASP trainings on use of the curricular materials and guide. Training will increase their comfort-level and excitement about afterschool science.
3) Offer incentives or rewards for staff who volunteer to facilitate afterschool science and for students who sign up for afterschool science.
4) Ask local scientists from research facilities, environmental organizations, government institutions, colleges and universities, science centers or cooperative extensions to visit your afterschool program to share their own ideas and information about their work. Meeting scientists will make science more relevant and exciting, and will help eliminate any apprehensions that you or any of your co-facilitators may have about integrating science into your afterschool program. Moreover, by sharing their personal journeys with you and the students, you will be giving the scientific community an opportunity to be more prominent in celebrating science with the public.
5) Talk about the afterschool science program at staff meetings, parent meetings and with the students—often!
6) Post signs and flyers and send notices home with students that describe the afterschool science program and what students will gain through their participation.
7) Send emails and post information about the activities with photos on your organization's website. Your excitement is contagious and you will convey not only how fun, but how important science in afterschool is to your colleagues, families and students.
8) Encourage all students to participate in afterschool science—not just high achievers or those with a clear interest in science.

IX. Safety Tips: Exploring Science in Afterschool

Afterschool science learning should be fun and safe. Safety should be a priority when incorporating science into the afterschool environment. We recommend that all students and parents/guardians of students sign a safety agreement before you begin science learning with students in your program. Safety agreements are commonly used by school-day science teachers to stress the importance of safety to students and caregivers.

The following guidelines will help foster a safe learning environment for students and facilitators:

- Review the activities in advance to ensure that you have the correct materials and that the materials are not broken or damaged.
- Always provide adequate adult supervision—a good rule of thumb is one adult for every five to ten students.
- Remind staff and students to wash their hands before and after conducting any science investigation.
- Provide a first-aid kit and know your program's guidelines for handling accidents or emergencies.
- Provide and review a student safety agreement with students and parents/caregivers.

A student safety agreement template is provided in the appendix of this guide. We recommend that students and their parents or guardians sign two copies of the safety agreement so they can refer to a hard copy at home. Please distribute and read the entire safety agreement aloud with students before they take them home. Afterschool providers should keep all signed agreements on file. Students should not be permitted to participate in science learning activities until a safety agreement is signed and returned to your afterschool program administrator, even if students and parents/guardians have already signed a similar agreement for a school-day science class.

X. Family Involvement in Afterschool Learning:

Research and anecdotal information on family involvement shows that parents who are involved in their children's education improve their parent-child relationships, have important impacts on their children's overall educational achievement, and significantly improve language skills, test scores and behavior, particularly in students from low-income families.[7] According to Tichenor (1998), parents need to know how educational institutions and families can work together to enhance their children's learning.

Actively engaging families in science learning in the afterschool setting can foster positive attitudes and enhance science literacy. Because parents and caregivers can unwittingly pass on their negative or ambivalent attitudes about science, it is important to provide positive science learning experiences that stimulate enthusiasm and curiosity in the whole family. Engaging students and their families in hands-on science exploration stresses the importance of science learning and makes science careers more relevant to children and their parents.

Family involvement should be defined according to each individual afterschool program's needs; however, any level and type of family involvement should be encouraged, clearly communicated to parents

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7 Henderson, A. *The Evidence Continues to Grow: Parent Involvement Improves Student Achievement--An Annotated Bibliography.* Columbia, MD: National Committee for Citizens in Education, 1987.

and families, and supported by the program's administration.[8] Afterschool programs can engage parents and families in meaningful ways, particularly through family science programs, projects and events.

Tips for Encouraging Family Involvement

- Initiate positive and straightforward contact with parents and families using phone, email and letters home regarding their children's participation in your afterschool program. Be sensitive to language barriers and other challenges such as reading-levels or hearing abilities.

- Encourage parents and families to communicate their goals and concerns regarding their children's learning;

- Schedule regular family involvement events, including family science programs, to encourage families to become more familiar with their children's afterschool program. Try to accommodate parent work schedules and meal times.

- Ask parents and families how they would like to become involved in the afterschool program to support their children's learning.

Family science events can be a wonderful opportunity for students and their families to experience science in a safe, fun and informal atmosphere. The event should engage families in cooperative learning, explore hands-on science activities, explain science concepts in simple terms as well as the importance of science learning, and provide ways for families to extend science learning at home.

To promote interest in your family science event, plan simple, fun activities or a project-based event (such as a river clean-up) that are not intimidating for your staff, or for the families to support. Start with a small themed program or project—don't overwhelm your staff or your families with a large event with multiple themes. Family science events can become more sophisticated as your afterschool program gains more experience and comfort planning and conducting the events.

Reach out to parents and caregivers who may work in the STEM (science, technology, engineering and math) field. Contact science and nature centers, local colleges and universities, officials from science and environmental government agencies, museums and zoos for help planning your event.

Identify a theme to help you set clear goals for your family science event or project: do you want to clean up a local wetland, learn more about the aquatic ecosystems in your area or expose families to various ways to explore science at home? If you decide to hold an event at your afterschool program, be sure to provide multiple stations where families can explore hands-on science, "make and take" activities, written materials explaining the activities, and suggestions for continuing science learning at home.

Spread the word! Make announcements about the family science event program at staff meetings, parent meetings, during transition times at your program. Post signs and flyers throughout your

8 Cotton, K., and Savard, *W. G. Parent Involvement in Instruction, K-12: Research Synthesis.* Portland, OR: Northwest Regional Educational Laboratory, 1982. (ED 235 397).

organization and send home invitations with students. Send emails and post information about the family science event on your organization's website. Invite VIPS to your event—members of your organization's board or officials from the local government. Encourage all students from all types of families to attend the family science night. Most importantly, have fun planning and conducting your event!

The following sample activities from 21st CASP Family Science events can also be found in Appendix D of this guide to help you design activities that may be appropriate for families at your afterschool program. A sample flyer template to promote your afterschool program's Family Science Event is provided in Appendix E of this guide.

21st CASP Family Science Night Activities: Unit 1: Properties of Water

Activity: *Watering Hole*
Materials: Pitcher, warm water, small plastic cups, confectioner sugar, measuring spoons, tally sheets, pens, markers or crayons
Concepts: Molecular structure of water, Surface tension
Description: Participants learn about the molecular structure of water and about the spaces between the molecules. Participants add confectioner sugar to the water and measure the change in volume. At first the volume does not change because the dissolved sugar fills in the spaces between the water molecules. Facilitator and participants discuss concepts.

Activity: *Breaking the Tension*
Materials: Pepper; dish soap; pie tins; water; pitcher
Concepts: Surface Tension
Description: Participants continue to learn about the molecular structure of water and about hydrogen bonds. Pepper is added to the water in the pie tin and participants are asked to "clean" the water by removing the pepper. Participants try to come up with creative ways of cleaning the water until a single drop of dish soap is added to the water, breaking the surface tension and forcing the pepper to the sides of the tin. The participants can now easily remove the pepper. Facilitator and participants discuss concepts.

Activity: *Water Cycle in a Bag*
Materials: Zippered plastic sandwich bags; water cycle diagram; warm water; scotch tape; pitcher
Concepts: Water Cycle
Description: Participants learn about the following parts of the water cycle: evaporation, condensation and precipitation. Participants color and label the diagram of the water cycle with assistance from the facilitator. The diagram is attached to the outside of a small zippered sandwich bag. The bag is filled with an ounce or so of warm water and sealed. The bag is then taped on a window such that the diagram is right-side-up facing the participant. The participants watch as the water cycle actually happens inside of the bag. Facilitator and participants discuss.

Activity: *Color Changing Celery*
Materials: Celery; water; food coloring; drinking glasses
Concepts: Adhesion and cohesion
Description: Participants continue to learn about adhesion and cohesion as it relates to the molecular structure of water. Participants insert a cut stalk of celery in colored water and witness the colored water rise into stalk of celery, changing its color. Facilitator and participants discuss.

Activity: *Long Distance Pour*
Materials: Pitchers and/or measuring cups; water; 9 oz–16 oz drinking cups; food coloring; various types of string and twine
Concepts: Adhesion and cohesion
Description: Participants continue to learn about adhesion and cohesion while attempting to seemingly defy gravity. Participants pour water into a cup two feet away from a pitcher on a 45-degree angle. The do this by pouring the water along a pre-soaked string attached to the spout of the pitcher and the other end held taught on the inside rim of the cup. The water runs down the string into the cup due to the adhesive and cohesive properties of water. Facilitator and participants discuss.

Activity: *Making Rainbows*
Materials: Spray bottles; water; white butcher paper; bright flashlights
Concepts: Refraction in Water
Description: Participants learn how light is bent when it passes through water. Participants hold a strong flashlight against white butcher paper while water is misted over the beam of light. Participants witness a rainbow forming. Facilitator and participants discuss.

Activity: *Whatever Floats Your Boat*
Materials: Aluminum foil; modeling clay; large bowl or container; water; pitcher
Concepts: Buoyancy
Description: Participants learn about buoyancy by trying to make aluminum foil sink and clay float. Participants learn about density and that in order for an object/substance to float it must be less dense than water. Similarly, in order for an object/substance to sink, it must be denser than water. Participants mold each of the substances until the desired effect occurs. Facilitator and participants discuss.

Activity: *Egg Float*
Materials: Hardboiled eggs; salt; warm water; pitcher; drinking glasses
Concepts: Density and Buoyancy
Description: Participants continue to learn about buoyancy by trying to make a hardboiled egg float in warm water. Participants continue to learn about density and how it relates to mass and volume. Participants add salt to warm water in an attempt to alter the density of the water. Eventually, the water becomes denser than the egg, causing it to float. Facilitator and participants discuss.

21st CASP Family Science Night Activities
Unit 2: Aquatic Ecosystems

Activity: *The Slime that Won't Go Away*
Materials: Large aluminum pie/lasagna trays, vegetable oil, eye droppers, spoons, nylon stockings, sand, cotton balls, dish detergent.
Concepts: Participants learn about the ecological impacts of oil spills and some of the techniques used to clean the spills including: vacuuming, skimming, burying, absorbing and dispersing. Participants also learn that there is no ideal way of cleaning spills and that each has consequences.
Description: Participants learn how devastating oil spills can be to the environment and how difficult they are to clean.

Activity: *Where Did All this Pollution Come from Anyway?*
Materials: Aquarium, plastic rectangular box with a large hole in the bottom, water, spray bottles, green food coloring, vegetable oil, soil, sand, aquarium pebbles, and shredded paper.
Concepts: Participants will demonstrate that "pollution" usually has many different sources. Using a model of a "storm drain" (i.e., the aquarium with the plastic box on top), participants add pollutants to the "street." The spray bottle allows rain to fall on the street, carrying the pollutants into the storm drain. Participants can observe how they were collectively responsible for the pollution of the water.
Description: Participants learn about the concept of non-point source pollution.

Activity: *Potable Water*
Materials: 1000 mL jar/container or 1-liter water bottle, 25 mL graduated cylinder, 10 mL graduated cylinder, eye dropper, and a pitcher.
Concepts: Participants learn about the concept of potable water by demonstrating how much water we can actually use. If the earth had only had 1000mL (1 liter) of water, 970mL would be saltwater, 24mL would be trapped in glaciers and in the polar icecaps, 6mL would be fresh water that is unavailable because it is trapped underground and only a single drop of water (about 0.003mL) is available for people to use.
Description: Participants learn about Earth's finite water supply and what percentage human beings can actually use.

Activity: *Water Filters*
Materials: Soil, 2-liter clear soda bottle, alum (potassium aluminum sulfate), fine sand, coarse sand, aquarium rocks, coffee filter, rubber band, measuring spoons, stirring rod/spoon, beaker or jar, pitchers, and a stopwatch.
Concepts: Participants will purify muddy water by passing it through a homemade water filter, by adding the aquarium rocks, course sand, fine sand and alum to an inverted soda bottle with the bottom cut off. The spout of the bottle will have a coffee filter, secured with a rubber band. The muddy water will go the purification processes of aeration, coagulation, sedimentation and filtration. Facilitators will need to discuss that the final step (i.e., disinfection) is not illustrated in this model.
Description: Participants learn how water is purified for human consumption.

Activity: *Aquifer in a Cup*

Materials: Plastic cups, modeling clay, play sand, aquarium gravel, food coloring (red), bucket, and a pitcher.

Concepts: Participants create an aquifer using rocks, play sand, and clay. Water is added, which illustrates how water becomes trapped in spaces between rocks. The water is then "contaminated" using red food coloring, which shows how improperly disposed chemicals seep into aquifers, making the water unusable for people.

Description: Participants learn how to design their own personal aquifer and learn about the concept of ground water and how pollution can ruin the water supply.

XI. Literacy Links

The following is a list of online educational, print and video resources for a variety of ages, skills, interests and abilities to help expand literacy, science, and math and language arts connections for your students. This list is designed to encourage you to incorporate the use of literature in your afterschool science program.

Websites and Online Resources:

EcoKids Clubhouse
Teaches kids all about the planet and its animals. Includes games, news and facts about animals, special guests, gallery of children's art, and a discussion area.
http://www.ecokidsonline.com/pub/

Pulse of the Planet
Check out today's two-minute sound portrait. Earth's nature, culture, and science are presented in interviews with extraordinary natural sound. From nationalgeographic.com.
http://pulseplanet.nationalgeographic.com/

Animal Diversity Web
Provides comprehensive data on all kinds of animals, from mammals to echinoderms. Features a quick search tool for finding specific animals.
http://animaldiversity.ummz.umich.edu/

Animal Doc Com
Ever think about being a veterinarian? Find out what vet students are learning about dogs, horses, sheep, cattle, llamas, and more from The University of Georgia. You can even ask a vet a question!
http://www.uga.edu/~lam/kids/

Animal Explorers
Presents a series of multimedia learning experiences on animal and science-related subjects for kids like you!
http://www.animalexplorers.org/

BBC: KS2 Revisewise Science
Check out your knowledge of living things, materials, and physical processes and then see how much you know by testing yourself with a fun game.
http://www.bbc.co.uk/schools/revisewise/science/

BrainPOP
This site has activities and movies that make learning about health, science, and technology loads of fun! Check out BrainBuzz and today's featured movie, too.
http://www.brainpop.com/

ClassBrain.com
This site provides students, teachers, and families with quick, manageable access to information and educational tools on the Internet. Host of "Movies in the Classroom" (http://www.moviesintheclassroom.com), a new area within the Parent & Teacher section that shows how to learn from the movies that provide scientific lessons. ClassBrain builds lesson plans based on these films.
http://www.classbrain.com

Discovery Education
Provides engaging digital resources to schools and homes with the goal of making educators more effective, increasing student achievement, and connecting classrooms and families to a world of learning. Discovery Education is a division of Discovery Communications, LLC the leading global nonfiction media company.
http://school.discoveryeducation.com

GoCyberCamp
Register for this free online camp for kids ages 8-12 so you can play games and learn about ecosystems, art, and science. From 4-H.
http://www.gocybercamp.org

Kinetic City Cyber Club
Science adventure, fun games, and more. Follow the crew on their adventures, or do some of their fun lab experiments.
http://www.kineticcity.com/

Science Essentials
Learn more about life science, physical science, and materials. Each section includes activities, interactive quizzes, and vocabulary on a variety of science topics.
http://www.channel4.com/apps26/learning/microsites/E/es...

Wonderville
Visit this cyber-town where kids can try scientific experiments, find cool science facts, download screen savers, and find out about careers in science while having fun! From the Science Alberta Foundation.
http://www.wonderville.ca/

Books

- *The Scientist in the Cribby* A. Gopnik A *et al*
- *Cloudy With a Chance of Meatballs* by Judi Barrett
- *Science Night Family Fun from A to Z* .Terrific Science Press, Steve Spangler
- *Blood, Bones, and Body Bits* by Nick Arnold
- *Come On, Rain! By* Karen Hesse
- *Teaching Science for All Children: Inquiry Lessons for Constructing Understanding (3rd Edition)* by Ralph Martin, Colleen Sexton, and Teresa Franklin
- *The Dinosaurs of Waterhouse Hawkins by* Barbara Kerley
- *Last Chance to See* by Douglas Adams and Mark Carwardine
- *It's True! Crime Doesn't Pay (It's True!)* by Beverley MacDonald and Andrew Weldon
- *Alfred Hitchcock's Ghostly Gallery by M*iscellaneous authors
- *A Medicine for Melancholy and Other Stories by* Ray Bradbury
- *Earth: Our Planet in Space* by Seymour Simon
- *The Down-to-Earth Guide to Global Warming* by Laurie David and Cambria Gordon
- *The Moon Seems to Change (Let's-Read-and-Find-Out Science 2)* by Franklyn M. Branley and Barbara & Ed Emberley
- *Dandelion: Celebrating the Magical Blossom* by Amy Wilensky
- *Eva* by Peter Dickinson
- *'Storm in the Night ("Tormenta en la noche")* by Mary Stolz
- *Heat Wave* by Helen Ketteman
- *Make It Work Plants A Creative Hands On Approach To Science (Make-It-Work!)* by Baker & haslam
- *Cam Jansen and the Mystery of the Dinosaur Bones ("Cam Jansen y el misterio de los huesos de dinosaurio")* David A. Adler
- *A Drop of Water : A Book of Science and Wonder* by Walter Adam Hibbert, Philip Steele
- *100 Things You Should Know About World Wonders* by Adam Wick
- *June 29, 1999* by David Wiesner
- *Egg-Drop Blues* by Jacqueline Turner Banks
- *The Blizzard's Robe* by Robert Sabuda
- *Things Around Us (The Process/Concept Science)* by Herbert Freestrom, Bernard Osterberger, and F. Alvin Blackman
- *The Librarian Who Measured the Earth* by Kathryn Lasky
- *Math and Science for Young Children* by Rosalind Charlesworth
- *Zathura* by Chris Van Allsburg
- *The City of Ember* by Jeanne DuPrau
- *Danny Dunn and the Swamp Monster* by Jay Williams and Raymond Abrashkin
- *Sounds All About (Stepping Into Science)* by Illa Podendorf and Darrell Wiskur
- *Motel of the Mysteries* by David Macaulay
- *Brave New World* by Aldous Huxley
- *Science Fiction, Science Fact* by Isaac Asimov
- *Popular Science Almanac for Kids* by Brainpop.com/Time Home Entertainment
- *The Microscope and What You See (The How and Why Wonder Book)* by Martin Keen and Walter Ferfuson
- *The Right Stuff* by Tom Wolfe
- *The Everything Kids' Science Experiments Book: Boil Ice, Float Water, Measure Gravity-Challenge the World Around You! (Everything Kids Series)* by Tom Robinson

- *I Wonder Why? Science Stories for Young Children [Science Stories Book One] (Curriculum Foundation Series)* by Wilbur, Gertrude Crampton and William S. Gray Beauchamp and Donn P. Crane, Studley Burroughs, Leon L. Pray and Frances Summers Miriam Story

Magazines

A report by Lesley Mandel Morrow, Ph.D., Professor and Chair of the Department of Learning and Teaching at Rutgers University's Grade School of Education, cites research demonstrating that magazines help educators improve student learning and build reading skills for students of varying learning levels.

- *Odyssey Magazine—Adventures in Science*, published by Cobblestone Publishing Company. Resources and subscription information available online at http://www.odysseymagazine.com or at 1-800-821-0115 / (603) 924-7209.
- *National Geographic Explorer* and *National Geographic Kids Magazine* published by the National Geographic Society. Resources and subscription information available online at http://www.nationalgeographic.com/magazines or at 1-800-638-4077 / (202) 857-7000.
- *Ranger Rick* magazine published by the National Wildlife Federation. Resources and subscription information available online at http://www.nwf.org/kids or at 1-800-588-1650.
- *YES Mag. Canada's Science Magazine for Kids*, published by Peter Piper Publishing Inc. Resources and subscription information available online at http://www.yesmag.ca/ or at 1-888-477-5543
- *DIG* magazine published with the Archaeological Institute of America by *Carus Publishing Company.* Resources and subscription information available online at http://www.digonsite.com/ or at 1-800-821-0115 / 603-924-7209.
- *Contact Kids (3-2-1 Contact),* published by the Children's Television Workshop. Resources and subscription information available online at http://www.sesameworkshop.org/aboutus/content_books.php or at (212) 595-3456.
- *Current Science* published by Weekly Reader Corporation. Resources and subscription information available online at http://www.weeklyreader.com/pubstore or at 1-800-446-3355
- *Dragonfly* published by the National Science Teachers Association http://www.nsta.org/ 1-800-722-NSTA
- *Super Science Blue, Super Science Red* and *Science World* published by Scholastic Inc. http://teacher.scholastic.com/products/classmags.htm
  1-800-325-6149

Movies

- October Sky (1999)
- *Gattacca (1997)*
- Chicken Run (2000)
- Finding Nemo (2003)
- Spirit - Stallion of the Cimarron (2002)
- The Wild Thornberrys (2002)
- The Core (2003)
- Harry Potter series

XII. Biographies: Diversity in Science

African American Scientists:

Rebecca Cole: Born in Philadelphia, Pennsylvania in 1846, Cole was the second Black woman to graduate from medical school (1867). She joined Dr. Elizabeth Blackwell, the first white woman physician, in New York and taught hygiene and childcare to families in poor neighborhoods.

Charles Henry Turner: (1867-1923) A native of Cincinnati, Ohio, Turner received a B.S. (1891) and M.S. (1892) from the University of Cincinnati and a Ph.D. (1907) from the University of Chicago. A noted authority on the behavior of insects, he was the first researcher to prove that insects can hear.

Roger Arliner Young (1889-1964) overcame racial and gender barriers to become the first African American woman to be awarded a Ph.D. in zoology, which she earned from the University of Pennsylvania in 1940. Her scientific contributions, resulting largely from research she performed at the Marine Biological Laboratory in Woods Hole, Massachusetts, include improved understanding of the structures that control salt concentration in the paramecium, as well as the effects of radiation on sea urchin eggs.

Lewis Howard Latimer: Born in Chelsea, Massachusetts in 1848, Latimer learned mechanical drawing while working for a Boston patent attorney. He later invented an electric lamp and a carbon filament for light bulbs (patented 1881, 1882). Latimer was the only African American member of Thomas Edison's engineering laboratory.

Frederick McKinley Jones: Jones was born in Cincinnati, Ohio in 1892. An experienced mechanic, he invented a self-starting gas engine and a series of devices for movie projectors. More importantly, he invented the first automatic refrigeration system for long-haul trucks (1935). Jones was awarded more than 40 patents in the field of refrigeration.

Dr. Daniel Hale Williams: Dr. Williams was born in Pennsylvania in 1856 and attended medical school in Chicago, where he received his M.D. in 1883. He founded the Provident Hospital in Chicago in 1891, and he performed the first successful open heart surgery in 1893.

Dr. Charles Richard Drew: Born in Washington, D.C. in 1904, Drew earned advanced degrees in medicine and surgery from McGill University in Montreal, Quebec, in 1933 and from Columbia University in 1940. He is particularly noted for his research in blood plasma and for setting up the first blood bank. Dr. Drew's project was the model for the Red Cross' system of blood banks, of which he became the first director. In 1950, Dr. Drew died after a serious car accident in which he needed blood, but was refused treatment at a hospital because he was Black.

Shirley A. Jackson: born on August 5, 1946, in Washington, D.C. Her father spurred her interest in science by helping her with projects for her science classes. Jackson began classes at MIT, one of fewer than twenty African American students and the only one studying theoretical physics. While a student, she did volunteer work at Boston City Hospital and tutored students at the Roxbury YMCA. She earned her bachelors degree in 1968. In 1985, Governor Thomas Kean appointed her to the New Jersey Commission on Science and Technology. Later, Governor James Florio awarded her the Thomas Alva Edison Science Award for her contributions to physics and for the promotion of science. Jackson is an active voice in the scientific field where her aim has been to actively promote women in science. From 1976 to 1991 Dr. Jackson was appointed as Professor of Physics at Rutgers University. In 1995, she was appointed head of the Nuclear Regulatory Commission by President Bill Clinton.

Willie Hobbs Moore: (1934 – 1994) The first African American woman to earn a Ph.D. in Physics (University of Michigan, Ann Arbor 1972) on vibrational analysis of secondary chlorides. While at Michigan, Moore worked for Datamax Corporation. She has also held engineering positions at Bendix Aerospace Systems, Barnes Engineering, and Sensor Dynamics where she was responsible for the theoretical analysis.

Marie Maynard Daly: was the first African American woman to earn a Ph.D. in chemistry, receiving her degree from Columbia University in 1948. Daly served as an instructor in Physical Science at Howard University between 1947 and 1948. From 1951 to 1955, she was a research assistant at the Rockefeller Institute. During her career, Daly served as an investigator for the American Heart Association (1958–1963) and cancer scientist for the Health Research Council of New York (1962–1972). Much of Daly's research focused on nucleic acids.

Mae Jemison: In 1977, Mae Jemison earned a B.S. degree in chemical engineering from Stanford University, having received a scholarship there at the age of 16. She then attended medical school and received a Doctor of Medicine degree from Cornell University in 1981. Following medical school, Jemison served as a Peace Corps medical officer in West Africa. In 1985, she began attending graduate classes in engineering and applied to the National Aeronautics and Space Administration (NASA) for admission to the astronaut program. In 1993, Jemison resigned from NASA and founded the Jemison Group, which focuses on integrating "science and technology into daily life."

Dorothy V. McClendon: For 24 years, Dorothy V. McClendon has been a professional microbiologist. She received a B.S. degree in biology in 1948 from Tennessee A&I State University. McClendon's studies on microorganisms led her to research in the U.S. Army. At present, she coordinates microbial research for the U.S. Army Tank Automotive Command (TACOM) in Warren, MI. As a microbiologist, she develops methods to prevent microorganisms from contaminating fuel and deteriorating military storage material. Currently, McClendon is developing a fungicide to protect storage materials and not harm the people who use them.

Percy Julian: (1899 – 1975) Percy Lavon Julian was born in Montgomery, Alabama. He graduated from DePauw University in 1920 first in his class with Phi Beta Kappa honors. He became a chemistry instructor at Fisk University, but in 1923, received an Austin Fellowship in Chemistry and went to Harvard to complete his master's degree. He traveled to Austria to obtain his PhD in chemistry from the University of Vienna in 1931. He returned to DePauw to continue his research. His original interest was investigating plant products, especially traditional medicinal plants such as the African calabar bean. In 1935, with Josef Pikl, he first synthesized from this plant a chemical called physostigmine which could treat the blinding disease of glaucoma by reducing pressure inside the eyeball. He left academia to become lab director at Glidden Company. During World War II, Julian developed foam from soy protein that could put out oil and gas fires; it was quickly adopted by the military. In 1948, the Mayo Clinic announced the discovery of a compound that relieved rheumatoid arthritis. It was cortisone, which was very difficult to come by. Julian and his team created a synthetic cortisone substitute, a less expensive but effective alternative to natural cortisone. Julian held more than 100 chemical patents. He founded The Julian Laboratories, Inc., with labs in the U.S. and Mexico and another chemical plant in Guatemala.

Latino American Scientists:

Dr. Luz Miranda-Martinez: received a Bachelor's and Master's in physics from the University of Puerto Rico and then decided to pursue a Ph.D. at M.I.T. because she liked the thought of being her own boss. Having a Ph.D. provides a scientist with a certain amount of independence and freedom, including the ability to decide the direction of your research. Now, as an associate professor in the Department of Materials, Science and Engineering at the University of Maryland, College Park, she teaches undergraduate classes while continuing her research in liquid crystals and supervising students who are undergoing research training. The use of liquid crystals is expanding in many directions including their use in Global Positioning System (GPS) maps. These GPS systems come equipped in many newer, high-end cars. Furthermore, the Air Force is developing liquid crystal visors for their pilots in order to make flying more efficient.

Dr. Inés Cifuentes: a seismologist who works for the Carnegie Institution of Washington, majored in physics with an emphasis in astronomy at Swarthmore College in Pennsylvania, where she was the only woman in the department. However, in her senior year, she realized that it would be difficult to pursue astronomy in Latin America. She wanted to balance my love of science with my passion for political work. She started her graduate work at Stanford University in geophysics. After receiving her master's degree, she was employed by the U.S. Geological Survey doing field research in Guatemala and Nicaragua where she was setting up portable seismographs in rural areas. As it turned out, there was an earthquake while she was there, and because she could speak Spanish, she was able to explain to villagers what we were doing. Suddenly, it felt like she could do science research in Latin America and help people at the same time. She realized that in order to do really interesting and beneficial scientific work, she needed to get a Ph.D., because that advanced degree would give her the independence and means to create her own projects. She enrolled in the Ph.D. program in seismology at Columbia University in New York City where she became very interested in studying the Chilean Earthquake of 1960. At 9.5 on the Richter scale, it is the largest ever-recorded earthquake. It lasted for almost five minutes and created tidal waves as far away as Hawaii!

Dr. Scottie Henderson: was born in 1968 to a Navajo father and a Mexican mother. She grew up in Española, New Mexico, a town filled with Pueblo Indians, Latinos, and Anglos. Even though Española is a diverse town, Native Americans were always treated a little differently. Native Americans weren't expected to achieve, and as a result, many Indians in the area didn't finish school. Without realizing it, Scottie began to see herself the way others saw her. When her mother saw that she was leaning towards staying home after high school, she encouraged Scottie to attend Northern New Mexico Community College. Eventually she moved on to UCSC where she received her B.S. in Marine Biology, and then to the University of Washington where she earned her Ph.D. in Zoology. She is currently at the University of Arizona in the entomology department where she is studying another invertebrate called the pink bollworm, a pest of cotton crops.

Franklin R. Chang-Díaz: Astronaut & Scientist, Costa Rican American, born 1950 in San Jose, Costa Rica. Raised in a poor family in Costa Rica, he studied hard to become a scientist and a U.S. citizen. Chang-Díaz was the first Hispanic person to enter the space program, becoming an astronaut in 1981. He is a veteran of six space missions and has spent nearly 1,300 hours in space. Chang-Díaz moved to the United States when he was in high school, and got a doctorate in applied plasma physics from MIT in 1977. He eventually achieved his dream of becoming an astronaut, entering space for the first time aboard Columbia in January 1986. He was the first Costa Rican astronaut, and, as of 2004, he was one of only two astronauts to have served on seven space missions. Chang-Díaz is also the director of the Advanced Space Propulsion Laboratory at NASA's Johnson Space Center, where he has been developing a plasma rocket.

Ellen Ochoa: Astronaut, Mexican American, Born in1958, Ochoa was the first Hispanic woman to become an astronaut. A veteran of two space flights, she first flew in space on the shuttle *Discovery* in 1993. Sally Ride, the first woman astronaut in the U.S., was one of her role models. Ochoa is not only an astronaut but also an inventor, holding three patents. When she is in space, she says that she loves "looking out the window at the Earth."

Severo Ochoa: (1905–1993) Nobel Prize Winner in Medicine and Physiology. Severo Ochoa won the Nobel Prize in 1959 for medicine. He received the prize for his discovery of the process that would allow humans to create RNA in a test tube—a vital life substance that makes cells work and grow. This knowledge can be useful in understanding many things about the body, like why some cells stay healthy while tumors grow in others.

Antonia C. Novello: a Doctor and former United States Surgeon General. She was born in Puerto Rico in 1944. In 1990, Novello became the first Hispanic person—and first woman—to be appointed as Surgeon General, the chief doctor in the United States. As a child, she had a chronic illness that hurt her digestion, causing her great suffering. She never forgot that experience. As surgeon general, Novello campaigned for better care for children. She also paid special attention to the problems of alcoholism, smoking, AIDS, and violence.

Carlos Juan Finlay: (1833–1915) Physician/Epidemiologist, Cuban American. Finlay solved the mystery of what caused yellow fever. This deadly disease had no known cure just over 100 years ago and killed thousands of people. In 1881, he discovered that mosquitoes spread yellow fever, but he could not prove it. Other scientists did not believe him. They made fun of him, calling him the mosquito man. Eventually, because of the work of Finlay and Walter Reed, another important physician, scientists were able to develop a vaccine using diseased mosquitoes and conquer this disease.

Luis Alvarez: (1911–1988) Luis Alvarez was a physicist with wide ranging interests. At the University of Chicago, he took a class called Advanced Experimental Physics: Light, and later claimed, "It was love at first sight." He graduated in 1932 and stayed at Chicago for his graduate work. Alvarez's colleagues sometimes called him the "prize wild idea man" because of the huge range of his activities. He did all kinds of research into the atomic nucleus, light, electrons, radar, and so forth. In 1943 he was part of the Manhattan Project in Los Alamos and developed a detonating device for the atomic bomb. He was on board the bomber *Enola Gay* when it dropped the bomb on Hiroshima. Alvarez was shocked and sickened by what he saw, but because the war ended so soon afterwards, he never expressed doubts about the bomb's use. In fact, he was one of few scientists who had worked on the bomb who felt the U.S. should continue weapons development and make a hydrogen bomb. He continued to do varied work in high-energy physics, and in 1968, received the Nobel Prize. In 1965 Alvarez took his physics expertise on an archeological expedition. A U.S.-Egyptian team was trying to find hidden chambers in the Giza pyramid in Egypt by using subatomic particles to calculate the pyramid's density. They didn't find any chambers, but this began Alvarez's work with his son Walter, a geology professor at

Berkeley. Together they developed a theory in 1980 that a giant asteroid striking Earth had killed off the dinosaurs around 65 million years ago. They had strong geologic evidence, but the theory is still being debated. *Radio distance and direction indicator*—Alvarez was awarded the Nobel Prize for Physics in 1968. He helped design a ground-controlled radar system for aircraft landings and with his son developed the meteorite theory of dinosaur extinction.

Miriam Rodón-Naveira, Ph.D.: Dr. Rodón-Naveira was born in San Juan, Puerto Rico. She attended high school in Puerto Rico and continued her education at Georgetown University in Washington D.C. where she received her undergraduate degree in Psychology and her Ph.D. in Biology-Aquatic Microbial Ecology. Dr. Rodón-Naveira began her career with NASA in December 2000 as an Earth Science Remote Sensing Scientist. There she was responsible for coordinating and conducting research to enhance collaboration between Directorates within DFRC, NASA Ames Research Center (Moffett Field, California), universities, Indian tribes and other governments and international entities; all in support of the integrated use of remote sensing instruments. Dr. Rodón-Naveira's professional accomplishments began with the US Environmental Protection Agency, where she served from 1990 to 2000. From 1990 to 1994 she worked as Biologist, Project Officer, and Environmental Research Scientist. In 1995, she became the first woman minority Branch Chief within the National Exposure Research Laboratory (NERL); and three years later, the first Hispanic woman to hold the Deputy Directorship for the Environmental Sciences Division (ESD) within the NERL.

Carlos Noriega: was born October 8, in Lima, Peru. Astronaut Carlos Noriega had a distinguished career as a Marine Corps pilot before venturing millions of miles beyond planet Earth. A mission specialist and computer scientist, Lieutenant Colonel Noriega has visited Mir and helped to assemble the International Space Station.

Mario Molina: was born March 19, 1943 in Mexico City, Mexico. At the University of California at Berkeley in 1973, Molina and Sherwood Rowland began researching chlorofluorocarbons (CFCs), then widely used in refrigerators, spray cans, and cleaning solvents. They discovered that the release of CFCs could destroy the ozone layer in the stratosphere, allowing more ultraviolet light to get through to Earth and potentially increasing the rate of skin cancer. Their efforts led to CFC production being banned in most countries, and they received the 1995 Nobel Prize in Chemistry.

Baruj Benacerraf: born October 29, 1920 in Venezuela. Benacerraf is an American immunologist whose contributions to an understanding of the mechanisms and genetic basis of the immune response and especially of its role in certain diseases known as the autoimmune diseases brought him a share of the 1980 Nobel Prize for Physiology or Medicine. From the age of five until the outbreak of World War II Benacerraf lived in Paris. In 1940 he entered Columbia University and graduated in 1942. He became a naturalized U.S. citizen in 1943, while a student at the Medical College of Virginia. After receiving his M.D. in 1945 and interning at Queens General Hospital in New York City, he served in the US Army in 1946-48. After a year of research at Columbia and six years at the Hôpital Broussais in Paris, he joined the faculty of New York University School of Medicine in 1956, advancing to professor of pathology in 1960. In 1968-70 he was chief of the immunologic laboratory of the National Institute of Allergy and Infectious Diseases, National Institutes of Health. From 1970 he held the Fabyan chair of comparative pathology at Harvard.

César Milstein: (1927–2002), Argentina, Immunologist. César Milstein shared the Nobel Prize in 1980 for "pioneering contributions to the theory and techniques of immunology, which were said to lay the basis for advances in medical areas such as cancer treatment and the detection of acquired immune deficiency syndrome (AIDS). In work with his co-laureate Georges J. F. Koehler, Milstein developed the techniques for producing monoclonal antibodies, antibodies with a specific affinity for certain sites in the body that might find diseased cells but leave healthy cells intact.

Women Scientists

Olive Ann Beech: Aircraft Manufacturer (1920–1986)
Olive Ann Beech confounded Beech Aircraft and worked alongside her husband, Walter, during the 1930's and 1940's. After his death, she became President and CEO of the company, and transformed the company into a multimillion-dollar, international aerospace corporation.

S. Josephine Baker: Health Researcher (1873–1945)
Baker went to the Women's Medical College in New York City to earn her MD. She took a part-time job with the Department of Public health as a public school health inspector where she rose in the ranks to create and run the Bureau of Child Hygiene. She helped track down "typhoid Mary" (Mary Mallon). She was one of the first doctors to recognize how important being held is to a child's health. She perfected the application of sliver nitrate eye drops to infants, now a standard procedure to prevent eye infections in newborns. She was the first woman to be assistant surgeon general in the United States. She was also the first woman representative to the League of Nations - Health Committee representative for the United States.

Elizabeth Blackwell: Physician (1821–1910)
Blackwell received the first medical degree granted to a women in the United States from Geneva College in NY in 1849. She started out as a teacher but sought a medical degree. She applied to numerous medical schools but was turned down by all until Geneva College accepted her "by accident." As Blackwell worked through her training and began a series of lectures on hygiene, where she came in contact with women who had the influence to get her started. In 1853 she opened a dispensary in a tenement district of New York City which later became the New York Infirmary for Women and Children in 1868. It closed in 1899. The Civil War halted her efforts to expand the Infirmary to include a medical college and a nursing school.

Bessie and Sadie Delaney: (Sadie: 1889–1999, Bessie: 1891–1995): Home Economics (Sadie) and Dentist (Bessie)
Known as the Delaney sisters, Sadie became a home economics teacher and Bessie became a dentist in the early 20th century in Harlem, New York City. In the early part of the 20th century many people suffered from diseases such as scurvy and rickets which were results from vitamin shortages. Home economics strived to teach people the basics of proper nutrition along with other household systems designed to improve peoples lives. Both sisters graduated from Columbia University and were active into their 100's. Bessie died in her sleep on September 25, 1995; Sadie in 1999, Their oral history was recorded into the book "Having Our Say" and was adapted into a play which was produced on Broadway.

Alice Fletcher: Anthropologist (1838–1923)
Alice Cunningham Fletcher was an ethnologist who became a special agent for the US Indian Bureau, and eventually a research fellow at the Peabody Museum, Cambridge, Massachusetts. She had studied archaeology at the Peabody, starting rather late in her life—in the late 1870's. In 1881 she arranged to live with and study the Omaha Indians of Nebraska. In 1889 she moved to the Nez Percé Reservation in Lapwai, Idaho. She brought the scientific rigor of archaeology to the study of ethnology. She served

as vice-president of the American Association for the Advancement of Science (1896), president of the Anthropological Society of Washington (1903), president of the American Folk-Lore Society (1905) and founding member of the American Anthropological Association (1902). She was the first ethnologist ever to produce a complete description of a Plains Indian ceremony.

Rosalind Elsie Franklin: Chemist (1920–1957)
Rosalind Franklin received her degree in Chemistry in 1951 from Cambridge University. It was while working as a research associate for James Randall at King's College that she was the first to recognize the helix shape of DNA. Her work was passed on to James Watson and Francis Crick, who along with Maurice Wilkins, a coworker of Rosalind's, shared the Nobel Prize in Physiology and Medicine for the discovery of the double helix. Her work, along with that of others, was built into Watson and Crick's detailed description of DNA. She has never received official credit for her contribution to the discovery. She also contributed much to studies of coal and plant viruses. She died at the age of 37 from cancer.

Kate Gleason: Engineer (1865–1933)
Gleason did not have any thorough training in engineering although she did attend Cornell University as a 'special student' in 1884 to study mechanical arts. She also attended the Sibley College of Engraving and the Mechanics Institute (which is now the Rochester Inst. of Technology) part time while she was at Cornell. Gleason began her career at her father's machine-tool factory where she propelled it into the leading U.S. producer of gear-cutting machinery prior to World War I. During World War I the president of the First National Bank of Rochester resigned to join the military. So from 1917 to 1919 she served as its president, becoming the first woman to be the president of a national bank. During that time she began to promote the large-scale development of low-cost housing and set to work on projects related to this. In 1918 she became the first women elected to the American Society of Mechanical Engineers. It was through her reputation in the housing construction field and the machine-tool business that this came about. She also served as the society's representative to the World Power Conference in Germany in 1930.

Lady Augusta Ada Byron Lovelace: Computer programmer (1815–1851)
She is considered the first computer programmer. She was the daughter of Lord Byron, the English poet. One of her patrons was Sir Charles Babbage, the inventor of the first mechanical computer. She wrote the "code" to run the machine. To honor her memory, the US Navy named one of its computer languages ADA.

Barbara McClintock: Geneticist (1902–1992)
Barbara McClintock showed that genes could transpose within chromosomes; that they could move around (the so-called "jumping genes"). This was done through the investigation of maize (corn) genetics through careful hybridization. Her work with genetics came only twenty-one years after the rediscovery of Mendel's principles of heredity, at a time when acceptance of those general principles was not wide-spread. Thus her work, which to some now seems to have been ignored when it first appeared, was simply too advanced for many to comprehend at the time. She also traced the evolutionary history of domesticated maize to determine the genetic ancestor of the grass we now call corn.

PART THREE: 21st CASP CURRICULUM — EXPLORING WATER SCIENCE IN AFTERSCHOOL

I. Water Science Curriculum: An Introduction

The hands-on activities in this water science curriculum are designed to help facilitators guide children through an exploration of science and nature. The activities imbed mathematics and language arts literacy skills into science learning to build literacy skills essential for the 21st century. Additionally, inquiry-based questions in the curriculum guide promote critical-thinking and problem-solving that support youth development as well as science learning.

The water theme lends itself to engaging experiences across the developmental age span, to the development of key scientific skills, and to the cultivation of strong community and environmental stewardship.[9] Additionally, it readily carries over to health and fitness applications for further exploration: What does water have to do with my body? How does my body use water? What does it mean to be dehydrated? What's the relationship between physical activity and the water in my body? Where do we get the water we drink? How do we make and keep water potable?

Water has at least four major roles in supporting life: a chemical role, a physiological role, as a physical medium to transport matter, and transporting itself. [10] In this water curriculum, students will learn about the properties of water and how these properties make water ideally suited to help sustain life on earth.

Introduction to Unit 1: Properties of Water

This unit explores the various chemical and physical properties that make water so special. In this unit, students will explore water's unique identity as the only natural substance that can be found in three of the four states of matter (liquid, gas and solid) at normal temperatures on Earth. Students will learn that water is made of molecules containing one oxygen atom and two hydrogen atoms (H_2O), and that pure water has no color, taste or smell. Students will also investigate water's important role as the universal solvent because of its ability to dissolve so many substances.

Students will learn that:

- Water molecules stick to each other and to many other substances.
- Water carries nutrients as it travels against the force of gravity through soil and through the trunks and stems of plants by a process known as capillary action

9 In partnership with the Rutgers Institute of Coastal and Marine Science, Liberty Science Center has prototyped a program called *On the Hudson* with the American Princess, a ferry boat that was originally designed as a whale watching vessel, but is now suitable for accommodating large groups of learners. As these experiences were developed, they were made available for the 21st CASP pilot project.
10 Ecology: A Systems Approach, Prassede Calabi, National Science Foundation

- Water has a very high surface tension, making it possible for many objects to rest on top of water without breaking its 'skin'.

NOTE: Family involvement strategies can be found in Part Two, Section X of this guide. Sample hands-on family science activities developed by the 21st CASP to complement the curriculum activities can be found in the appendix of this guide.

Introduction to Unit 2: Aquatic Ecosystems

This unit explores aquatic ecosystems and water's vital ecological role on our planet. In this unit, students will learn about ecosystems, the exchange of energy and matter between organisms, and the important relationships between living and non-living elements in an ecosystem, water in particular.

Students will learn that:

- Every ecosystem, community, person and animal on Earth depends on water for survival.
- Water plays an important role in regulating temperatures and climates around the world.
- Water shortages and poor water quality can lead to loss of plants and organisms, increase in malnutrition and disease, and damage to whole environments and ecosystems.

II. Student Journals: An Introduction

The field journal is a valuable tool in scientific investigation. Scientists use field journals to record their observations, questions, predictions, findings and diagrams so they may refer back to them later. Accurate record-keeping is a fundamental part of the scientific process. Documentation helps scientists build upon their own work or the work of their colleagues. Different scientists may have many different styles of field journals, because each journal represents their own personal method of documentation.

Students should use the student journals provided in this guide during each scientific investigation. Provide adequate time for students to document their thoughts, questions, observations and diagrams in their own individual style as they go through the lessons. You may even want to show students excerpts of noted scientists' field journals so they can get a sense of different approaches to documentation. You can download or photocopy additional copies of the student journals provided in this guide for students in your afterschool science program. We encourage you to add your own questions that stimulate further thinking about each investigation. We recommend that the student journals remain at the afterschool sites. Students can be given additional journal paper to take home if they choose to continue investigations outside of the program. These pages can then be added to their journals at a later time.

III. Resources (Local, Online and Print)

The following resources will further help you to enrich hands-on science learning in your afterschool program and to make science more accessible and interesting to a wide range of students of varying skill levels and educational backgrounds. To plan an educational program for your afterschool, extended-day or summer program contact the organizations directly.

If your program is not located in the State of New Jersey, contact your local land-grant college or university, or your state's environmental agency.

Local:

Rutgers Institute of Marine and Coastal Sciences
New Brunswick, NJ
Provides outreach and education to a variety of audiences, including K-12 educators, students, local/state government, families, and resource users through *The C.O.O.L. Classroom* (http://www.coolclassroom.org/home.html) and through the Jacques Cousteau National Estuarine Research Reserve.
More info at:
http://marine.rutgers.edu/index.html

Brigantine Division of the Edwin B. Forsythe National Wildlife Refuge
Ocean County, NJ
Established to protect tidal wetland and shallow bay habitat for migratory water birds. Offer self-guided trails and orientation to the Refuge.
More info at:
http://www.stateparks.com/brigantine.html/

Cape May Point State Park Nature Center
Cape May Point, NJ
Site on the New Jersey Coastal Heritage Trail with an environmental that houses a classroom for interpretive programs and a museum on the area's natural and historic features. Virtual tours are also available.
More info at:
http://www.state.nj.us/dep/parksandforests/parks/capemay.html

Meadowlands Environment Center
Lyndhurst, NJ
Offers teacher workshops, student field trips and downloadable pre- and post visit activities on the New Jersey Meadowlands.
More info at:
http://www.meadowlands.state.nj.us/ec/index.cfm

Great Swamp National Wildlife Refuge
Basking Ridge, NJ
Offers foot access trails and tours arranged through the Friends of the Great Swamp National Wildlife Refuge Group.
More info at:
http://www.fws.gov/northeast/greatswamp/

New Jersey Marine Sciences Consortium
Sandy Hook Field Station, Ft. Hancock, NJ
Offers marine and environmental science education workshops and coastal field trips for families and groups.
More info at:
http://www.njmsc.org

New Jersey Pinelands Commission
New Lisbon, NJ
Offers volunteer speakers on aquatic ecology and a downloadable water curriculum guide.
More info at:
http://www.state.nj.us/pinelands/edu/curriculum/

Jacques Cousteau National Estuary Research Reserve
Tuckerton, NJ
Offers professional development in the classroom and in the field related to New Jersey's marine and coastal habitats.
More info at:
http://marine.rutgers.edu/cousteau/education/mare01.htm

The Wetlands Institute
Stone Harbor, NJ
Provides coastal research and education programs and internships.
More info at:
http://www.wetlandsinstitute.org

Liberty State Park Environmental Center
Jersey City, NJ
Open year-round and features exhibits focusing on the natural history and ecology of the Hudson River Estuary and offers programs for school and community groups and the general public. The center also offers a variety of Professional Development Workshops for formal and informal educators.
More info at:
http://www.state.nj.us/dep/parksandforests/parks/liberty_state_park/liberty_education.html

New York State Department of Environmental Conservation
Dutchess County, NY
Offers teacher and student workshops on the Hudson River Estuary, field trips to their interpretive center and free lesson plan downloads.
More info at:
http://www.dec.ny.gov/education/66.html

Cattus Island County Park
Toms River, NJ
Birding, boardwalk through wetlands, conservation area, environmental education site, nature trails, picnic area and scenic overlooks.
More info at:
http://www.ocean.nj.us/parks/cattus.html

New Jersey Science Teachers Association (NJSTA)
A local organization whose primary goal is the advancement of science education in New Jersey. NJSTA holds an annual conference featuring a catalog of workshops led by science educators from around the state.
More info at:
http://www.njsc-online.com/

National Science Resources:

Environmental Working Group
Offers *The National Tap Water Database*, a great source of test results on water quality from anywhere in the country.
More info at:
http://www.ewg.org/tapwater/yourwater/

The Groundwater Foundation
Focuses on education for action: understanding that pollution prevention is the most effective, cost efficient way to protect groundwater.
More info at:
http://www.groundwater.org

National Science Teachers Association (NSTA)
NSTA publishes books and journals for science teachers from kindergarten through college. They hold four annual conferences on science education: three regional events in the fall and a national gathering in the spring. NSTA provide ways for science teachers to connect with one another. They educate and lobby Congress and the public on issues affecting science literacy and a well-educated workforce.
More info at:
http://www.nsta.org

Terrific Science
Offers several resources for parents and caregivers to become and stay involved in their children's science education.
More info at:
http://www.terrificscience.org

General Afterschool Resources

21st Century Community Learning Center (21st CCLC)
The 21st Century Community Learning Center is a federally funded program supported by the New Jersey Department of Education for before-school, afterschool or summer programs in New Jersey.
More info at:
http://www.state.nj.us/education/21cclc

Harvard Graduate School of Education
This free resource offers an online publication of several OST evaluations.
More info at:
http://www.gse.harvard.edu/hfrp/projects/afterschool/resources/index.html#issues

Educational Equity Center at AED
EEC is a national non-profit organization that promotes bias-free learning through innovative programs and materials. Their mission is to decrease discrimination based on gender, race/ethnicity, disability, and level of family income.
More info at:
http://edequity.org/files/ase.pdf

Southwest Educational Development Laboratory
SEDL provides tools, models, assistance and training to help state and local practitioners develop high-quality, balanced programming to engage students and to improve afterschool learning.
More info at:
http://www.sedl.org/afterschool/toolkits/index.html

Science After School webpage
This website contains summaries of STEM curriculum that is available for use by after-school providers and links to other pages which list curriculum. These are primarily products that are specifically adapted for use in after-school settings.
More info at:
http://scienceafterschool.wikispaces.com/Curriculum+Resources

Exploratorium
A hands-on museum of science, art, and human perception in San Francisco. Website provides interactive online exhibits and exhibitions for educators.
More info at:
http://www.exploratorium.edu/explore/handson.html

National Afterschool Association
The NAA holds an annual conference featuring a catalog of workshops on useful topics and issues relevant to afterschool and OST programs.
More info at:
http://www.naaweb.org/

Afterschool Alliance
A source of information for news in the afterschool community. This website provides advice on beginning a private afterschool program and helpful links and a periodical email newsletter are available.
More info at
http://www.afterschoolalliance.org/home.html

Learning Support
Offers several useful tools to afterschool providers free-of-charge. A few examples include ice-breaking techniques, team-building activities, lesson plans, document sharing, and discussion forums. A great tool for provider-networking. Learning Support also currently offers one online professional development course on aligning afterschool programming to Core Curriculum Standards.
More info at:
http://www.learningsupport.org/

Printed Resources

Beyond the Bell: Linkages Video, North Central Regional Educational Laboratory. Offers a video featuring two elementary and two middle schools that implement and benefit from a related school-day and afterschool curriculum. "The video can be used as a resource for facilitating discussions on starting an after-school program. A companion training guide accompanies the video." $19.95
More info at:
http://www.ncrel.org/after/bellkit.htm

Cost Worksheet for Out-of-School Time and Community School Initiatives, Martin H. Blank and Barbara Hanson Langford. Offers a worksheet to help facilitators estimate cost of operating or expanding their programs.
More info at:
http://www.financeproject.org/costworksheet.pdf

Afterschool Action Kit, Afterschool Alliance offers a kit that explains what afterschool programs can and should do for young people and how to locate or even start one. Available in Spanish. No Charge
More info at:
http://www.afterschoolalliance.org/action_kit.cfm

Quality Time After School: What Instructors Can Do to Enhance Learning
Public/Private Ventures. This 64-page book compiles results from 400 interviews with participants and instructors from five Philadelphia-based Beacon Centers. The books also lays out a "road map" for leaders in the afterschool community. Free download.
More info at:
http://www.ppv.org/ppv/youth/youth_publications.asp?section_id=8#pub213

Building Successful Partnerships: A Guide for Developing Parent and Family Involvement Programs, National PTA.
A resource to help build parent and community involvement in your afterschool program. Text is based on interviews with PTA leaders, teachers, and principals. $18.95
More info at:
http://www.pta.org/

IV. Appendix

Appendix A. Project Evaluation and Outcome

Design and Methodology

Design

The formative evaluation of the 21st Century Afterschool Science Project sought to answer the following questions:

1) How well was the model integrated into existing afterschool programs?
2) Did participation in the pilot project build the capacity of participating afterschool sites to offer science programming at their sites?
3) What youth outcomes are achieved by the model components?

In Year One of the 21st CASP, the Unit One curriculum was piloted at each site and revised based on pilot site feedback. In Year Two, the revised Unit One curriculum was piloted at each pilot site, and the Unit Two curriculum was piloted. The aim was to assess the effectiveness of the model and make improvements prior to disseminating the model statewide and nationally. The intent of the pilot was to implement a replicable science model in three pilot sites and to engage students in science-learning in the afterschool setting.

Data collection methods

The evaluation employed mixed methods. Metrics of achievement were both administrative (numbers reached, timely delivery) and substantive (for example, interviews of afterschool staff regarding implementation of water science activities). A formative evaluation was conducted to aid in the revision and refinement of curricular activities in Units One and Two, as well as to identify model implementation strategies.

Specific data collection methods included observations, semi-structured interviews, student feedback forms, and staff feedback forms. The 21st CASP evaluator and other project staff conducted observations of the pilot sites. Feedback forms were collected from 21st CASP training participants and semi-structured interviews were conducted with pilot site staff at the end of pilot year. During Year Two, pilot sites were also asked to complete a 'checklist' feedback form on the Unit Two activities. Feedback was also captured from project staff through written observation notes and face-to-face meetings on how the 21st CASP model (curriculum/training, etc.) was working and how the model components could be improved. In the original evaluation plan, 21st CASP intended to use the student journals to gauge students' progress; however, the student journal was not implemented consistently during the project in Years One or Two for various reasons, including time restraints and length of journal questions. Therefore, the student journal was not a reliable data source to assess student engagement and learning. Additional student outcome data was captured through feedback forms administered to students at least once at each pilot site to assess engagement and learning in the 21st CASP curricular activities.

To gather additional feedback on the 21st CASP training and Unit One activities, feedback forms were also administered at the NJSACC events on May 5, 2006 and November 4, 2006 where 21st CASP staff presented the use of guided-inquiry methodology along with several activities from Unit One. Participants from the trainings included various afterschool staff from around the state of New

Jersey, including other 21st CCLC grantees. Participants were asked how well the training met their expectations, what they liked and did not like about the training, and why.

Two additional sets of data were collected in the summer of 2007 to further determine what afterschool programs need in order to consistently incorporate science learning into their regular program offerings. First, a survey of 21st CCLC project directors was conducted at an NJDOE-sponsored project directors meeting. The survey included questions about afterschool programs' staffing levels, staff educational background and experience with science, whether the afterschool site offered science programming, what kind of science programming, and what types of support the site would need to implement a new science program. Second, a focus group was conducted at the NJSACC office with 10 afterschool providers. Focus group participants were asked to identify what type of support they would need to implement science learning and to identify which barriers exist to limit implementation of science programming in the afterschool environment. Liberty Science Center project staff also facilitated an activity from the 21st CASP piloted curriculum and the focus group participants were asked to comment on whether similar activities would work at their programs. The focus group was also asked to comment on the student journal and to suggest ways to tie literacy and math into such activities.

Pilot sites

The 21st CASP model was piloted at three 21st CCLC afterschool programs in New Jersey. The 21st CCLC programs are required to supplement the education of children who live in high-poverty areas with academic, artistic and cultural enrichment during out-of-school time hours. The pilot sites were selected to participate in the two-year pilot project, through a Request for Application (RFA) process, to test and provide feedback on the 21st CASP model (trainings, curriculum, student journals, and on-site technical assistance).

Englewood

At the Englewood pilot site, there was one staff member who facilitated the 21st CASP pilot program and curriculum. The facilitator was a middle school science teacher who had taught 6th grade earth science two years prior to participating in the pilot project. In Year One, the 21st CASP program was implemented from March 2006 to June 2006 and held twice a week for approximately one and a half hours a session. Between seven and eleven students participated in the 21st CASP program. The students ranged in age from eleven to thirteen years old.

In Year Two, the 21st CASP was offered from October 2006 to June 2007 and was conducted for approximately 90 minutes per session. In January 2007, a second group was added and the 21st CASP program was held twice per week for 45 minutes per session—one group included new 6th grade students and the second group consisted of 6th- 8th grade students who had previously participated in the pilot project.

Lakewood

At the Lakewood pilot site, there were one to three staff members who facilitated the 21st CASP pilot program and curriculum. The main facilitator was a K–6th grade science teacher. Two assistant facilitators (paraprofessional staff) rotated in and out of the 21st CASP sessions based on the staffing needs of the Lakewood Latchkey program. In Year One, the 21st CASP pilot was implemented from April 2006 to June 2006 and held once a week for one group of students for approximately 45 minutes. Between 18 and 21 students participated in the pilot program. The students ranged in age from nine to eleven years old.

In Year Two, the pilot project was implemented from October 2006 to June 2007 and was held weekly for one group of 4th grade students and for a group of 5th and 6th grade students for approximately 45 minutes each. A second group was added because additional students wanted to participate.

Atlantic City

At the Atlantic City pilot site, two staff members implemented the 21st CASP pilot program and curriculum. The main facilitator was an 8th grade science teacher. The assistant facilitator was a youth development worker. The 21st CASP program was conducted twice in Year One—from April 2006 to June 2006 (with three separate groups of students) and from June 2006 to August 2006. Some of the program activities were also incorporated into the facilitator's ongoing Oceanography club, which met separately from the 21st CASP pilot program. The 21st CASP program sessions were held three times a week with a different group of students each session. The Monday sessions were 4th and 5th grades, Tuesday sessions were 6th and 7th grades, and Wednesday sessions were 8th grade students. These groups ranged in size from 6 to 22 students.

In Year Two, the 21st CASP pilot was conducted from October 2006 to June 2007 (with two separate groups) and during a summer session from June 2007 to August 2007. The main facilitator continued to incorporate 21st CASP program activities into the afterschool Oceanography club. The 21st CASP program sessions were held three times per week with a different group of students each day: Mondays were 4th and 5th grades, Tuesdays were 6th and 7th grades, and Wednesdays were 8th grade students. The Atlantic City pilot site also offered the 21st CASP curriculum to students in its summer 2007 program to 2nd through 8th grade students two times a week.

During the two-year pilot project, the 21st CASP pilot program was conducted at the Atlantic City pilot site from April 2006 to May 2007 (which indicates that all of their program activity was not accurately reported because the 21st CASP pilot evaluation collected data in the summer of 2007).

Program Implementation Summary

The three pilot sites varied in the frequency and duration of their implementation of the 21st CASP curriculum. As evidence in the following table demonstrates, the 21st CASP curriculum was a key program offering in the Englewood afterschool program, where participating students received the program in approximately three-hour doses with a monthly average of nearly 30 hours and ten sessions. The Lakewood and Atlantic City sites had fewer sessions and less time devoted to each session, one hour for Lakewood and approximately one and a half hours for Atlantic City.

Table 1. Program Implementation Summary

21st CASP Program Implementation and Participation,

	Total		Monthly Average		Total
	Hours	Sessions	Hours	Sessions	Participants
Englewood	492	164	29	9.5	14
Lakewood	98	98	3.75	3.75	19
Atlantic City	63	48	5.75	4	11

21st CCLC project directors

In March of 2007, thirty-nine 21st CCLC project directors who did not participate in the 21st CASP pilot program were surveyed. Almost half of the respondents reported having between one and 20 staff members. Over one-third reported having 20 to 40 staff members. The remainder had more than 40 staff members in multiple 21st CCLC sites.

A little over one-third reported having up to 10 certified teachers on staff while another third reported having 10 to 20 certified teachers. The remaining third had between 20 and 80 certified teachers on staff (possibly across multiple sites). About half of the project directors reported that they have up to two staff members who are science teachers or have science backgrounds. The remaining sites reported having between three and six staff members who are science teachers or have science backgrounds. More than half of the project directors said that they have up to 5 paraprofessionals on staff, while one-quarter had between 5 and 10 paraprofessionals. The remaining had between 10 and 20 paraprofessionals.

Three-quarters of the 21st CCLC sites currently offer science programming. The 21st CCLC project directors reported that their science programming included science clubs, hands-on activities or experiments, project-based activities, preparation for the science fair, and science kits or specific curricula. Some sites also reported using outside providers such as *Mad Science* or Liberty Science Center's *Traveling Science Programs* to demonstrate science learning, though they reported that this was a cost-prohibitive option.

Most of the sites offer their science programming for either 60 minutes or 45 minutes with a few offering it for 30 or 90 minutes. Two-thirds offer science programming weekly with a few offering it twice per week and a few offering it only in the summer. A couple of sites offer science programming daily, while another couple of sites offer science programming on a monthly basis. The majority of the sites have 4th through 8th grade students participating in their programs. Small numbers of sites have 9th through 12th grade students participating but no sites had 1st through 3rd grade students.

All of the 21st CCLC project directors reported that they incorporate some type of parental involvement into their afterschool programs. They host parent nights or events and workshops for parents and families. A few programs incorporate parental-involvement by inviting parents and caregivers to participate in science fair activities, as program newsletter staff or as field trip chaperones.

Focus group participants

In May 2006, the NJSACC invited all afterschool providers who were registered on the NJSACC after-school flash listserv to take part in a focus group to discuss science programming in afterschool and to specifically get feedback on the 21st CASP model. Ten afterschool providers participated in the focus group. Though the focus group invitation requested participation from sites which did not currently offer science, a few of the participating programs did offer some science activities at their sites. The focus group participants represented afterschool and out-of-school time programs that serve students of varying ages from kindergarten to 8th grade. The participants included professional staff members, paraprofessionals and program directors of varying educational and professional backgrounds.

NJSACC conference participants

At the NJSACC conference held on November 4th, 2006, 26 afterschool staff members from across New Jersey provided feedback on the training session facilitated by 21st CASP staff. Of the 26 afterschool staff members who responded, 21 were women and 5 were men. Of the respondents 11 were classroom teachers and the remaining included a combination of other professional and paraprofessional staff members.

Findings and Conclusions

What have we learned from the 21st Century Afterschool Science Project?

A two-unit science curriculum and student journals embedded with math and language arts literacy components were created and piloted. The original intent was to pilot the 21st CASP model in three afterschool programs whose staff did not have a formal science background or teaching experience. However, the pilot sites selected had classroom science teachers facilitating the 21st CASP science curriculum. Training sessions on guided-inquiry and the 21st CASP curriculum were provided, and Science Educators from Liberty Science Center modeled delivery of informal, inquiry-based science learning, engaging students and adults in six Traveling Science Programs at each pilot site. In addition, 21st CASP trainers visited each of the pilot sites to observe progress of the model implementation, as well as to provide additional facilitation and logistical support. Each pilot site also coordinated and hosted two Family Science events facilitated by Liberty Science Center staff in an effort to incorporate a family-involvement component into the model. The Family Science events were well-received by the families, and proved to be a simple and effective way to get families involved in science learning in the afterschool setting. The 21st CASP model was successfully implemented at all the three pilot sites.

Implementation of the Curriculum

During the piloting process, the 21st CASP gained valuable input through on-site observations and interviews with pilot site staff to further refine the curriculum activities and student journals prior to statewide and national dissemination.

The 21st CASP evaluated the piloted curriculum by:

- Defining key outcomes regarding science content and skills and literacy skills that the water curriculum activities should address;
- Analyzing pilot site and project staff feedback of what worked, what didn't work, and what OST program staff would change about the curriculum activities;
- Observing participating youth regarding how engaged they are and what they appear to be learning;
- Interviewing key OST staff to gather their impressions on student engagement and learning; and
- Identifying how activities/curricular materials need to be revised in response to evaluation data by conducting observations at the pilot sites as well as interviews with OST staff.

Each of the pilot sites tested the 21st CASP water curriculum for various durations from 45 to 90 minutes, and from once to three times per week during the piloting process. The three pilot sites were able to implement the curriculum at their afterschool programs, on different schedules and with students of different age groups, suggesting that the 21st CASP model is flexible enough to be appropriately tailored according to the needs of each afterschool program.

Both curriculum units received positive feedback from the pilot sites. Adjustments were made to the curriculum during and after the piloting process in response to observations made by 21st CASP trainers during site visits and based on direct feedback from the pilot sites. For example, pilot site facilitators reported that some of the activities in Unit One were too simplistic for their older students (7th and 8th grades) and that some of the concepts in Unit Two were difficult for their younger students (4th and 5th grades). The curricular materials and trainings were adjusted to include guidance and additional extension activities on how to conduct the activities across grade spans as well as for students of varying abilities. Also, the pilot sites reported that the *Freshwater Ecosystems* activity from Unit Two worked well because the students liked working with live organisms. Each of the pilot sites reported that the water testing activity worked well because students were able to use 'scientific' equipment from a water testing kit, suggesting that students responded positively to modeling the roles of professional scientists. In response to lukewarm reaction to the *Abiotic/Biotic Elements* lesson in Unit Two, 21st CASP revised the activity to include more interaction between students and the facilitator in the form of a game that encourages critical-thinking and cause and effect skills.

The curriculum, including the student journals, integrates inquiry-based learning with interdisciplinary skills and learning. Learning objectives identify the main ideas and tasks that will be accomplished by the end of each activity, and the activity introductions provide background information about the science concept to be explored, as well as a historical, social or environmental context for the activity. The activities also include specific tasks such as graphing, measuring, recording, making simple and advanced calculations and conversions, forming hypotheses based on prior learning, and making predictions. Guided-inquiry questioning is infused throughout each activity, encouraging students to formulate additional thoughts and observations regarding outcomes. Each activity also contains cross-curricular extension activities that further enhance the concepts, skills and learning objectives outlined in each activity. For example, students are invited to research how a ship's crew knows how much cargo a ship can carry; to create a food chain that includes themselves and explains their role in the food chain; to use a Venn diagram to compare and contrast different types of wetlands; or to conduct a mock interview of one of the wetland animals explored in the activity and record the animal's thought about what is happening in its habitat.

Additional adjustments to the overall curriculum included: changing the order of the activities in both curriculum units to take advantage of prior knowledge and to build upon skills and concepts presented in the investigations; changing the format of the lessons and providing headings to aid the flow of the procedures and to follow the scientific method; further exploring concepts such as adhesion or density by including multiple activities which highlight these themes; changing overly-technical language to plain-English; rewording or refining procedural steps for further clarification; adjusting learning objectives and goals within the lessons; and removing or replacing piloted activities or parts of the activity from the final curricular materials altogether.

Student Journal

The student journal component of the model proved challenging to integrate from the beginning of the pilot. In general, the pilot sites reported difficulty incorporating the student journals, particularly for the Unit Two activities. While the student journals were not used consistently by the pilot sites, the 21st CASP received feedback from the pilot sites as well as from focus group participants on how to revise the student journal to make it more likely to be used in an afterschool setting.

Feedback captured from the pilot sites and from focus group participants focused on the format and content of the student journal and how best to incorporate literacy and math. The initial student journal that accompanied the Unit One curriculum was a one-page template of general questions designed to elicit observations and feedback about each activity. The pilot sites reported that the original version of the student journal was not used because the questions were generic and not specific to the lessons. The journal questions were revised and re-piloted in the Fall of 2006 to follow each of the inquiry-based questions provided in the facilitator's curriculum guide. Also, a family science activity was developed and included at the end of each activity for students to take home and conduct with their families. The pilot sites reported that the second version of the student journal was too long and required too much writing of the students for an informal afterschool program. When asked what they would change about the journal to make it more user-friendly and to better tie-in literacy and math into the model, the pilot sites suggested using different types of media, shortening the journal entries, creating a "word wall" with the vocabulary from the activities, including a reading that goes along with the unit, and making the journals relevant to students' lives.

Focus group participants suggested providing only a few written questions and group discussion questions. They also suggested incorporating graphs and charts into the journal and providing drawing opportunities for the younger children. Based on feedback received from the pilot sites during regular site visits and from focus group participants, the journal was revised a second time—reduced in size, highlighting fewer and specific questions from each activity while still maintaining the flow of the investigation, incorporating more charts and photographs specifically related to the activity and demonstrating the procedural steps. The journals were also revised to include the cross-curricular extension activities (Curriculum Match-Up) highlighted in the facilitator's curriculum guide.

A large part of the literacy and math integration in the project relied on the use of the student journals. As stated earlier, the journals were not consistently used by the pilot sites for various reasons. While the evaluation was unable to assess student outcomes related to literacy and math, feedback was captured from the pilot sites and from other afterschool program staff who participated in the focus group regarding how to best incorporate literacy and math into the 21st CASP model.

Overall, the evaluation supported the position that the curricular materials are: flexible enough to be implemented in a variety of afterschool settings, easily navigated by users, and provided sufficient information and questions to help the users comfortably facilitate the lessons utilizing guided-inquiry methodology.

Student Outcomes

Student outcomes including attitude, engagement and learning were assessed through observations at the pilot sites, interviews with pilot site staff and student feedback forms. Unfortunately, the original evaluation design planned on assessing student outcomes by assessing the student journals, but the journal was not used consistently by the pilot sites to gather meaningful data. Students were eager to conduct the curricular activities, stayed focused and were excited by the outcomes of the science investigations. In Year Two at the Englewood and Lakewood pilot sites, additional students wanted to participate in the 21st CASP pilot, and these sites offered additional sessions to accommodate the extra capacity. Engagement was reported as stronger with Unit One than with Unit Two for the pilot sites, mostly because Unit Two was more complex and with more abstract concepts to illustrate. Based on this data, it was concluded that students were very engaged in the 21st CASP curriculum activities.

When asked to name something they learned from the activities, students who participated in the 21st CASP pilot were able to name concrete examples and science concepts related to the lesson topics facilitated when feedback was collected. For example, after conducting the *Freshwater Ecosystems* activity in Unit Two, students reported that they learned something about the fish whether it was about their fins, the differences between male and females, how much to feed them or their behavior. When asked to name something that they learned from the *Wetlands* activity, students responded that wetlands are like a sponge, that wetlands prevent pollution, that plants and animals need wetlands, or that wetlands are related to erosion. Students demonstrated learning by using vocabulary from the activities and by discussing the concepts with the staff and other students. Student feedback forms demonstrate that students learned concepts about ecosystems and wetlands that align with the goals of the lessons cited above. From this data it can be reported that students learned from the activities in both curriculum units.

Pilot site staff were asked what they would do to enhance student engagement and learning in after-school. Feedback included having the students create an electronic portfolio of writing and photos, having the students go out into the field to have on-site experience. They also suggested offering science learning programs with more frequency and having as much hands-on activity as possible, noting that the students loved to see reactions in experiments and to have the ability to build projects.

Family Involvement

Two Family Science events were held at each pilot site and featured hands-on activities related to the water theme in the 21st CASP curriculum. Based on parent/caregiver surveys from the Family Science events, the events were well-received. The Atlantic City and Lakewood Family Science events received particularly positive feedback and recorded strong attendance which increased from the first event to the second event. Englewood did not have strong attendance at the first Family Science event held in October 2006, which the pilot site reported as a result of the poor weather (rain) and because the date of the event had been changed within days of the originally scheduled event.

Families who participated in a Family Science Night in Lakewood (November 2006) reported that they came to the event because they wanted to spend time together as a family and were excited to learn something. When asked what they liked best about the event, parents identified specific activities such as *Drops on a Penny* and *Walking the Tightrope* as well as the opportunity to do the experiments as a family. Families reported that the experiments were "amazing."

Overall, parent participants reported that they enjoyed feeling a part of their students' school-community and that they liked seeing their children doing constructive and fun activities that were related to their school work. One of the parents reported that she came to the Family Science event despite being tired from working because her son had repeatedly expressed a strong desire to participate. From the feedback and observations, we can conclude that the Family Science Nights were a successful and important component of the 21st CASP model.

Staff Capacity and Training

A main objective for the 21st CASP was to build capacity of afterschool staff and of the afterschool programs overall to be able to integrate and sustain integration of science programming at their sites. Training was offered to the 21st CASP pilot sites, as well as to other afterschool providers who did not participate in the 21st CASP pilot. 21st CASP trainings were open to all attendees at NJSACC-sponsored events in May 2006 and November 2006. These trainings highlighted activities from the Unit One curriculum, as well as guided-inquiry methodology for facilitating hands-on science. Trainings on the Unit One curriculum and on guided-inquiry were provided to the pilot sites in February 2006 and again on the revised Unit One curriculum in September 2006. Training on the Unit Two curriculum and on guided-inquiry was provided to the pilot sites in January 2007.

Since all three lead staff from the pilot sites were classroom science teachers, it was not possible to measure how the project affected their comfort-level and ability to facilitate science; they were already familiar and comfortable with the subject matter and had some prior experience with inquiry-based learning. The lead pilot site facilitators each reported that their knowledge in science helped ease facilitation of the 21st CASP water science curriculum. Nevertheless, the pilot site facilitators each felt that they had to spend a fair amount of time (approximately one hour) to prepare for each activity. They also indicated anyone unfamiliar with the subject matter would probably need more time to prepare for each activity. It should be noted that 21st CASP staff observations during site visits included reports that additional training on guided-inquiry was needed to help pilot site facilitators transition effectively from "teacher mode" to "informal science learning mode", indicating that while the facilitators knew the subject matter, they needed further reinforcement on how to facilitate science learning informally and on how to fully incorporate guided-inquiry methodology.

Training participants reported that the 21st CASP curriculum made science fun, that it encouraged collaborative group work, it was easy for non-science people and was accessible. Training participants also reported that the trainings were useful in the implementation of the 21st CASP curriculum.

The 21st CASP evaluation did gather feedback from the pilot projects, 21st CCLC project directors and other afterschool staff regarding what they would need in terms of training, materials and technical assistance. Respondents provided encouraging feedback that the 21st CASP model does indeed meet their needs for the integration of hands-on science activities which are easy to implement; training that is not intimidating, and project materials that are fairly easy to obtain.

Additionally, two of the three pilot sites were planning to continue to use the 21st CASP curriculum at their sites, extending it beyond the length of the two-year pilot project, despite the fact that they would not receive additional training, technical assistance or materials from the 21st CASP pilot. This result positively suggests that the curriculum and training model support sustained integration of science programming into two of the three pilot sites, and that capacity to provide science programming in afterschool and OST settings was achieved through the two years of the pilot project.

Post-training feedback was received to help 21st CASP make minor adjustments to improve the training component. For example, training participants suggested providing an overview of the lessons with more simple concepts and/or procedural steps, such as *Drops on a Penny (Cohesion)* and providing a more in-depth facilitation of activities with more challenging concepts and/or detailed procedural steps such as the *Water Body Salinities (Making a Hydrometer)* activity.

Overall, the evaluation revealed that the modeling of the lessons at trainings, site visits and during Traveling Science Programs enhanced the capacity of providers to integrate and sustain science learning in afterschool settings.

What Afterschool Programs Need for Science-Learning

The data collected from afterschool project directors and afterschool staff who did not participate in the 21st CASP pilot confirmed what has been learned from the three pilot sites. Afterschool programs need a model that includes an easy-to-use curriculum, and training and coaching on use of the curriculum, as well as online resources and learning and teaching methodologies appropriate for informal learning environments.

Survey and focus group participants reported the following barriers to integrating science programming: difficulty finding appropriate curriculum, district or state focus/priority on math and literacy, lack of comfort in facilitating science by staff, a lack of resources, the need for storage space and funding, a disinterest in science by the students, a lack of time to implement a new program, and other available curricula (previously tested) that was too complicated for use. Storage of supplies is an issue for programs that do not have consistent access to the same room or storage rooms. Funding is not a significant impediment to implementation of a science curriculum, provided that the materials are simple, common items that can be re-used, and provided that the curriculum is proven to meet the core curriculum standards outlined by the state or the district.

Afterschool programs reported needing a curriculum that is flexible for use by both non-science and science teachers/staff. Respondents also stated that afterschool programs need staff who are enthusiastic about doing science, which makes training and on-site assistance a key part of the implementation process. Preparation time is limited for afterschool staff and must be considered if a new science curriculum is to be used consistently.

The 21st CASP model addresses the issues reported by afterschool staff related to storage, managing time and space, informal learning in the OST environment in the facilitator guide which accompanies the curriculum and student journals. Afterschool sites reported spending an average of 45–60 minutes providing science programming, which matches the timeframe recommended for the 21st CASP curriculum activities. Most afterschool sites offer some sort of science programming but not on a consistent basis. Afterschool and OST programs clearly want to offer science programming to improve students' knowledge and skills as well as help with state educational assessments.

The 21st Century Afterschool Science Project was successful on many fronts including:

- Creating a replicable model designed for afterschool, OST and extended-day programs to implement science programming;
- Increasing OST staff capacity to facilitate science learning in the afterschool setting;
- Increased student engagement, skill and knowledge related to science;
- Developing and piloting curricular materials tailored for the OST setting, which imbed math and language arts components, and which are grounded in the New Jersey Core Curriculum Content Standards and inquiry-based learning; and
- Involving families in hands-on science, math and literacy activities in support of their children's learning.

Appendix B. Glossary

Adaptation: changes in the form or behavior of organisms in response to conditions in their environment.

Adhesion: the property of sticking together or the joining of surfaces of different composition

Aquatic: growing or living in water.

Atom: the smallest component of an element having the chemical properties of the element.

Attraction: A force that pulls two objects together.

Buoyancy: The force that pushes upward on an object submerged in a liquid allowing it to stay afloat.

Capillary Action: The movement of a liquid within a material caused by the attraction of liquid molecules to the molecules of the material.

Capillary: A hollow tube with a very small internal diameter.

Chemical property: property used to characterize materials in reactions that change their identity depending on the arrangements of atoms in a molecule.

Cohesion: The force of attraction that holds together molecules of a substance

Concave: To curve inward.

Control: A standard of comparison for checking or verifying the results of an experiment. In an experiment to test the effectiveness of a new drug, for example, one group of subjects (the control group) receives an inactive substance or placebo, while a comparison group receives the drug being tested.

Converge: To move together toward a central point.

Convex: To curve outward.

Density: How much matter is packed into a certain amount of space. Density is calculated as the measure of mass per unit of volume (D = m/v).

Displacement: When water is pushed out of the way (moves from one place to another) when an object is placed into water.

Distort: To twist or change the shape or view of an object.

Elastic: Flexible, pliable, springy, or stretchy.
Field Journal: A collection of writing usually in a binder or tablet that consists of written observations, essays, or other composition made by a scientist about research.

Force: A push or a pull on an object that results in a change in its speed, direction or shape.

Gravity: The natural attraction that draws objects at its surface towards Earth.

Hydrogen Bonding: attractive force between Hydrogen and some other element, namely in water molecules.

Hydrogen: The lightest and most abundant element in the universe, normally consisting of one proton and one electron.

Hypothesis: An idea about the solution to a scientific problem, observation or phenomena based on knowledge and research. Hypotheses can be tested by further investigation.

Lens: a molded piece of glass, plastic or other transparent material with opposite surfaces—at least one of which is curved—that allows light rays to bend and form an image.

Liquid: One of the four common states of matter. Liquids are made of molecules that can move about in a substance but are bound loosely together by attractive forces. Liquids have no fixed shape, and therefore take on the shape of any container.

Magnify: To increase the size or volume an object or image of an object.

Matter: Anything that has mass and occupies space. Matter exists as a solid, liquid, gas, or plasma.

Mass: The amount of stuff (matter) contained in a physical space or body.

Meniscus: The curved top of a liquid in a tube.

Molecule: The smallest unit of a substance that can exist and still retain the physical and chemical properties of that substance.

Observations: the act of viewing or noting a fact or occurrence or phenomena for scientific purpose.

Oxygen: A gas that makes up 21% of Earth's atmosphere (the air we breathe). Humans breathe oxygen and our bodies use it to fuel chemical reactions that give our bodies energy.

Physical Properties: Any property characteristic used to describe matter and the way it interacts with other types of matter.

Physics: The study of matter and energy and their interactions.

Prediction: a statement about the future or the outcome.

Properties: A basic or essential attribute shared by all members of a class. <u>Not</u> used to describe living things.

Reflection: The process of throwing or bending back (light, for example) from a surface.

Refraction: The bending or turning of light as it passes through one surface into another.

Scientific Method: The basis for scientific inquiry. The scientific method follows a series of steps: (1) identify a problem you would like to solve; (2) formulate a hypothesis; (3) test the hypothesis (4) collect and analyze the data; (5) make and share your conclusions.

Scientist: a person having advanced knowledge of one or more sciences, and who uses the scientific method.

Sphere: Round in shape and sometimes hollow, for example: a soccer ball. A three-dimensional (having height, width and depth) object or surface having all of its points the same distance from a given point.

Submerge: To place or sink an object below the surface (of a liquid).

Surface Area: The total area (sum) of the flat surfaces of an object. Area is usually calculated by multiplying length X width.

Surface Tension: The attraction of molecules to each other on a liquid's surface which produces an effect within the surface layer of a liquid that causes that layer to behave like an elastic sheet.

Teddy Bear Molecule: A reference to the idea that the diagram of a water molecule resembles the head of a teddy bear. The large oxygen atom can be thought of as the teddy bear face, while the two smaller hydrogen atoms can be thought of as its ears.

Variable: The things that have an effect on an experiment. There are three kinds of variables: an independent variable is the variable you purposely change. The dependent variable is the variable that is being observed, which changes in response to the independent variable. A controlled variable is <u>not</u> changed in an experiment.

Viscosity: The measurement of resistance to flow in a liquid. The higher the viscosity the more resistance it has to flow.

Volume: The amount of space that matter occupies.

Water: A clear, colorless, odorless, and tasteless liquid. A water molecule is comprised of two Hydrogen atoms and one Oxygen atom (H_20). Water has a freezing point of 32 degrees Fahrenheit (0 degrees Celsius) and a boiling point of 212 degrees Fahrenheit (100 degrees Celsius). Water is essential for most plant and animal life and is the most widely used of all solvents.

Appendix C. New Jersey Core Curriculum Content Standards

Language Arts Literacy Standards

Standard 3.2 (Writing) - All students will write in clear, concise, organized language that varies in content and form for different audiences and purposes.
Unit 1 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Unit 2 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Standard 3.3 (Speaking) - All students will speak in clear, concise, organized language that varies in content and form for different audiences and purposes.
Unit 1 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Unit 2 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Standard 3.4 (Listening) - All students will listen actively to information from a variety of sources in a variety of situations.
Unit 1 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Unit 2 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Mathematics Standards

Standard 4.1 (Number and Numerical Operations) - All students will develop number sense and will perform standard numerical operations and estimations on all types of numbers in a variety of ways.
Unit 1 Lessons 1, 2, 4, 5, 6, 7, 8, 9, 10, 11
Unit 2 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Standard 4.2 (Geometry and Measurement) - All students will develop spatial sense and the ability to use geometric properties, relationships, and measurement to model, describe and analyze phenomena.
Unit 1 Lessons 2, 3, 8, 9, 10, 11
Unit 2 Lessons 1, 5, 6, 7, 8, 9, 10

Standard 4.4 (Data Analysis, Probability, and Discrete Mathematics) - All students will develop an understanding of the concepts and techniques of data analysis, probability, and discrete mathematics, and will use them to model situations, solve problems, and analyze and draw appropriate inferences from data.
Unit 1 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Unit 2 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Standard 4.5 (Mathematical Processes) – All students will use mathematical processes or problem solving, communication, connections, reasoning representations, and technology to solve problems and communicate mathematical ideas.
Unit 1 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Unit 2 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Science Standards

Standard 5.1 (Scientific Processes) - All students will develop problem-solving, decision-making, and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.
Unit 1 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11
Unit 2 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Standard 5.3 (Mathematical Applications) - All students will integrate mathematics as a tool for problem solving in science, and as a means of expressing and/or modeling scientific theories.
Unit 1 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Unit 2 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Standard 5.5 (Characteristics of Life) - All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.
Unit 2 Lessons 2, 3, 4, 7, 8, 9, 10

Standard 5.6 (Chemistry) - All students will gain an understanding of the structure and behavior of matter and liquids. Estuaries
Unit 1 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Unit 2 Lessons 1, 5, 6, 7, 8, 9, 10

Standard 5.7 (Physics) - All students will gain an understanding of natural laws as they apply to motion, forces and energy transformation.
Unit 1 Lessons 3, 10, 11
Unit 2 Lessons 1, 5, 6, 7, 10

Standard 5.8 (Earth Science) - All students will gain an understanding of the structure, dynamics, and geophysical systems of the Earth.
Unit 2 Lessons 1, 2, 9

Standard 5.10 (Environmental Science) - All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.
Unit 2 Lessons 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Appendix D. Sample 21st CASP Family Science Night Activities:

Unit 1: Properties of Water

Activity: *Watering Hole*
Materials: Pitcher, warm water, small plastic cups, confectioner sugar, measuring spoons, tally sheets, pens, markers or crayons
Concepts: Molecular structure of water, Surface tension
Description: Participants learn about the molecular structure of water and about the spaces between the molecules. Participants add confectioner sugar to the water and measure the change in volume. At first the volume does not change because the dissolved sugar fills in the spaces between the water molecules. Facilitator and participants discuss concepts.

Activity: *Breaking the Tension*
Materials: Pepper; dish soap; pie tins; water; pitcher
Concepts: Surface Tension
Description: Participants continue to learn about the molecular structure of water and about hydrogen bonds. Pepper is added to the water in the pie tin and participants are asked to "clean" the water by removing the pepper. Participants try to come up with creative ways of cleaning the water until a single drop of dish soap is added to the water, breaking the surface tension and forcing the pepper to the sides of the tin. The participants can now easily remove the pepper. Facilitator and participants discuss concepts.

Activity: *Water Cycle in a Bag*
Materials: Zippered plastic sandwich bags; water cycle diagram; warm water; scotch tape; pitcher
Concepts: Water Cycle
Description: Participants learn about the following parts of the water cycle: evaporation, condensation and precipitation. Participants color and label the diagram of the water cycle with assistance from the facilitator. The diagram is attached to the outside of a small zippered sandwich bag. The bag is filled with an ounce or so of warm water and sealed. The bag is then taped on a window such that the diagram is right-side-up facing the participant. The participants watch as the water cycle actually happens inside of the bag. Facilitator and participants discuss.

Activity: *Color Changing Celery*
Materials: Celery; water; food coloring; drinking glasses
Concepts: Adhesion and cohesion
Description: Participants continue to learn about adhesion and cohesion as it relates to the molecular structure of water. Participants insert a cut stalk of celery in colored water and witness the colored water rise into stalk of celery, changing its color. Facilitator and participants discuss.

Activity: *Long Distance Pour*
Materials: Pitchers and/or measuring cups; water; 9 oz–16 oz drinking cups; food coloring; various types of string and twine
Concepts: Adhesion and cohesion

Description: Participants continue to learn about adhesion and cohesion while attempting to seemingly defy gravity. Participants pour water into a cup two feet away from a pitcher on a 45-degree angle. The do this by pouring the water along a pre-soaked string attached to the spout of the pitcher and the other end held taught on the inside rim of the cup. The water runs down the string into the cup due to the adhesive and cohesive properties of water. Facilitator and participants discuss.

Activity: *Making Rainbows*
Materials: Spray bottles; water; white butcher paper; bright flashlights
Concepts: Refraction in Water
Description: Participants learn how light is bent when it passes through water. Participants hold a strong flashlight against white butcher paper while water is misted over the beam of light. Participants witness a rainbow forming. Facilitator and participants discuss.

Activity: *Whatever Floats Your Boat*
Materials: Aluminum foil; modeling clay; large bowl or container; water; pitcher
Concepts: Buoyancy
Description: Participants learn about buoyancy by trying to make aluminum foil sink and clay float. Participants learn about density and that in order for an object/substance to float it must be less dense than water. Similarly, in order for an object/substance to sink, it must be denser than water. Participants mold each of the substances until the desired effect occurs. Facilitator and participants discuss.

Activity: *Egg Float*
Materials: Hardboiled eggs; salt; warm water; pitcher; drinking glasses
Concepts: Density and Buoyancy
Description: Participants continue to learn about buoyancy by trying to make a hardboiled egg float in warm water. Participants continue to learn about density and how it relates to mass and volume. Participants add salt to warm water in an attempt to alter the density of the water. Eventually, the water becomes denser than the egg, causing it to float. Facilitator and participants discuss.

Unit 2: Aquatic Ecosystems

Activity: *The Slime that Won't Go Away*
Materials: Large aluminum pie/lasagna trays, vegetable oil, eye droppers, spoons, nylon stockings, sand, cotton balls, dish detergent.
Concepts: Participants learn about the ecological impacts of oil spills and some of the techniques used to clean the spills including: vacuuming, skimming, burying, absorbing and dispersing. Participants also learn that there is no ideal way of cleaning spills and that each has consequences.
Description: Participants learn how devastating oil spills can be to the environment and how difficult they are to clean.

Activity: *Where Did All this Pollution Come from Anyway?*
Materials: Aquarium, plastic rectangular box with a large hole in the bottom, water, spray bottles, green food coloring, vegetable oil, soil, sand, aquarium pebbles, and shredded paper.
Concepts: Participants will demonstrate that "pollution" usually has many different sources. Using a model of a "storm drain" (i.e., the aquarium with the plastic box on top), participants add pollutants to the "street." The spray bottle allows rain to fall on the street, carrying the pollutants into the storm drain. Participants can observe how they were collectively responsible for the pollution of the water.
Description: Participants learn about the concept of non-point source pollution.

Activity: *Potable Water*
Materials: 1000 mL jar/container or 1-liter water bottle, 25 mL graduated cylinder, 10 mL graduated cylinder, eye dropper, and a pitcher.
Concepts: Participants learn about the concept of potable water by demonstrating how much water we can actually use. If the earth had only had 1000mL (1 liter) of water, 970mL would be saltwater, 24mL would be trapped in glaciers and in the polar icecaps, 6mL would be fresh water that is unavailable because it is trapped underground and only a single drop of water (about 0.003mL) is available for people to use.
Description: Participants learn about Earth's finite water supply and what percentage human beings can actually use.

Activity: *Water Filters*
Materials: Soil, 2-liter clear soda bottle, alum (potassium aluminum sulfate), fine sand, coarse sand, aquarium rocks, coffee filter, rubber band, measuring spoons, stirring rod/spoon, beaker or jar, pitchers, and a stopwatch.
Concepts: Participants will purify muddy water by passing it through a homemade water filter, by adding the aquarium rocks, course sand, fine sand and alum to an inverted soda bottle with the bottom cut off. The spout of the bottle will have a coffee filter, secured with a rubber band. The muddy water will go the purification processes of aeration, coagulation, sedimentation and filtration. Facilitators will need to discuss that the final step (i.e., disinfection) is not illustrated in this model.
Description: Participants learn how water is purified for human consumption.

Activity: *Aquifer in a Cup*
Materials: Plastic cups, modeling clay, play sand, aquarium gravel, food coloring (red), bucket, and a pitcher.
Concepts: Participants create an aquifer using rocks, play sand, and clay. Water is added, which illustrates how water becomes trapped in spaces between rocks. The water is then "contaminated" using red food coloring, which shows how improperly disposed chemicals seep into aquifers, making the water unusable for people.
Description: Participants learn how to design their own personal aquifer and learn about the concept of ground water and how pollution can ruin the water supply.

Appendix E. Online and Storefront Retailers for Curriculum Supplies

21st CASP purchased materials for the water curriculum from the following online and storefront retailers during the two-year pilot project. You can find many of the curriculum supplies from local grocers and other retailers in your area. The online retailers will deliver materials directly to your afterschool program if someone is there to receive the package.

Online: (may include catalog shopping)

Science Kit / Boreal Laboratories: sells materials for biology, chemistry, earth science, physics and forensics. Includes online and catalog shopping.
http://www.sciencekit.com

Doctors Foster and Smith: sells aquarium supplies, small live organisms and eggs, tropical fish supplies and fish tank supplies, pet supplies including dog supplies, cat supplies, and products for horses, birds, small pets, reptiles, and pet medicines from their pharmacy.
http://www.drsfostersmith.com

American Science & Surplus: offers science kits, educational toys, school supplies, arts and crafts items, hobby tools, scales, lab glass, house wares and hard-to-find items.
http://www.sciplus.com

Carolina Biological: sells science supplies and live organisms for educators.
http://www.carolina.com

Sargent-Welch: offers products for science educators of all science disciplines and levels.
http://www.sargentwelch.com

Arbor Scientific: provides educators, parents and caregivers, and students with science products for teaching physics, physical science, and chemistry.
http://www.arborsci.com

Delta Education: provides inquiry-based, research driven, hands-on science curriculum, kits, live plants and organisms, and other educational programs and materials.
http://www.delta-education.com

Oriental Trading Company: carries an assortment of value-priced products and supplies.
http://www.orientaltrading.com

Steve Spangler: offers science-related supplies, videos, toys and games for children and educators.
http://www.stevespanglerscience.com

Kelvin: has Products, activities and kits designed to assist educators and motivate students through hands-on activities.
http://www.kelvin.com/

Storefront Retailers: (may also include catalog and online shopping)

Petco and Petsmart: These stores offer pet accessories, products & services
http://www.petco.com
http://www.petsmart.com

Office Max, Office Depot & Staples: Office supply stores, furniture, electronics, ink and toner, copy paper and computers.
http://www.officemax.com
http://www.officedepot.com
http://www.staples.com

The Container Store: Features storage and organization products. Offers space-planning.
http://www.containerstore.com

Michaels: Operates specialty retail stores which provide an assortment of general crafts, home decor items, picture framing materials and services, art and hobby.
http://www.michaels.com

A.C. Moore: Operates arts and crafts superstores throughout the Eastern United States
http://www.acmoore.com

Jerry's Artist Outlet: accepts phone orders with a credit card for art supplies.
http://www.jerrysartistoutlet.com

Student Safety Agreement Template

Safety is a priority in the afterschool science (program/workshop/lab/environment). The following guidelines will help foster a safe learning environment for students and facilitators. **Please read the entire contract before you sign**. Students will not be allowed to participate in hands-on science activities until their safety contracts are signed and returned to the (name of your afterschool program).

1. Never eat, chew gum or while doing these investigations.
2. Never taste any of the materials that you will be handling in these investigations.
3. Follow all instructions carefully. If you do not understand a direction or part of a procedure, ask the instructor before you continue.
4. Don't touch any equipment or other materials until you are told to do so.
5. Keep hands away from your face, eyes, mouth and skin while using investigation materials. Wash your hands with soap and water after doing all experiments.
6. Clean (with detergent), rinse, and wipe dry all work surfaces (including the sink) and equipment at the end of the experiment. Return all equipment clean and in working order to the proper storage area.
7. When transferring materials from one container to another, hold the containers over a table or sink.
8. Never remove chemicals or other materials from the room.
9. Carry glass tubes in a vertical (straight up) position to prevent damage and injury.
10. Never handle broken glass with your bare hands. Use a brush and dustpan to clean up broken glass.
11. When removing an electrical plug from its socket, grasp the plug, not the electrical cord. Hands must be dry before touching an electrical switch, plug or outlet.
12. Examine glassware and other containers before each use. Never use chipped, cracked or dirty containers.
13. Notify your instructor immediately if you find damaged equipment or materials. Look for cracks, chips, frayed cords, exposed wires, and loose connections. Do not use damaged electrical equipment.
14. If you do not know how to use a piece of equipment, ask the instructor for help.
15. Do not place hot glassware in cold water—it may shatter.

16. Allow heated metals and glass to cool before use. Use tongs or heat-protective gloves if necessary.

17. Never look into a container that is being heated.

18. Do not place hot equipment directly on the desk. Always use an insulating pad. Allow plenty of time for hot equipment or tools to cool before touching them.

19. Use a wafting motion of the hand to check odors or fumes.

20. Never force rubber stoppers into glassware.

21. Know where the fire extinguisher, eyewash, shower, and exits are located.

22. Report all injuries to the instructor immediately.

I, ______________________________________ (student's name) have read and agree to follow all of the safety rules stated in this contract. I realize that I must obey these rules to insure my own safety, and that of my fellow students and facilitators. I will cooperate with my instructor and fellow students to maintain a safe learning environment. I will also closely follow instructions provided by the facilitator. I understand that if I violate this safety contract, I may be removed from the afterschool science activity.

______________________________	______________________________
Student Signature	Date
______________________________	______________________________
Parent / Guardian Signature	Date

Family Science Event Flyer Template

(*Name of Your Afterschool Program*) invites you and your family to attend **Family Science Night** to be held (*Date, Location, Address and Time*).

Come and experience science in a safe and fun environment!

This event is FREE for the whole family!

Special activities include: *(examples)*

- Traveling Science demonstrations provided by Liberty Science Center
- Hands-on water science activities that you can do with your children
- Presentation on the Hudson River Estuary by scientists from the Rutgers Institute for Marine and Coastal Sciences
- Make and take crafts and other hands-on activities for all family members

A free, healthy dinner will be provided during the evening.

For more information, contact (Name of Contact, title and phone number and alternate phone number and email address, if available)

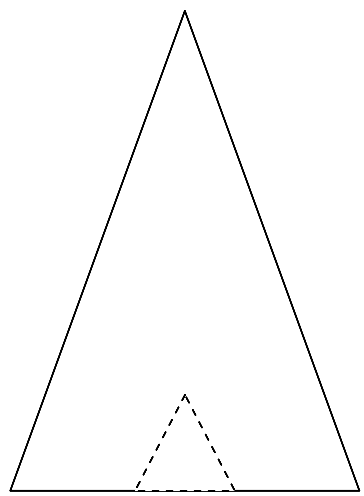
Bring the family and explore the world of science!

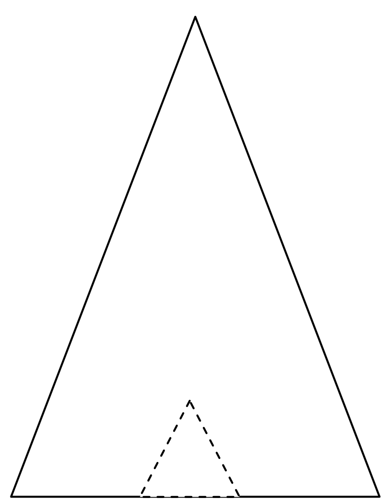
Unit 1, Lesson 6, Surface Tension I
Water Strider Photo

Water Striders *(Aquarius sp.)* using surface tension when mating (courtesy Wikimedia)

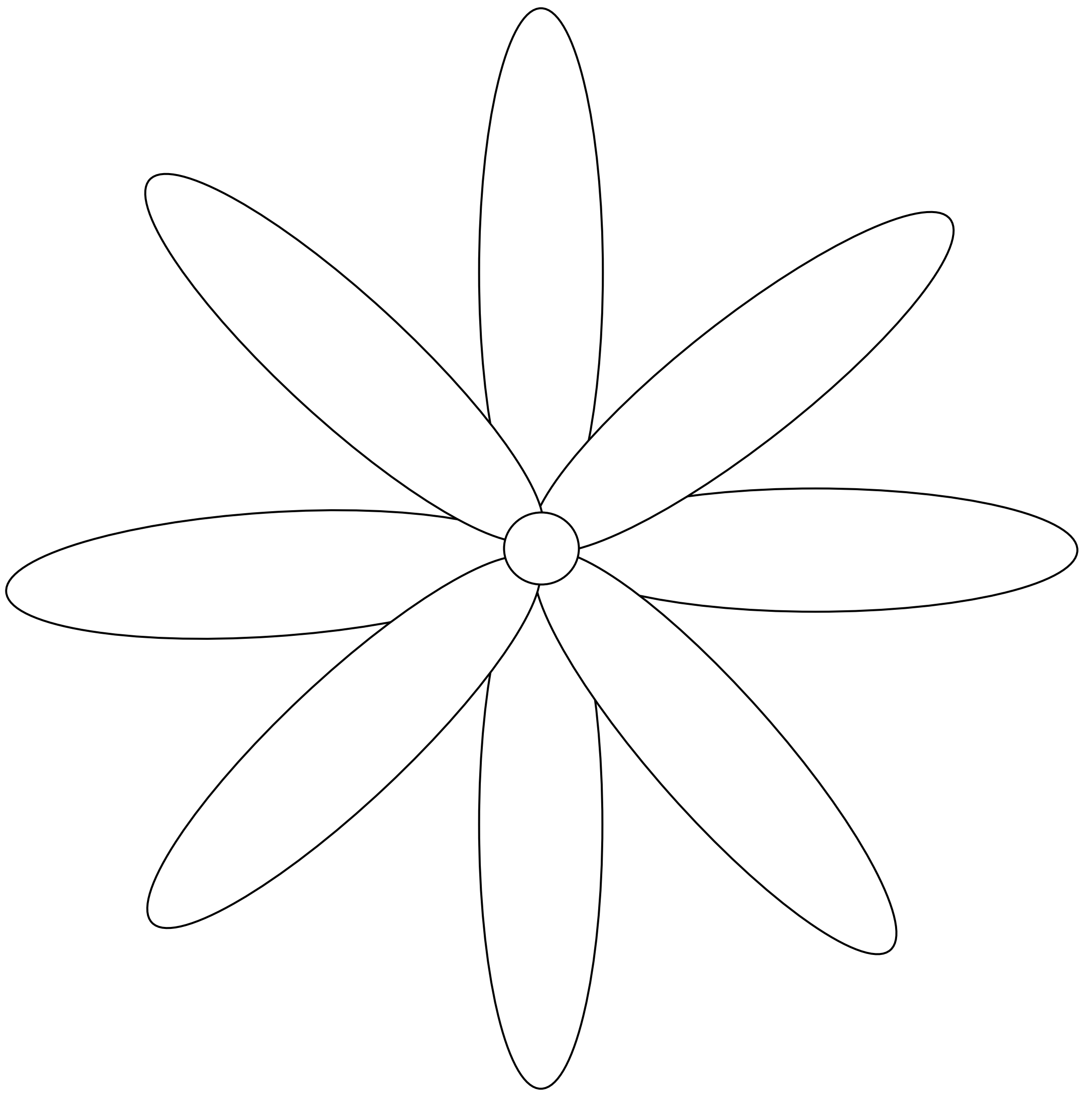
Unit 1, Lesson 7, Below the Surface: Surface Tension
Investigation #1: Floating Along Template

2 ½ X 1 ½ inches





Unit 1, Lesson 9, Moving On Up: Capillary Action II
Investigation #1: Paper Blooms Template



Unit 2, Lesson 2, What's in the Water? Biotic & Abiotic Elements in Aquatic Ecosystems
Part 1: Biotic and Abiotic Identification, Photos of Aquatic Ecosystems

Large river (courtesy USFWS)

Freshwater marsh (courtesy USGS)


Goose on a cliff of low brush overlooking the ocean (courtesy Free Nature Pictures)


Wood pylons and aluminum can in a stream (courtesy Free Nature Pictures)


River basin (courtesy USFWS)

Saltwater cliffs (courtesy Free Nature Pictures)

Frog swimming in a creek (courtesy Free Nature Pictures)

Seagulls entering the stream on a beach (courtesy Free Nature Pictures)

Sea turtle on the rocky beach (courtesy Free Nature Pictures)

Unit 2, Lesson 5, Water Body Salinities I
Map of New Jersey Rivers

Unit 2, Lesson 5, Water Body Salinities I
Part 1, Oceans, Rivers, and Estuaries
New Jersey Outline Template

Unit 2, Lesson 7 Addendum
Wetlands Plants and Animals/Wetland Types

Aquatic Bed Wetland (courtesy USFWS)

Plants of Aquatic Wetlands

Duckweed has many rounded leaves that float on the water. Duckweed leaves are small and serve as food for water birds and beavers. Cattails are the most common wetland plants. They grow more than eight feet tall on stiff stems. Cattails have flower spikes shaped like hot dogs. Muskrats, beavers and geese eat cattails. Birds nest among the cattails. Muskrats use this plant to build their homes. Early Americans used cattail stems to weave baskets and bedding. Cattail spikes could be torches when soaked in oil. Cattails were once used to insulate gloves and shoes, and cattail pollen is used to make flour.

Bog (courtesy of EPA)

Plants of the Bogs

Peat moss has a unique structure that allows it to hold 15 times as much water as the weight of the plant. Because of its ability to hold water, peat moss can survive during long dry periods.

Forested Wetland (courtesy USDA CFWR)

Yellow Iris *Iris pseudacorus* L. (courtesy USDA NRCS Wetland Science Institute)

Plants of Forested Wetlands

The forest wetland is full of Venus flytrap plants. This carnivorous plant has pointed hairy leaves that trap insects for food. Venus flytraps are becoming endangered because people dig them up to sell for a profit. Willow trees grow in forested wetland. Their roots trap sand and other sediment, preventing erosion and helping other trees grow in the wetland. Some of the trees that grow in swamps form a set of roots above the soil surface or above the water that allows them to get oxygen to the lower roots.

Plants of Emergent Wetlands

Purple loosestrife grows faster than any other wetland plant. It is a non-native and invasive plant that thrives in freshwater wetlands, crowding out native plants. Yellow iris is another invasive plant. Native Americans used Iris flowers as perfume and Iris leaves to make ropes and snares to trap elk for food. Iris is poisonous to humans, but it can be used to make a paste to stop swelling.

Scrub/Shrub Wetland in an Estuarine Ecosystem
(courtesy NOAA CSC)

Plants of Shrub/Scrub Wetlands
Blackberry shrubs can grow roots from the branches if the branch is resting in a wet area. Blackberry thorns protect small animals hiding in the branches. Birds and bears eat blackberries. Birds and insects are protected in the cover of willow. Rats, birds and rabbits eat willow twigs. Willow trees also grow in shrub/scrub wetlands. Its branches are flexible and can be used to make baskets, twine, dye and furniture. Native Americans chewed willow bark for pain relief since it contains a chemical similar to aspirin.

Salt marsh (courtesy of Rutgers University)

Plants of Saltwater Marshes
Saltwater marsh plants include salt marsh grass and spartina. These plants have special glands that allow them to eliminate excess salt that they take in from the water and soil.

Wetlands Marsh (courtesy USFWS)

Insects of the Wetlands
Wetland insects include mosquitoes, water striders, dragonflies and mayflies. Mayfly larvae and adults serve as a food source for fish and amphibians. Water striders use a property of water called *surface tension* to walk on water. The surface of water acts likes a skin to help water striders and pond skaters. Pond skaters have specialized, paddle like legs that enable the insect to “skate” on the surface of the water.

Types of Wetlands Found in New Jersey:

The Great Swamp Refuge is located in Morris County, New Jersey. The refuge holds 7,600 acres of varied wetland habitats, serving as a breeding, nesting and feeding ground for birds, foxes, deer, muskrats, turtles, fish, frogs, wildflowers and plants.

Aquatic beds are found near the edges of lakes or stream and are dominated by plants that generally grow on or below the surface of the water. Water lily, duckweed and pondweed grow in aquatic beds three to six feet deep. Waterfowl such as ducks and herons feed and rest in aquatic beds because they offer food and protection. Fish spawn (deposit their eggs) and feed in aquatic beds.

Emerging wetlands are found next to lakes and streams. They are home to green plants that produce flowers and fruit. Plants in emerging wetlands have soft stems, roots that are submerged in the water or wet soil, and leaves that are above the water or wet soil.

Bogs are covered by thick carpets of moss, lichen and peat (dead plant material). The water in bogs is low in oxygen, highly acidic and usually cold. Almost all of the water found in bogs comes from precipitation (rain and snow). Plants and animals that live in bogs have adapted to the low nutrient levels and acidic waters. Carnivorous (meat-eating) plants such as Venus flytraps eat insects because the water and soil in bogs lack the minerals and other nutrients needed for survival. Cranberries are harvested from bogs in New Jersey.


Bog (courtesy EPA)


Aquatic Bed Wetland (courtesy USFWS)


Willow tree *Salix babylonica*(courtesy Wikimedia)


Great Swamp (courtesy of USFWS)

Fens have slow moving water that rinses acid from the soil. Minerals and nutrients drain into fens from surrounding soils and from groundwater. Fens are covered by grasses, rushes, sedges and wildflowers—mostly vascular plants with specialized tissues that transport water and minerals. These plants provide food and shelter for other aquatic organisms. Fens provide shelter to insects such as mosquitoes; amphibians such as the Eastern tiger salamander; birds, and mammals such as shrews, voles and muskrats.

Marsh wetlands usually have shallow, standing water throughout the year. Marshes are often "riparian", meaning they form a transition or buffer zone between water and land. Marshes contain lots of nutrients for plants and animals, but the water and soil found in marshes are "anaerobic" or lacking oxygen. Marsh plants adapt to the low levels of oxygen by drawing air through hollow spaces from their leaves to their roots and to the soil around their roots. There are several types of marshes, including freshwater and saltwater. Saltwater marshes can be found at the edges of estuaries (where freshwater flows into the ocean). Saltwater marsh plants have adjusted to growing in salty, waterlogged soil and can excrete excess salt from specialized cells in their stems, roots and leaves. Cattails, rice, crabs, shrimp, tadpoles and insect larvae can all be found in marshlands.

Forested wetlands or swamps are covered by large trees and woody plants more than twenty feet tall. Swamps have water-saturated soils during the growing season and standing water during other times of the year. Both evergreen trees (having foliage that stays green throughout the year, such as the Eastern white pine) and deciduous trees (having leaves that fall off or shed seasonally, such as the Willow oak) grow in swamps. Few green plants grow in forested wetlands because of the acidic soil and lack of oxygen. Swamps also contain a layer of rotting plants called "peat".

Scrub/shrub wetlands are densely populated by small trees and bushes that are less than 20 feet in height. These wetlands are often found in estuarine areas and are flooded with shallow, standing water for extended periods during the growing season. Their thick vegetation protects small birds and amphibians from larger prey. Scrub/shrub wetlands are important breeding areas for amphibians because of the absence of predator fish. Pussy willow, dogwood and elderberry are typical shrubs found in this type of wetland. Wood ducks, song birds, herons, muskrats and deer can also be found in scrub/shrub wetlands.

Scrub/Shrub Wetland in an Estuarine Ecosystem (courtesy NOAA CSC)

Wetlands Marsh (courtesy USFWS)

Forested Wetland (USDA CFWR)

Fen (courtesy EPA)

Cranberries are red berries used in foods and in herbal products. Cranberries are a unique fruit. They can grow and survive only in acid peat soil, an adequate fresh water supply, and a growing season that extends from April to November. Cranberries grow on low-lying vines in bogs or marshes layered with sand, peat, gravel and clay. *Cape Cod Cranberry Growers' Association*

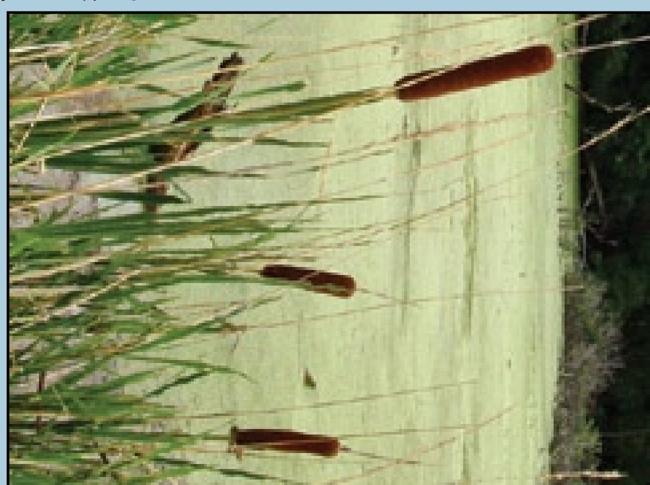
Blackberry grows in relatively open, disturbed, and moist sites such as shrub/scrub wetlands. Blackberry shrubs grow quickly and tolerate poor soil. Blackberry bushes are often called brambles, from a word that means prickly. The plants have stiff, sharp prickles along the stems and midrib of leaves. White-tailed Deer, Eastern Cottontail, and Beaver eat the leaves and stems of the blackberry shrub. The shrub also provides great cover and protection for birds and small animals. Many plants often grow closely together to form a thicket. Several species of birds nest in blackberry shrubs. Birds and other animals eat blackberries and spread the seeds through their droppings. *Community Mapping Network*

Cattails or bulrushes are wetland plants, typically 1 to 3 meters tall, with spongy, strap-like leaves and starchy, creeping stems. Cattails grow along lake margins and in marshes, often in dense colonies, and are sometimes considered a weed in managed wetlands. The plant's root systems help prevent erosion, and the plants themselves are often home to many insects, birds and amphibians. The disintegrating heads are used by some birds to line their nests. The downy material was also used by Native Americans as tinder for starting fires.

The **bog turtle** is found in the eastern United States in colonies from New York and Massachusetts south to southern Tennessee and Georgia. This is a semi-aquatic species, preferring habitats with cool, shallow, slow-moving water, deep soft mucky soils, and herbaceous vegetation. Bog turtles live in shallow, spring-fed fen, sphagnum bogs and swamps, marshy meadows and pastures generally dominated by sedges or sphagnum moss with soft, muddy bottoms, slow-flowing water and open canopies. Like other cold-blooded or ectothermic species, they require habitats with regular solar penetration for basking and nesting. The bog turtle is one of the smallest North American turtles with the adult shell measuring 3 to 4 ½ inches in length. It has a large, bright orange, yellow or red blotch on each side of its head. When danger threatens, the turtle burrows rapidly into the mucky bottom. They beetles, insect larvae, snails, seeds and millipedes. *U.S. Fish and Wildlife Service*

Bog Turtle *Glyptemys muhlenbergii* (courtesy USFWS)

Blackberry Shrub (courtesy Wikimedia Commons)



Cattail (courtesy of Derek Jensen)

Cranberry in a Bog (courtesy USDA Agricultural Research Service)

The **pitcher plant** is a carnivorous, or meat-eating, plant. Carnivorous plants have adapted to living in low-nutrient environments by developing features to attract, trap, kill, digest prey and absorb nutrients. They eat invertebrates and occasionally small frogs and mammals. The most common habitat for pitcher plants is in bogs and fens, where nutrient concentrations are low but water and sunshine are seasonally abundant. Most plants absorb nitrogen from the soil through their roots; but carnivorous plants absorb nitrogen from their animal prey through their leaves that are specially modified as traps. Pitcher plants use "pitfall" traps with leaves folded into deep, slippery pools filled with digestive enzymes. *The Botanical Society of America*

Mosses are small, low-lying, soft plants that grow 1–10 cm tall. They usually grow close together in clumps or mats in moist, shady areas. They do not have flowers or seeds, and their simple leaves cover thin wiry stems. Mosses are non-vascular plants. Unlike flowering plants, they do not have special channels to transfer nutrients up the stalk. Moss plants do not possess true roots. Instead, mosses get their nutrients and moisture from the air. Because of this they prefer damp places and have adapted to dealing with long dry periods. Mosses use spores to reproduce. Sphagnum peat-mosses are large mosses that form extensive acidic bogs in peat swamps. The leaves of peat-mosses have large dead cells alternating with living photosynthetic cells. These dead cells help to store water. Because of its water-holding capacity, peat moss is added to soil to improve its water-holding capacity and has been used as an absorbing material for oil spills. The Eskimo used peat moss to curb diaper rash. *College of Natural Sciences & Mathematics, University of Massachusetts Amherst*

Herbaceous angiosperms (flowering plants) are the dominant and most familiar group of land plants. They have true roots, stems, leaves and flowers. They also have seeds. Angiosperm means "seed born in a vessel". These plants are more highly evolved that the algae, mosses, fungi and ferns. Their advanced structures allow angiosperms to thrive on land. They have roots that hold the plant in place and take in needed minerals and water. They have stems that hold the plants up and move nutrients and water through the plant. Angiosperms are the primary food source for animals and provide oxygen to breathe. *Monroe County Women's Disability Network*

Mosquitoes are two-winged insects. Female mosquitoes have mouth parts that form a long proboscis for piercing the skin of mammals, birds and sometimes reptiles and amphibians to suck their blood. The mosquito proboscis is serrated. The females need protein to produce and lay their eggs, while male mosquito diets consist of nectar and fruit juice. The females lay their eggs in water and the larvae and pupae live entirely in water. When the pupae change into adults, they leave the water and become flying land insects. Mosquitoes lay their eggs on the surface of woodland pools, tidal floodwaters, freshwater swamps, standing water or containers of collecting water.

Mosquito *Aedes sollicitans* (CDC)

Mossy log *Sphagnum apiculatum* (courtesy of Free Nature Pictures)

Herbaceous angiosperm (courtesy USDA NRCS)

Pitcher Plant *Sarracenia oreophila*(courtesy USGS)

Eastern garter snakes live in moist fields, forests, meadows and marshes. They are non-venomous and feed on small fish, frogs, toads, salamanders, earthworms, tadpoles, mice, bird eggs, slugs, crayfish, leeches, insects and other small snakes. They grow between 14 and 48 inches in length and have narrow heads and bodies. They range in color from light brown to black with two alternating rows of black spots. Eastern garter snakes have black lines on their lip scales. They also have three long stripes, usually with a yellow dorsal stripe. The lateral stripes are cream to yellow and are located on the second and third scale rows. There can also be a row of black spots below the lateral stripes.

American black ducks are large ducks found in wooded ponds, salt marshes and estuaries. The American black duck is chocolate brown with bright white feathers on their underwings. They have a lighter brown neck and head, red legs and feet. Males have a flat, broad yellow bill, while females have a darker olive bill. The American black duck feeds mainly on aquatic plants, but will also forage near the shore for seeds and insects. They float high in the water and are strong fliers. Their legs are placed more towards the center of their bodies. Nests are built close to the water, often on the ground and lined with soft plant material.

Spotted Salamanders are amphibians—vertebrates that begin the first part of their lives under water (breathing with gills) and the rest of their lives on land (breathing with lungs). Amphibians are ectothermic—they warm themselves by obtaining heat from the environment. Salamanders have soft, moist skin covering their long bodies and tails. Salamanders must return to the water to mate and lay their eggs. Females lay a milky egg mass about four inches long and attach the eggs to sticks or plant stems submerged in water. During the rainy season and early summer, spotted salamanders can be found in wetland vernal ponds formed from melted snow and heavy spring rains. Spotted salamanders eat insects, worms, snails, and small fish. Their skin is bluish-black or dark gray, and they have two rows of round yellow or orange spots down their backs. Their bellies are slate gray.

Red-spotted newts are amphibians that live near fens, marshes and emergent wetlands. Newts have long and slender bodies and a flattened tail. In its larval stage, this newt is called a *red eft* because of its bright reddish-orange color. After reaching maturity, this newt's skin will turn olive, and its sides will acquire red spots that are surrounded by black.

Red-spotted Newt *Notophthalmus viridescens* (Paul Hurtado)

American Black Duck *Anas rubripes* (USFWS)

Spotted Salamander *Ambystoma maculatum* (USDOT)

Eastern Garter Snake *Thamnophis sirtalis sirtalis* (NPS)

Spring peepers are small tree frogs that live near marshes, ponds, streams, or vernal pools (water that forms in large pools in the spring, but dries up in the summer). Like all amphibians, spring peepers must lay their eggs in water. Like many salamanders, spring peepers are nocturnal—highly active at night. They grow less than an inch and a half in length and can be tan, gray or dark brown with a dark *"X"* on their backs. Spring Peepers also have large toe pads to grip plants when they climb.

Muskrats are large rodents that live in aquatic environments throughout New Jersey watersheds, swamps, lakes and marshes. They prefer to make their home in aquatic habitats where the water level remains fairly stable, preferably at a depth of four to six feet. The muskrat's thick, glossy pelt (skin with fur) is dense and waterproof. It has a rudder-like, scaly tail to help it easily move backwards and forward in water. Muskrat's have partially webbed hind feet that make it a strong swimmer and diver. Muskrats are generally herbivores, eating plants such as cattails, water lilies, sedges and rushes; but they may also feed on fish, crayfish, frogs and freshwater clams. Muskrats have strong lungs and can swim underwater for up to 17 minutes before surfacing to take a breath.

Fiddler crabs live near water on the mud or sand. They dig burrows during high tides that can reach a foot deep. These burrows are often linked to other tunnels and have more than one entrance to provide fiddler crabs with escape route from predators like fish, raccoons and aquatic birds. Male fiddler crabs have one large front claw and one small one, while females and young fiddlers have two small claws. The male fiddler crab uses the large claw to wrestle other males, to mark his territory and to attract a mate. The small claw is used to gather food. Fiddlers roll a ball of mud and use it to plug the hole of their burrow during high tides. The ball of mud traps a tiny pocket of air inside for them to breathe. All crabs have gills, which they must keep moist in order to breathe, so they stay near water at all times. Fiddler crabs grow between one and two inches and may be tan, blue-green, turquoise, black, yellow, or orange in color. Fiddler crabs eat algae, microbes, fungus and other decaying detritus. Some scientists believe that fiddler crabs help preserve wetland habitats because they aerate (expose to air) the soil and prevent anaerobic conditions as they forage for food and burrow in the sand.

Banded sunfish live in heavily vegetated areas of bogs, lakes and streams with sandy or muddy bottoms. Its body is lined by six or seven dark vertical stripes on its body. The banded sunfish has rounded pectoral (front side) fins, a gill cover spot that is larger than its eye, and an arched line on the side of its body that ends just before its tail. It has an olive-colored body sprinkled with iridescent gold, green and purple markings. Banded sunfish feed mostly on aquatic insect larvae, scuds and other small crustaceans. They grow two to four inches in length and live up to four years. Spawning can occur from early spring into summer. The female lays eggs in a small, round nest built by the male.

Banded Sunfish, *Enneacanthus obesus* (USGS)

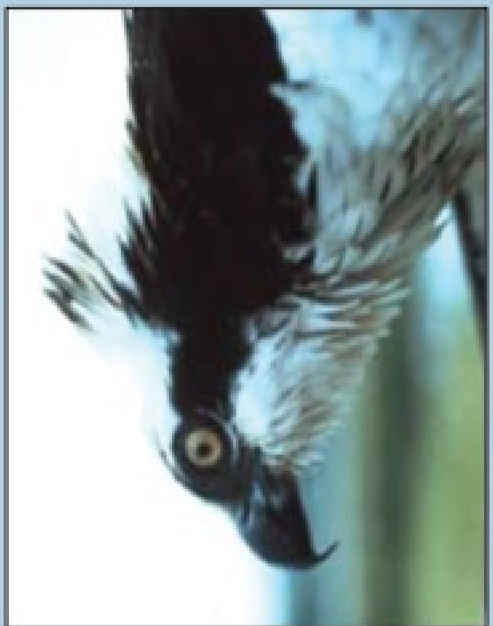
Muskrat, *Ondatra zibethicus* (USFWS)

Fiddler Crab, *Uca pugnax* (NOAA)

Spring Peeper *Pseudacris crucifer* (NPS)

River otters are expert swimmers and divers. They can stay underwater for up to two minutes. They have specially built ears and diamond-shaped noses with a valve-like skin that closes when the otter swims underwater. Otters have webbed and clawed feet that are useful for running on land and swimming. They can run up to 15–l8mph. River otters are three to four feet long and weigh 15 to 25 pounds. Their colorful coats range from nearly black to reddish or grayish brown on their backs. Their belly is silvery or grayish brown. The throat and cheeks are silvery to yellowish gray. Otters eat fish, crustaceans, and other aquatic invertebrates and they have few natural enemies, especially in water. On land, young otters are vulnerable to a variety of predators such as the fox, wolf and raptors.

An **osprey** is a raptor (bird of prey). Raptors are at the top of their food chain and prey on smaller animals. The osprey has special adaptations to hunt fish but will occasionally eat rodents, birds, small vertebrates and crustaceans. The adult is blackish-brown on top of its body and white below. Ospreys range in size from 21 to 25 inches long with a wingspan of 59 to 67 inches. They are the only raptor that will plunge into the water for food. Ospreys will hover 30–100 feet above the water looking for fish. When a fish is spotted, the osprey dives feet first into the water. The osprey's method of catching prey calls for some adaptations not found in land hawks. The osprey's feathers are slightly oily to limit water absorption. Its leg shank is scaled, not feathered, with short, dense feathers on the thighs. The pads of the toes are covered with small spikes for grasping slippery fish. The osprey also has a reversible outer toe that can either be at the front of the foot or moved to the back to carry fish. They build nests close to water near the tops of trees. The nest is built of sticks and lined with grasses, seaweed, moss, lichens, bark and mud.



Osprey *Pandion haliaetus* (USGS)

River Otter *Lutra Canadensis* (USFWS)

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Unit 2, Lesson 7 Addendum: Photo and Information Credits

- The Botanical Society of America
- Cape Cod Cranberry Growers' Association
- Centers for Disease Control and Prevention, United States Department of Health and Human Services, Public Health Image Library
- College of Natural Sciences & Mathematics, University of Massachusetts Amherst
- Community Mapping Network
- Hudson River National Estuarine Research Reserve, New York State Department of Environmental Conservation
- Monroe County Women's Disability Network
- National Oceanic & Atmospheric Administration (NOAA) Coastal Services Center
- Paul J. Hurtado, Center For Applied Math, Cornell University, Ithaca, NY
- http://plants.usda.gov/java/nameSearch
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture Forest Service, Southern Research Station, Center for Forested Wetlands Research
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- U. S. Geological Survey Patuxent Wildlife Research Center Laurel, Maryland
- U.S. Department of Transportation (DOT)
- U.S. Department of the Interior, National Park Service (NPS)

21st Century Afterschool Science Project
Feedback Form

Your feedback is important to us! Please complete this feedback form and return it to:
Melissa Wadman, Director, Impact Evaluation at Liberty Science Center, FAX: 201-451-6383
222 Jersey City Blvd, Jersey City, NJ 07305.

- Name of your Afterschool Program: ______________________________
- Gender: ◯ Male ◯ Female
- Are you a teacher? ◯ Yes ◯ No
- Grade(s) Taught: __________ Subject(s) Taught: ______________________
- If not a teacher, what is your position? ______________________
- How many students did you have on average participating in the science program? __________
- What age range? ______________________
- How often did you do the science activities? (1x per week, etc) ______________
- Are you comfortable facilitating science activities? ◯ Yes ◯ No
- Why or why not? ______________________

____

____

- Why did you want to offer the 21st Century Afterschool Science Project (21st CASP)? __________

____

____

- Overall, how well did the 21st CASP meet your expectations? (Please circle)

Greatly Exceeded	Met & Exceeded	Just Met	Nearly Met	Fell Below	Fell Far Below

Please turn over….

- Why did you rate it this way?

- What activities did you find the most interesting, informative and useful for your afterschool program? Why?

- What activities did you find to be the least interesting, or difficult to implement at your afterschool program? Why?

- How would you rate students' engagement? (circle one)

1	2	3	4	5
not engaged				*very engaged*

- How would you rate students' learning? (circle one)

1	2	3	4	5
did not learn				*learned a lot*

Please give an example of student engagement or learning.

Additional Comments:

Thank You!