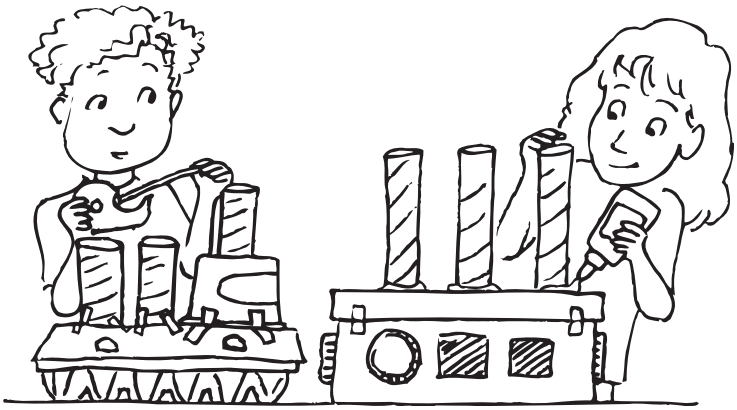
Teacher Reference Materials

Article 3

Developing the Child Scientist

ScienceCompanion® CHICAGO SCIENCE GROUP



Who is the child scientist? Is it the child…

- Reading a book about volcanoes?
- Sprinkling a trail of sugar in front of an ant?
- Pointing to the double rainbow after the rainstorm?
- Asking what the green stuff is on the bottom of the refrigerator?
- All of the above and more?

The child scientist is the curious, inquisitive, energetic, wondering child that you see in every seat in your classroom. Children bring characteristics to the classroom that are naturally compatible with the study of science. Most enter school assuming they'll learn new things. As they learn, they want to share their knowledge with others. Each time a child asks *why*, they give voice to their desire to gain understanding. Since every child has a drive to learn and explore; they are all child scientists.

As you work with the child scientists in your class, guide them through the processes that adult scientists use. Help them develop discussion skills. Facilitate the refinement of their cooperative group skills. You'll soon see young scientists stretch and test their ideas and perhaps even participate outside their normal comfort zone. The child scientist brings the natural world into the classroom and asks *how, why, what*, and *when*. The child scientist gains answers through experiences and confirms findings by working with others. These beginning traits grow and improve over time.

This article includes a discussion on how to present scientific processes and skills and how to use the "I Wonder" circle; ideas for discussing science and tracking children's ideas and questions; and information on how to develop cooperative and collaborative work, address science to the special needs population, and orchestrate an active, energetic science class.

You'll Find Inside:

Presenting Scientific Processes and Skills

Beginning with kindergarten, the Science Companion curriculum presents scientific processes and skills that develop through each grade. The focus on each process and skill progresses and the emphasis shifts as the children grow and learn. Skills are introduced in an age-appropriate manner during specific grades, but once introduced they continue to evolve. For example, in kindergarten observation skills are a primary focus, and this skill is emphasized for the duration of the child's school experience. Other skills, such as measuring and recording, become the primary focus in a later grade.

As a teacher, you know that the level of progress and rate of skills acquisition differ widely between individuals. Be aware that not all of the science skills will be perfected at a certain grade level and there will be marked differences between individuals. Scientific process skills continue to develop over the course of the year as well as over the child's entire life.

Scientific Processes and Skills

The activities in the Science Companion lessons encourage children to use many scientific processes and skills. These skills may be used across all areas of your curriculum. They include:

- **Observing**—Paying close and careful attention to the shape, texture, color, size, and any other attribute of an object. Taking advantage of the senses, and looking at objects over time for changes in all of the noted attributes.
- **Describing**—Using rich details and precise accurate language to convey or record observations.
- **Questioning**—Asking questions to clarify misunderstandings or elicit information. Asking questions simply to muse and wonder about something. Advanced questioning skills include skepticism and critical evaluation.
- **Predicting**—Suggesting a path or process that is likely to occur based on the evidence.
- **Scientific drawing**—Conveying an observation, a plan, or an idea graphically. Using detail, labels, and scale. Focusing on drawing only what is directly observed. Drawing procedures others can easily follow. Using graphics to get across ideas that are hard to put into words.
- **Comparing and contrasting**—Observing something in relation to others like it, and noting the differences and similarities.
- **Sorting**—Separating objects into groups based on attributes that are distinguishable or different.
- **Classifying**—Mixing up a collection of items and then finding new characteristics to make new groupings. Consolidating by finding shared attributes between sorted groups. Grouping them again into fewer, larger collections of samples.
- **Sequencing**—Putting items in order based on time or sequential steps or stages.
- **Recognizing Repetition**—Identifying patterns that occur over time.
- **Recording**—Using writing to track and remember observations, events, and ideas.
- **Explaining**—Using words to describe what happened and the reasons why.
- **Reasoning**—Drawing conclusions from observations. Includes responses that use evidence and explain ideas with concrete examples.
- **Communicating**—Participating in active listening and discussions to share ideas, restate or clarify, and demonstrate understanding.

Using the "I Wonder" Circle

The "I Wonder" circle is a graphic tool to use in your classroom that captures the way both children and scientists think and work. It presents the familiar "scientific method" or "experimental method" as a web of discreet processes that may be pursued in any order to do science. The experimental method is typically taught as a linear procedure wherein the scientist begins with some observations, forms a testable hypothesis or question, designs a controlled experiment to test the hypothesis, gathers data, and draws conclusions. This simplified progression of steps is a useful description, but it is not always how things work in the real world of science. For example, a child may wonder, "why can't I get rid of my

I Wonder: notice, ask questions, state problems

I Think: consider, gather information, predict

I Try: experiment, model, test ideas, repeat

I Observe: watch, examine, measure

I Record: record data, organize, describe, classify, graph, draw

I Discover: look for patterns, interpret, reflect, conclude, communicate discoveries

Using the "I Wonder" Circle

shadow?" but be unable to articulate a readily testable question or hypothesis. After further thought, the child conducts some trial and error tests, and eventually notices that the way to get rid of a shadow is to move into the shade. Or the child observes that the shadow's direction depends on the location of the light source. These surprising discoveries may lead the child to ask more questions and wonder further about their experience of the world. That's science! The traditional experimental method can easily be tracked on the "I Wonder" circle, as well as other valid variants of scientific thinking.

The "I Wonder" circle fits better in a classroom setting because it allows children to keep track of what they are actually doing (observing, recording, etc). It helps them organize their thoughts and explorations, identify the processes they have tried, and determine a logical next step. Using a circular web of scientific processes is less confusing than forcing a child to fit what they are doing into locked linear steps.

Incorporating the "I Wonder" Circle

The Science Companion program offers an introductory lesson called "Doing Science" that is meant to be taught at the beginning of the school year. It is included in the *Teacher Reference Materials*. The goal of this lesson is to familiarize children with the thinking processes associated with studying science and to introduce the concept of the "I Wonder" circle. In addition, the lesson incorporates some great practice using group discussion skills.

An important part of using the "I Wonder" circle is revisiting it as each Science Companion unit progresses. This way, children come to understand that the scientific method is an ongoing process. After introducing the "I Wonder" circle, refer to it in future lessons when children discuss their ideas and reflect on their own scientific process.

Using the "I Wonder" circle, you'll find that learning is not a linear process, but is instead a web of continuous dynamic experiences. You'll be surprised and pleased to see even the youngest children exercise the critical thinking skills used during scientific thought.


WHAT ARE WE DOING?
I WANT A BIG ROCK!
WHY DO WE ONLY GET ONE ROCK?
EACH PERSON TAKE A ROCK, PLEASE!
CAN WE DRINK THE WATER?
ROCK


MAYBE IT'S SOME KIND OF SPECIAL WATER.
MAYBE WE'RE SUPPOSED TO WASH THEM!
I THINK WE SHOULD SORT THEM!


WHAT HAPPENS NEXT?
I'M PUTTING MINE IN THE WATER!


THE ROCK IS A DIFFERENT COLOR...
SO WHAT'S IT DOING?
THE WATER GOT CLOSER TO THE TOP OF THE CUP...


We put the rocks in the water.
the water got higher.
the rock sank
AND IT HAPPENED THE SAME FOR ALL OF US, TOO.
NUH-UH, ONE OF THEM FLOATED!
WHAT IF WE USED WOOD INSTEAD?
OR IF WE ONLY HAD A TINY ROCK TO PUT IN?

Discussing Science

During science, talking and listening are essential parts of the learning process. Although many forms of communication take place during a child's day, discussions during Science Companion lessons are used to distribute and gather information, practice critical thinking skills, develop group processes, deepen thinking, make connections, and assess understanding. Discussions are an important part of inquiry-based science learning.

Encouraging Successful Discussions

Children's wonderings provide a starting point for sharing meaningful insights. They can jumpstart a series of related thoughts, comments, and conversations. (See the "Using the 'I Wonder' Circle" section on the preceding pages.) Good science discussions can help children engage in the topic and make sense of what they've learned in the activities. They provide a means for children to make connections between various explorations, and communicate findings from them. Maximizing "kid talk" will give you and your children amazing information about what they know and want to know. Within the lessons, you'll find a plethora of opportunities to use discussion as an integral part of teaching and learning science. The following suggestions will help promote successful discussions during science:

- Sit so that all children can see each other's faces. In a large group, that may mean sitting in a circle; in a small group, children can probably sit face-to-face. This promotes participation from every group member rather than funneling all comments and questions through you.
- Let the conversation be driven by what happens and what children notice and wonder about at that moment.
- Avoid rushing to conclusions or aiming for the "right" answers.
- Help children build on and respond to each other's ideas and observations.
- Encourage children to use details and concise examples to explain or describe what they mean.
- Invite all questions and theories; model respect for all commentary.
- Use differences in opinion as opportunities to encourage children to articulate, expand upon, reconsider, and possibly revise their ideas.

Listening to Children

When you listen carefully to children, you demonstrate an essential group discussion skill. As a teacher, you'll hear children's gems of understanding as well as some extremely interesting misconceptions. In the science discussion arena, everyone gets more information if children know they can talk freely and will be fully heard. Show children that active listening includes responding and confirming. Demonstrate that you are thinking about what's being said by restating what you hear or asking clarifying questions. Step back and encourage children to practice listening to each other.

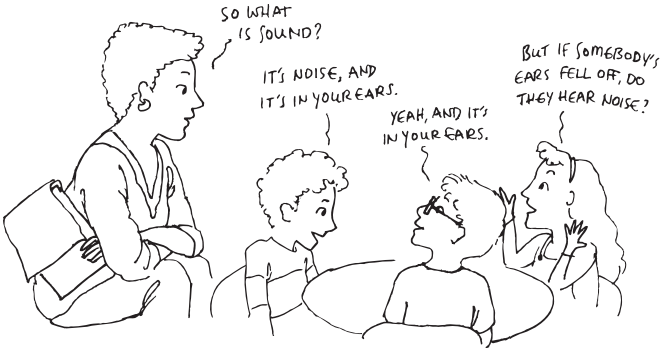
To encourage listening, incorporate the following techniques into your teaching practices:

- Define and describe the various discussions you'll use in your class.
- Show examples of when to use different discussion techniques. For example, a talk with a partner during an exploration might be different than a discussion with a guest speaker. Both need active listening, but one might require more verbal interaction than the other.
- Review and model simple techniques for active listening. These might include maintaining eye contact, thinking about what's being said, repeating interesting points in your mind, and asking questions of the speaker.
- Run a tape recorder in the background during various discussion times. Replay it for yourself and your class, making note of gestalt moments and examples of interesting insight.
- Let a willing child be the discussion "leader." This way you can step into a less authoritative role and model how children should listen to others.

Discussing Science

Types of Discussions

Listening and talking to each other is a skill that benefits everyone. It is a key component to science and an inherent goal of the Science Companion lessons. The primary discussion goals for all children are to freely ask questions, share findings, draw conclusions, and extrapolate ideas. Building the skills of discourse—actively listening, taking turns talking, expanding on the ideas of others, and disagreeing respectfully—takes time, and lots of practice.



Types of discussions used during the Science Companion lessons include:

Introductory Discussions

Teacher-led discussions that establish what a lesson is about. These are intended to probe children's knowledge about a topic, boost their confidence, spark their interest, and focus the group on a topic before beginning an exploration.

Informal Group Discussions

Discussions that arise within small groups or pairs of children engaged in an investigation together. They occur without your direction, but you will hear them in the Science Center or while children do explorations. Most children are very comfortable with informal discussions. These conversations are rich in ideas and highlight children's thinking. Though Science Companion lessons contain prompts and questions that encourage informal discussions, whenever possible let children's science conversations evolve naturally, as part of their scientific process.

Children who participate in informal group discussions are practicing skills needed for more prescribed interactions such as science talks.

Science Talks

These open-ended class discussions are teacher facilitated rather than teacher directed. The purpose of the science talk is to allow the children both to articulate their own ideas, and, as a group, build on each other's ideas. A successful science talk is a genuine group thinking session, rather than a collection of discrete ideas. The job of the teacher is to model active listening and open your ears to what your children are thinking.

Science talks begin with an open-ended question that does not have an obvious right or wrong answer. The question may come from the teacher, a child, or a suggestion in a lesson plan. It is best if the children sit facing each other, rather than facing the teacher. As the facilitator, the teacher should focus on the following:

- Help children connect their ideas to those previously aired. ("John, it sounds like you're saying something a little bit different than Margaret. Can you explain that a little more?")
- Give extra time to children who need it to put their thoughts into words. ("Let's be quiet and listen to what Sarah has to say.")
- Prevent a few children from monopolizing the discussion. ("That's good thinking Hirona, but let's give Jacob a turn.")
- Involve those who look like they've got something to say, but remain silent. ("I see you wiggling there Eric, would you like to add something?")
- Let those who prefer to remain quiet do so without pressure.

For more detailed information about science talks, read *Talking Their Way Into Science* by Karen Gallas, an educator and researcher who has done extensive research on using science talks in classrooms. (Karen Gallas. *Talking Their Way Into Science: Hearing Children's Questions and Theories, Responding with Curricula.* New York: Teachers College Press,1995.)

Reflective Discussions

Usually a discussion that includes sharing, summarizing, or synthesizing information. Sometimes these are teacher-led, so children receive help to reach a conclusion. In other cases, children should be capable of relating findings and probing for further questions.

Because these discussions come at the end of a lesson, you may wish to take a less active speaking role and, instead, use this as an opportunity to assess children's scientific understanding. Resist the temptation to solve remaining mysteries or answer questions. Try not to conclude reflective discussions with a finite solution; instead, pose questions or encourge thinking that extends into the next lesson or outside science class.

Some teachers like to use reflective discussions to review and continue the topic in greater depth or connect it to a related topic. Although reflect and discuss periods normally follow an exploration, you may find it more useful to use reflective discussions at the beginning of a lesson or as a transition to another science session. See the *Teacher Reference Materials* article, "Planning a Science Companion Lesson," for more information.

Tracking Children's Ideas and Questions

Children are full of questions. Queries often pop up at inopportune times—on the way to lunch, in the middle of an unrelated project, during recess. Questions matter a lot to children, but it is not always possible to answer them right away. Try to develop a strategy for saving questions that come at these times for later. Return to them when it is appropriate (and possible) to address them.

You might want to record the children's conversation during their discussions and science talks. A recording is a useful tool for summarizing and evaluating children's questions. If you have a record of questions, then you can go back over them after a day, a week, or even a year, and add solutions or answers, as they are discovered.

Another way to track questions is for you or an appointed recorder to write down the questions on self-sticking notes or message pads as they occur. Putting questions in a binder in a central area such as the Science Center or posting them on a bulletin board will remind you and the children to refer to them regularly.

Other suggestions for tracking children's questions throughout the year include:

- **K-W-L Charts (Know-Want to Know-Learned)—**Use the "Want to Know" column of a K-W-L chart to record children's questions about a particular area of science.
- **Question Board—**Create a bulletin board just for questions. Let the children write questions on index cards, self-sticking notes, or scrap paper or let them dictate questions to you to write and post on the board. Return to the board from time to time to see if any of the questions have been answered through the experiences the class has had, or if anyone has learned the answer by other means.

- **Question Box or Envelope—**Leave a box or large envelope in the Science Center or post it on a bulletin board. Tell children to write questions and deposit them in the envelope or box. This method allows a shy child a chance to ask a question without fear of being pinpointed. Again, from time to time sort through the questions. You can add them to the K-W-L chart as appropriate, assign them as independent research, or use them as discussion topics.
- **Notebook—**Put a blank notebook in the Science Center to serve as a place to store questions. Have the children write their questions at the top of a page and leave room at the bottom of the page for the answer or answers when they are found.

For more information on tracking ideas and questions, see also the *Teacher Reference Materials* article, "Setting Up a Science-Friendly Environment."

Developing Cooperative and Collaborative Learning

The ability to work with others is a skill that will serve children for a lifetime. It's also a fundamental part of working as a scientist, as reflected in the national science standards and benchmarks. Working together is important, particularly when studying science, but it's not something that always comes easily. On the contrary, many young children strive for independence. The group process to them might mean, "I participate best by doing it myself." To work as equal participants in a group, children need to know the benefits of working with others as a team. They need to practice the necessary skills to be a successful group member. They need to know what it means to work as a partner versus what it means to work alone.

The Science Companion curriculum incorporates elements of cooperative learning with the goal of improving attitudes toward learning and academic achievement. It strives to improve social skills and reduce time off task, and helps develop speaking, listening, and writing skills. Collaboration creates an atmosphere in which children can share ideas and ways of thinking as they solve problems. It also prepares children for real life situations. When they are adults in the work force, they will see that people share responsibilities with others, cooperate, and work together toward common goals.

Cooperative learning requires that children work on group interactions (such as social and communication skills) while focusing on the task at hand. This is especially important to practice for children who have had less experience with group work. Small groups are better for very young children or those without group-based experience. A pair is considered a group and can be a good place to start building cooperative skills. The following are some suggestions for setting up cooperative learning groups in your classroom:

- Brainstorm rules for positive behavior and post them in your classroom.
- Identify the different types of talent and personalities within your class, and support them when assigning groups.
- Praise appropriate group interaction behavior.
- Start with small groups and be flexible with group sizes.
- Assign and rotate roles.

Some children get excited and want to do everything, while others may feel less inclined to participate. To make roles more equitable, you may wish to assign each child a different task, and rotate the roles. By assuming a role, each child has a responsibility not only to him or herself but also to the group. In a collaborative setting, group members listen to and respect others' perspectives, and time is provided for children to be exposed to other ways of thinking and problem solving. All group members are individually accountable, yet their reflections may be a result of collaborative thinking.

"We believe that when students work in cooperative groups, sometimes their peers reach different learning styles better than the teacher."

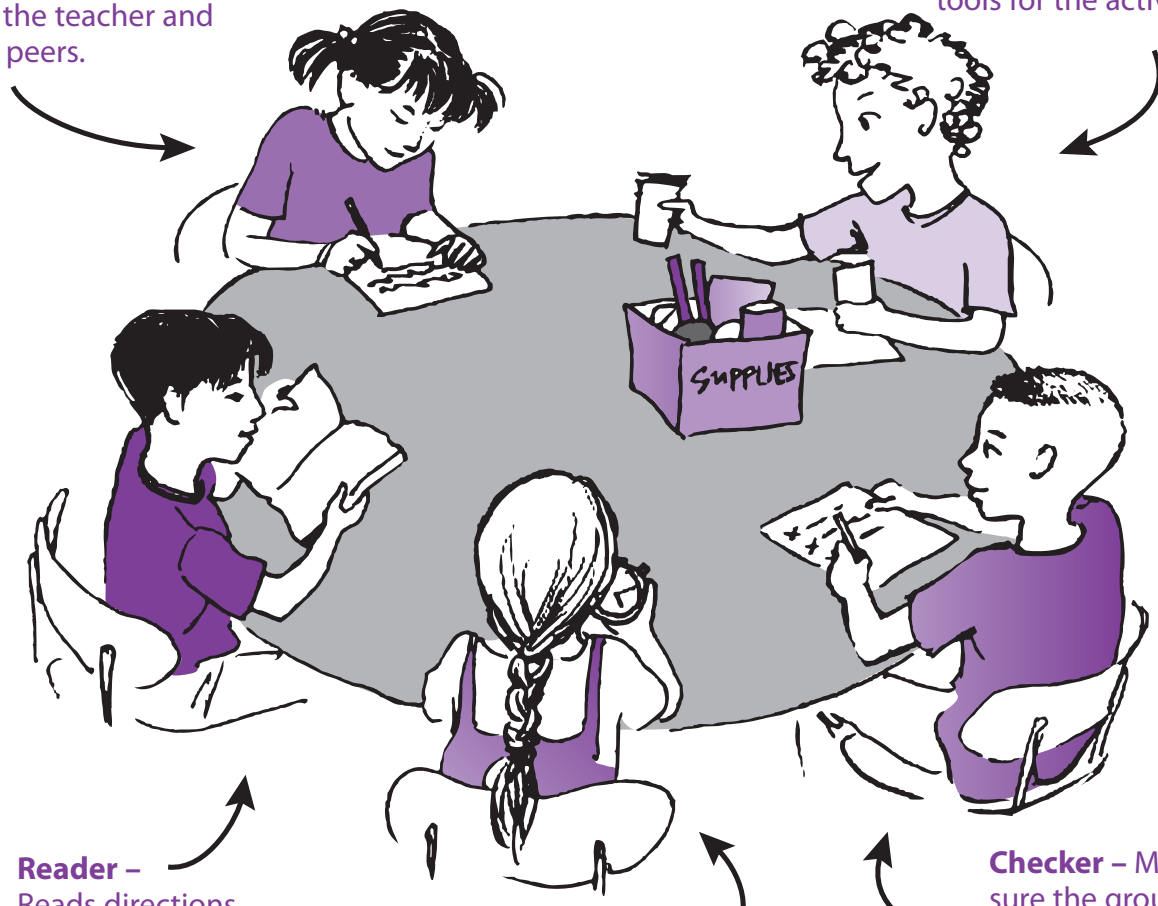
Kerry Wylie (Edwardsville Elementary)

Developing Cooperative and Collaborative Learning

Cooperative group roles and tasks might include the following:

Reporter – Presents what the group did to the whole class. This role provides a chance to have an extended discussion with the teacher and their peers.

Materials Collector – Gathers supplies and tools for the activity.



Reader – Reads directions

Timer – If necessary, monitors time.

Checker – Makes sure the group is doing all parts of the activity.

Developing Cooperative and Collaborative Learning

More Cooperative Learning Tips

- **Plan seating arrangements according to groups. Seating can assist transitions between whole group, small group, and individual work times.**
- **Group children accordingly. For example, grouping one high skill/achievement child, one low skill/achievement child, and two middle skill/achievement children can work well.**
- **Refer to the three basic principles of constructive partner and group interaction—guide, check, and praise—before, during, and after activities.**
- **Post rules for working in small groups and practice them in a variety of settings:**
  - **Be polite.**
  - **Take turns.**
  - **Talk about problems.**
  - **Speak quietly.**
  - **Praise each other.**
  - **Help each other.**
  - **Share.**
  - **Listen to each other.**
- **Use visual signals to indicate group functioning. For example, give each group one red and one green cup. Tell the children to stack and display the cups to indicate whether they need help. (Green: Everything is running smoothly. Red: We need help.) No group should display a red cup until every group member has tried to solve the problem or answer the question.**
- **Dedicate at least one full lesson to teaching cooperative group skills.**

From Everyday Mathematics™ (The University of Chicago School Mathematics Project, Everyday Learning Corporation, 2001.)

Working with Special Needs

The classroom is a diverse mini-world filled with all kinds of learners with different backgrounds. If you teach in a full inclusion classroom, you're already aware of the challenge to meet the diverse needs of the children in your charge. Fortunately, you'll find that many of the teaching methods in the Science Companion curriculum are adaptable to all of your children's learning styles and levels.

Two of the most frequently used methods are cooperative groups and working as partners. These methods insure that all children get involved. They learn from each other and can be less reliant on you as a helper, fostering independence for each team member. They can come up with ways to assist each other based on their existing skills.

Children of all ability levels can experience science by using the program's focus on hands-on activities and discovery-by-doing methodology. While the Science Companion program can't claim to address every special need of every child in every classroom, the very nature of inquiry-based science gives a broader range of strategies for teachers to use, and for children to learn from.

The following suggestions can help you address special needs students in a science-friendly classroom. Adapt or emphasize these ideas for the individuals in your classroom.

- Involve the child's parent or guardian by communicating with them frequently and inviting them into the classroom. A parent or guardian may be the child's best advocate and may be able to give you specifics about a child's situation that you could use at school.
- Share science process skills and concept goals with the ESL (English as a Second Language) staff, resource room teachers, and special education teachers in your setting. Collaborate with them to think of ways to incorporate science for children with whom you share instructional time. If you find skills that can be combined, consider including science-related goals on children's IEPs (Individualized Education Plan). These also can be helpful for measuring growth and communicating with parents or administrators.
- During your advance planning of the unit, identify and make note of those tasks that may need adjustment for the special needs child. For example, the deaf or hard of hearing child may need to have an interpreter for the discussions that are imperative to understanding the lesson's concepts. If there is a lot of writing involved, the language-impaired child may need a different method to record their observations.
- Positive feedback is especially important for the special needs child; it helps them stay focused and motivated, and feel included in the group.

Orchestrating an Active Class

As you read through the *Teacher Reference Materials*, note the areas that you think will require extra attention in your class. For example, if you have a class that is inexperienced with cooperative group work, you may want to focus on that area. Some explorations may require more detailed and specific management techniques. These include explorations that involve going outdoors or to a special setting, inviting guests, or using materials that require special handling. Throughout the lessons, you'll find management and safety notes to remind you to pay special attention while addressing these types of situations. In addition, A Quick Look and Preparation sections of the lessons include suggestions for enlisting an extra pair of adult hands or eyes. If you use outside help, make sure your volunteers also know your expectations and understand the activities.

Inside the Classroom

Science is an active, hands-on learning time; children get excited working through the process and learning the content. They love it! Science time may get a bit more noisy, and have more things happening at once than other parts of the school day. But learning thrives on focused high energy, and not chaos. In order to balance children's productive excitement and energy with the need to stay focused and calm, it is important to establish clear behavior expectations early in the school year.

Generally, expect your established classroom rules to continue during a science session. There are a few guidelines that you'll want to emphasize when focusing on science. These include students knowing how to:

- Work cooperatively in small and large groups
- Use tools correctly and safely
- Clean up the area and store supplies
- Use space for designated activities
- Watch and listen for attention signals
- Practice effective listening and discussion skills
- Take care of supplies and respect others' materials

Orchestrating an Active Class

Outside the Classroom

Just when you think you've got your class under control, you realize it's time to go on an off-site exploration! (Or at least leave your classroom.)

Field work is another reason why children love science. Although there are lots of science opportunities and some simulations that can be done in class, the outdoors is the natural laboratory for the scientific world. Regardless of whether you venture into the schoolyard or visit the zoo, preparation is the key to a successful learning experience.

Though each trip outside your classroom is different, the following guidelines may help make your science-related field trips successful:

- Preview the site well before the day you go there. Make notes of potential problems, such as possible weather changes, harmful plants, and accessibility.
- Make lists to insure that everything you'll need goes with you. Take a pen and paper on a clipboard. Depending on your destination, you might want to bring hand cleaner, water, and perhaps a cell phone, in case of emergencies.
- Have adult volunteers arrive early before an outing and advise them of the details of the trip.
- Make sure your class leaves the environment as you found it.
- Review safety rules with children, such as "never eat anything off the ground."
- Review with children the processes of observing, touching or handling, and using tools.
- Include rules that emphasize staying within boundaries, sticking with a partner, and reporting back regularly to an adult.
- Stress that any living thing that's collected should be returned to the site some day. (Purchased animals should not be released outdoors.)
- Share the adage "Take only memories; leave only footprints." This guideline promotes long-term environmental stewardship even when children are not in class.