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Science for Young Children

Our Theme

In 1956, marine biologist and conservationist Rachel Carson wrote a book, *The Sense of Wonder,* about the time she spent along the Maine coastline with her young nephew, Roger. From the time Roger was just a baby until he was more than 4 years old, he and Rachel shared adventures in the world of nature. She never set out to "teach" him anything, but rather to have fun and marvel at the plants and animals, the sounds and smells, the rocks and waves they encountered on walks through the woods and along the ocean. Roger, of course, learned a great deal as Rachel explored with him, calling his attention to various things and talking with him about what they observed. Roger learned as the two of them made discoveries *together*.

In *The Sense of Wonder,* Carson wrote, "a child's world is fresh and new and beautiful, full of wonder and excitement. It is our misfortune that for most of us that clear-eyed vision, that true instinct for what is beautiful and awe-inspiring, is dimmed and even lost before we reach adulthood. [I wish that] each child in the world be [given] a sense of wonder so indestructible that it would last throughout life …" (Carson 1956). "Sense of wonder" has become the theme of our *A Head Start on Science* (*HSOS*) program (see Appendix C); we strive to bring teachers of young children the resources and support they need to heighten and expand children's innate curiosity about the natural world. *A Head Start on Life Science* lessons are written to help adults facilitate young children's learning as they work as partners in exploring the natural world. We hope your sense of wonder will be heightened as you engage in science explorations with children, actively following as their curiosity leads them to discoveries about all that they see, hear, smell, and touch.

High-Quality Early Childhood Science Education

Science learning experiences are important in early childhood education. Early childhood science education (ECSE) engages teachers and children in high-quality interactions that can not only promote children's understanding of science concepts and skills but also can narrow the achievement gap (Cabell et al. 2013) and provide a meaningful context for developing literacy and math skills (Gelman et al. 2009). In fact, compared to other learning contexts (e.g., reading or math instruction), teachers engage in higher-quality teacher–child interactions when they engage in science (Cabell et al. 2013). These high-quality interactions, including supports for concept development, expanding on child ideas, and use of open-ended questions and advanced language, significantly enhance children's cognitive development and thus their academic outcomes (Mashburn et al. 2008). Additionally, ECSE can lead to gains in language achievement for English-language learners, particularly for speaking and listening skills (Gomez Zwiep and Straits 2013).

However, ECSE varies greatly in classroom practice. In the extreme cases, "science" experiences look more like arts and crafts projects (for example, painting pumpkins or gluing feathers on paper birds) that do little to promote children's science learning. At the opposite extreme, ECSE can consist of teacher-directed activities that emphasize academic learning and scientific vocabulary. Although the balance in ECSE has been much debated, this book is written with the belief that the optimal early learning experiences for children lie somewhere between these two extremes. ECSE should not be a series of isolated activities that occupy children but fail to engage them in prolonged investigation or produce long-lasting, meaningful learning. Likewise, ECSE should not consist of experiences that are entirely teacher directed and academic, placing emphasis on the products of learning (e.g., vocabulary) rather than the process; that do not develop children's abilities to engage in science practices; and that fail to foster science dispositions such as persistence, curiosity, questioning, and exploring.

ECSE experiences should address topics relevant to children's everyday experiences that can be experienced firsthand, serve as bases for collaboration and communication among children and adults, and have the potential for meaningful investigation. And, although these high-quality ECSE experiences can take many different forms, they generally have three components at their core: generating and relating to children's interests; facilitating collaborative, child-driven investigation; and providing opportunities for children to reflect on, represent, and apply what they've discovered. The three components are sequential, systematically building children's understanding. Importantly, the three components should be accomplished over days of instruction, in amounts of time consistent with the development and age of your children.

High-quality ECSE experiences begin with children's interest and curiosity. At the beginning of ECSE learning experiences, teachers must tap into children's existing curiosity and generate new interest about the phenomenon to be explored. Aligning with children's curiosity helps to ensure that children are intellectually engaged and sustain interest during a sequence of prolonged and meaningful investigations of science phenomena present in the world around them. Although teacher facilitated, these investigations need to be child driven, emphasizing children's decisions and meaning-making. It is during investigations that children develop their skills in using science practices, such as observing, measuring, comparing, sorting, communicating, and graphing, as well as important language and social skills. Although engaging in science investigations and employing different science and communication skills are important for learning, they alone are insufficient. For meaningful, lasting learning, children also need opportunities to reflect on, represent, and apply their new understandings. This thinking about, sharing, and using new understandings helps children to solidify what they've learned, builds metacognitive skills, and also leads children to new explorations. The lessons in *A Head Start on Life Science* are consistent with this view of learning and are written to help you as the teacher learn to design and implement effective science learning experiences.

Our Beliefs About Science for Young Children

Central to our understanding of young children is the idea that a sense of wonder is innate; children are naturally awestruck by and curious about the natural world. Further, the exploration of this amazing natural world is natural for young learners. We believe that a sense of wonder is part of all children's experience and that children are intrinsically motivated to explore the natural world. Therefore, it is important that *all* children have access to culturally relevant science experiences that are of value in learners' everyday worlds. Formal science education settings must tap into this natural interest in science by providing authentic materials, allowing a degree of child autonomy, and celebrating each child's success. Additionally, science education for young learners must utilize play and emphasize free exploration as a means for learning, provide opportunities to teach and learn from peers, recognize that trial and error are natural parts of the scientific learning experience, and emphasize the importance of process over right and wrong answers.

Teachers charged with facilitating science education for young learners face a great challenge. Teachers must abandon the traditional view of the teacher as disseminator of information and adopt roles as facilitators of learning. Consistent with this, a primary role of the early childhood science teacher is to provide an appropriate learning environment and opportunities for children to explore, represent, and share their discoveries. Teachers need to model excitement and enthusiasm when involved in science exploration and when planning and anticipating discoveries. Throughout the design of learning experiences, teachers need to recognize that the process of discovery and the science practices children engage in are more important than learning science facts and that science experiences can be highlighted at all times and in all parts of the classroom and outdoors, not just during "science time" or at the "science center." As children engage in science investigations, adults should observe children's actions and listen to children's conversations so that they can follow children's leads; child-initiated learning is of great importance and should be encouraged and supported. Additionally, effective early childhood teachers must be effective parent educators and involve families in their children's science activities.

Throughout our work with children we must all emphasize the exciting process of discovery over science information. Rather than understanding science as the learning of already-known answers, our children should see science as the exploration of a vast and wondrous world of infinite mysteries. The experience is the objective; instead of telling children science facts, nurture their curiosity, interest, and joy. These attitudes and foundational experiences can serve as a basis for a lifelong love of science.

We firmly believe that children enrolled in the types of early childhood programs described here, where active learning and children's exploration are central, where teachers emphasize science practices and child-initiated investigation, and where teachers and families are actively involved in children's science learning, are more likely to succeed in school, and in life, than children who are denied these important learning experiences.

Developmentally Appropriate Science

The lessons in *A Head Start on Life Science* were created with these beliefs in mind and designed for developmentally appropriate use in early childhood education settings. Inspired by and adapted from the activities in NSTA's *A Head Start on Science: Encouraging a Sense of Wonder,* edited by the founder of our project, William Ritz, each lesson has as its basis active, hands-on involvement of children and focuses not on teaching children "science facts," but rather on nurturing children's innate curiosity about the natural world and encouraging children to make discoveries on their own. Teachers familiar with the activities in the original book will find the lessons here to be useful models for expanding science activities into integrated inquiry lessons. The lessons are intended to help teachers to expand children's thinking in an area of interest and are designed to help teachers to come to understand a method for sequencing learning opportunities that promotes understanding. In ECSE, children's interest and prior knowledge are key—developmentally appropriate science meets children where they are and allows children to participate at their own level. These lessons provide experiences that are hands-on, concrete, and relevant and allow children to learn through play and social interaction. *A Head Start on Life Science* integrates learning across domains, allowing for science learning throughout a child's school day as well as at home with his or her family. The learning situations across all lessons and activities are flexible, allowing teachers to follow children's interests and questions. And throughout all the lessons we emphasize children's thinking and use of science practices rather than focus on factual knowledge or right or wrong answers.

Lesson Overview

Introduction

Each lesson in *A Head Start on Life Science* provides teachers with introductory information to help prepare for the learning experience. The information includes a brief description of the lesson and a listing of the learning objectives, required materials, and safety considerations. This information is here to assist you in preparing your lesson and deciding where in your unit of study this lesson would best fit. Additionally, for each lesson we provide relevant teacher content background. In our many years of working with early childhood educators, we have often heard teachers express a desire for more science content. We are providing it in this revised version. However, we emphasize that this information is for teachers' knowledge only and is there to assist you in your own learning. This information should NOT be directly taught to young children. Studies have shown that formal, teacher-directed instruction is at best ineffective and at worst detrimental to children's long-term growth as learners. Our goal is not for children to acquire "facts," but to be active explorers, reveling in the process of discovering more about the natural world around them. In addition to the teacher content background, we provide a list of key science terms for teachers to be aware of as they prepare for the lesson. Keep in mind that vocabulary acquisition is not our primary intent. Capitalize on opportunities for vocabulary development when they arise naturally during your conversations with children, but do not feel compelled to

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force vocabulary into these learning situations. In all situations, our primary goal is to enhance children's sense of wonder—their innate curiosity about and appreciation for the natural world all around them. Following the introductory material, the procedure for each science lesson is described.

Procedure

Aligned with high-quality ECSE and inspired by the learning cycle[1] (Atkin and Karplus 1962), we've designed lessons where children are first, oriented toward the topic to be investigated; second, given a chance to explore and develop an understanding of concept; and third, supported in formalizing that understanding by explaining or applying. Subsequently, the procedure for each lesson is divided into three sections: *Getting Started*, *Investigating*, and *Making Sense*, each of these sections serving an important purpose in the development of new knowledge. Although there is broad consistency across lessons, the specific ways that children are oriented toward a topic, explore and develop an understanding, and formalize that understanding can vary from lesson to lesson. We have been intentional in our effort to highlight these alternatives across the lessons provided here, and these options are described below and in the model in Figure 1.1, on page 6.

In all learning, it is important to give children an introduction before engaging in teacher-structured explorations. We call this introduction *Getting Started* and encourage teachers to use this time to allow children to play with materials, share what they already know about a topic, and ask questions. Only after this introduction are children ready for directed exploration. *Getting Started* helps prepare children to learn by activating prior knowledge, allowing free exploration of materials, generating interest, and giving purpose to their investigations. What you choose to do with children can vary from lesson to lesson, but for all lessons children need an opportunity to orient to the topic before structured learning experiences can occur. There are five categories of teacher actions in the *Getting Started* section; most lessons employ two or three of these. The teacher actions are

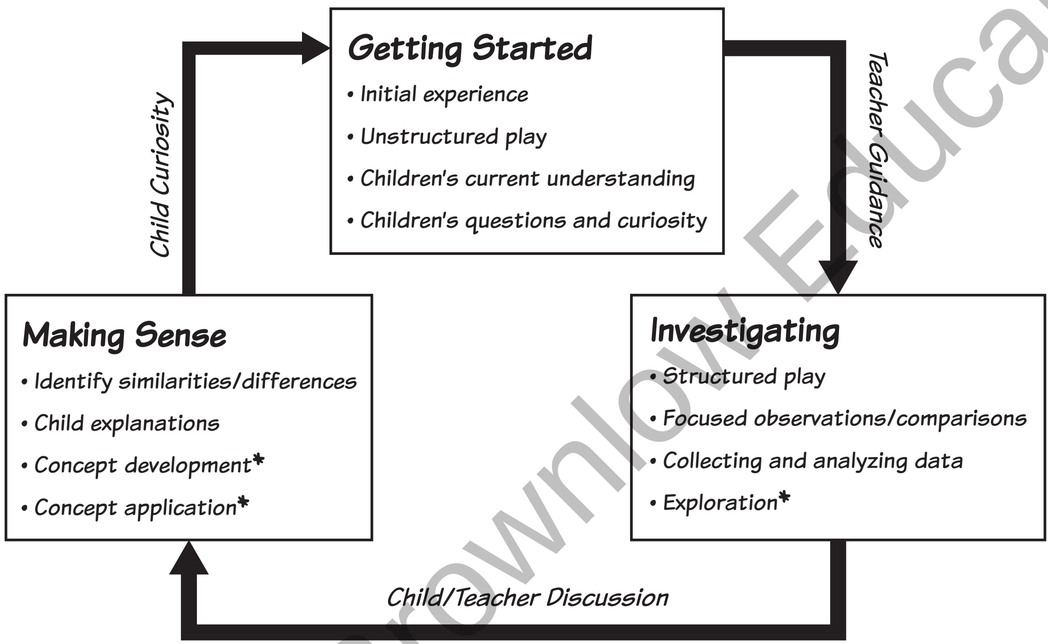
1. **Prior knowledge.** Show or describe an example of the topic of interest and use questioning to probe children's prior knowledge about the topic. (For example, "What do you know about elephants?")
2. **Introduction.** Introduce phenomena or materials to children to explore, asking children to describe them. (For example, "Look closely at these seeds and share what you notice.")
3. **Child questions and curiosity.** Ask what they know about the phenomenon and what questions they have about it. (For example, "What questions do you have about fish?")
4. **Prompting questions.** After children have gotten a chance to explore and wonder themselves, introduce a question. (For example, "How have the seeds changed?")
5. **Initial explanations.** Ask children to explain the reasoning behind their initial answers to your prompting questions and record their responses. (For example, "Why do you think it will move or change that way?")

1 The learning cycle is a three-part teaching model. The first phase, "exploration," has students engaged in teacher-facilitated experiences; in the second phase, "concept development," teachers guide students in understanding the concept(s) related to their explorations; and finally, in "concept application," the teacher presents a situation for students to use their new understanding(s). In this book, you'll find parallels between "exploration" and the *Investigating* of many lessons, as well as between the "concept development" and "concept application" phases and some aspects of *Making Sense*.

Figure 1.1

Lesson Model

Model demonstrating the three-phase lesson sequence used for each of the A Head Start on Life Science lessons and the components that can be included in each of the three phases.



** Denotes connections to the learning cycle (Atkin and Karplus 1962)*

All five do not need to be in each lesson, but high-quality science lessons nearly always begin with one (or more) of these actions.

Investigating provides an opportunity for children to actively work with materials to generate new understandings of and appreciation for some natural phenomenon. Capitalize on opportunities to discuss new science concepts and vocabulary, but use a light touch. With our young children, the experience is our primary objective. Let children's interests shape the direction and outcomes of your science explorations. The *Investigating* descriptions (like all of the descriptions) provided in each lesson are intended as guides, suggesting one set of possibilities. You do not need to adhere strictly to them. Let your children's curiosity take you and your lesson in new directions. Throughout this time, use questioning to encourage children to observe details, make comparisons, and notice differences that might otherwise have been overlooked. Keep in mind that your aim in this questioning (and in questioning throughout the lesson) is to be conversational; be a learner with your children. Share ideas, insights, excitement, and questions. Model for your children what enthusiastic science learning looks like. Whether you are a preschooler or a professional scientist, there are two important parts to investigating:

1. **Collecting data.** This includes experimenting, observing, measuring, and documenting and can be encouraged by the teacher by asking prompting questions such as "How can we test that idea? What do you notice? How big is it? How could we keep track of these ideas?"
2. **Analyzing data.** This includes comparing and sorting (across objects and processes as well as across children's ideas and findings), encouraged by prompting questions such as "Which of these are similar? Which are different? How are these alike? In what ways are these different? Can you put these in order from smallest to largest?"

In the *Investigating,* phase children take center stage as they actively explore phenomena. However, teachers play a very important role in these investigations, including providing appropriate materials and supports; sequencing activities so that they build understanding and curiosity; and being active participants, engaging in explorations with children. The conversations and questions you have with children will help them to better understand and appreciate the science topic being explored. [Note: Sometimes lessons have two separate but related activities that take place during the *Investigating* section. When this occurs, the individual activities are designed to be experienced sequentially and are referred to as *Investigating 1* and 2.]

Making Sense provides children with an opportunity to represent and share results and to apply, sum up, think about, and discuss what they discovered during their investigations. To develop critical thinking skills and a more lasting understanding of what they learn, learners need to be given the opportunity to reflect on their investigations. This reflection may mean the discussion of similarities or differences or the identification and generalization of patterns discovered during the *Investigating* section. Teacher questioning and guidance are important to facilitate this sense making. Throughout the *Making Sense,* section, remember that child explanations, based on discoveries made during their Investigating, are more important than the "correct" scientific explanation. There are four important processes in *Making Sense:*

1. **Describing findings.** Articulating our thoughts helps us to clarify and reinforce our understandings; this is true for children as well as adults. Communicating about the outcome of an exploration is important for learning and can be part of the investigation itself or the sense making that follows. In *Making Sense,* encourage children to describe and represent (through drawings, text, graphs, etc.) what they've learned and how different phenomena compare. For example, while making sense of an investigation, children might state, "The spiny seed sticks to things, but the smooth seed doesn't" or "All of these birds have feathers."
2. **Generating explanations and identifying patterns.** Here, learners, just like scientists, take an investigation one step further, going beyond simply stating the results to explaining the meaning of the results or the trend across multiple results. In these efforts, children use (and further develop) their reasoning and critical-thinking skills as they engage in concept development. For example, after exploring the insides of several fruits, a child may be able to tell you that (or ask you if) all fruits have seeds. Although developmentally, many of our younger children may not be ready to make these leaps, as a part of science investigations they should still have opportunities to explain their thinking at a level appropriate

for each individual child. The correct explanation is not our goal; our goal is to provide children with opportunities to explain their thinking and develop their reasoning skills.

3. **Application.** Opportunities to apply new knowledge are important for long-term learning. In *Application* children are asked to use what they discovered during the investigation(s) to explore a different, yet similar, phenomenon. For example, after developing the skill of sorting using beans, children could use this new skill to sort buttons; after studying a goldfish, children could observe other fish to see if they too have fins, gills, tails, and so on.

4. **Curiosity**. Science investigations often lead to new ideas and new investigations. This continued exploration is one of the aspects of science that most interests scientists and motivates them to devote their lives to scientific study. We want to help nuture this same passionate curiosity in our children by encouraging them to identify what questions they have about the phenomenon studied and what they'd like to explore next. Let their interests determine your next *Getting Started* experience.

Each lesson encourages children to engage in one or more of these four processes. And very often, these processes will prompt the exploration of new topics or questions; a successful lesson is one that inspires further learning. [Note: As in the *Investigating* section, on occasion there are two parts to this final section. When this happens, the parts are referred to as *Making Sense 1* and 2.]

Beyond the Lesson

After the lesson, we provide ideas for extending the science learning in a section called *What's Next?* We first provide an extension activity that describes one or more science activities related to the topic explored during the lesson. It's our hope that these extension activities link to the *Making Sense* section by connecting to children's curiosity and offering additional opportunities for children to apply what they've learned. The ideas provided in the extension activity are not as detailed as in the lesson; it's up to the teacher to structure these activities in a manner consistent with the *Getting Started*, *Investigating*, and *Making Sense* format.

It's important to remember that science need not be a stand-alone subject limited to science time or relegated to a dusty science table. Science naturally connects to math and language arts. Ideas for making these connections are provided in the *Integration to Other Content Areas* section. In *Other Connections*, we present still more ideas for connecting the science lesson to other parts of the school day. Examples for increasing the relevance of the science lesson in the child's life are given, as are ideas for the art, sensory, and dramatic play centers. Additionally, the Family Activities section provides ideas for how families might interact with their child; these are provided in English and Spanish and are written with parents and guardians in mind.

What to Look For and *Standards* are the final sections provided. The *What to Look For* section lists questions that teachers can ask themselves in an attempt to gauge children's progress toward learning goals. After each question, the academic skills that may be demonstrated by children as they respond are briefly indicated. These academic skills are based on indicators included in several preschool and primary grade frameworks and assessments,including HighScope's *Preschool Child Observation Record* (2015), *Teaching Strategies GOLD: Objectives for Development and Learning* (Burts et al. 2016), *Head Start Early Learning*