Learning science in informal environments is a diverse enterprise and serves a broad range of intended outcomes. These include inspiring emotional reactions, reframing ideas, introducing new concepts, communicating the social and personal value of science, promoting deep experiences of natural phenomena, and showcasing cutting-edge scientific developments. This book recognizes several principles:

- Knowledge, practice, and science learning commence early in life, continue throughout the life span, and are inherently cultural.
- Science is a system of acquiring knowledge through systematic observation and experimentation.
- The body of scientific knowledge that has been established is continually being extended, refined, and revised by the community of scientists.
- Science and scientific practice weave together content and process features.
- Effective science education reflects the ways in which scientists actually work.

Science learning involves much more than the acquisition of disciplinary content knowledge and process skills. Like the scientific proficiencies enumerated in Taking Science to School (National Research Council, 2007), science learning can be envisioned as strands of a rope intertwined to produce experiences, environments, and social interactions that provide strong connections to pull people of all ages and backgrounds toward greater scientific understanding, fluency, and expertise. Informal science learning experiences often occur in situations that immediately serve peoples' interests and prepare them for their future learning in unanticipated ways. Learning experiences in informal settings also grab learners' attention, provoke emotional responses, and support direct experience with phenomena. In this sense, informal settings occupy an important and unique space in the overarching infrastructure of science learning. At a broad level, informal environments have strengths that are unique and complementary to the strengths of schools. (pp55-56)

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Public discussions of learning usually focus on the experiences and outcomes associated with schooling. Yet a narrow focus on traditional academic activities and learning outcomes is fundamentally at odds with the ways in which individuals learn across various social settings: in the home, in activities with friends, on trips to museums, in potentially all the places they experience and pursuits they take on. The time that children spend pursuing hobbies of their own choosing—in such activities as building, exploring, and gaming—often provides them with experiences and skills relevant to scientific processes and understanding. Adults faced with medical conditions typically learn what they can do to manage them from a wide variety of information sources. Families spend leisure time at science centers, zoos, and museums engaged in exploration and sense-making. Communities defined by linguistic and cultural ties maintain science-related practices and socialize their children into their routines, skills, attitudes, knowledge, and value systems as a part of their daily activities and rituals.

For all these pursuits, the range of learning outcomes far exceeds the typical academic emphasis on conceptual knowledge. Across informal

settings, learners may develop awareness, interest, motivation, social competencies, and practices. They may develop incremental knowledge, habits of mind, and identities that set them on a trajectory to learn more.

The ongoing connections among experiences, capabilities, dispositions, and new opportunities to learn continue throughout a person's life. The fundamental influence of early childhood experiences is increasingly recognized as providing the foundation for discipline-specific learning (National Research Council, 2007). As the population ages, demographic shifts heighten the need to understand the ongoing role that science learning has in the lives of adults, including the elderly.

The informal education community pursues a range of learning outcomes. The idea of lifelong, life-wide, and life-deep learning has been influential in efforts to develop a broad notion of learning, incorporating how people learn over the life course, across social settings, and in relation to prevailing cultural influences (Banks et al., 2007). (pp27-28)

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We propose a "strands of science learning" framework that articulates science-specific capabilities supported by informal environments. It builds on the framework developed for K-8 science learning in Taking Science to School aligns tightly with our Strands 2 through 5. We have added two additional strands—Strands 1 and 6—which are of special value in informal learning environments. The six strands illustrate how schools and informal environments can pursue complementary goals and serve as a conceptual tool for organizing and assessing science learning. The six interrelated aspects of science learning covered by the strands reflect the field's commitment to participation—in fact, they describe what participants do cognitively, socially, developmentally, and emotionally in these settings.

> Learners in informal environments:
>
> Strand 1: Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.
> Strand 2: Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.
> Strand 3: Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.
> Strand 4: Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.
> Strand 5: Participate in scientific activities and learning practices with others, using scientific language and tools.
> Strand 6: Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science.

The strands are distinct from, but overlap with, the science-specific knowledge, skills, attitudes, and dispositions that are ideally developed in schools. Two strands, 1 and 6, are particularly relevant to informal learning environments. Strand 1 focuses on generating excitement, interest, and motivation—a foundation for other forms of science learning. Strand 1,

while important for learning in any setting, is particularly relevant to informal learning environments, which are rich with everyday science phenomena and organized to tap prior experience and interest. Strand 6 addresses how learners view themselves with respect to science. This strand speaks to the process by which individuals become comfortable with, knowledgeable about, or interested in science. Informal learning environments can play a special role in stimulating and building on initial interest, supporting science learning identities over time as learners navigate informal environments and science in school. (pp3-4)

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Virtually all people of all ages and backgrounds engage in informal science learning in the course of daily life. Informal environments can stimulate science interest, build learners' scientific knowledge and skill, and—perhaps most importantly—help people learn to be more comfortable and confident in their relationship with science. Researchers and educators interested in informal settings are typically committed to open participation in science: building and understanding science learning experiences that render science accessible to a broad range of learners. There is increasing interest in understanding cultural variability among learners and its implications: how learners participate in science and the intersection of values, attitudes histories, and practices that are evident in learner and scientific communities. Accordingly, two notions of the culture of science underlie the committee's conclusions and the recommendations that follow.

In one sense, there is a culture of science in that science involves specialized practices for exploring questions through evidence (e.g., the use of statistical tests, mathematical modeling, instrumentation) which people must acquire if they wish to enter the formal domains of science. This first sense of the culture of science also includes social practices such as peer review, publication, and debate. In a second sense, science reflects the cultural values of those who engage in it—in terms of choices about what is worthy of attention, differing perspectives on how to approach various problems, and so on. From this latter perspective, as is the case with any cultural endeavor, differences in norms and practices within and across fields reflect not only the varying subject matters of interest but also the identities and values of the participants. The recognition that science is a cultured enterprise implies that there is no cultureless or neutral perspective on science, nor on learning science—any more than a photograph or painting can be without perspective. Thus, diversity of perspectives is beneficial both to science and to the understanding of learning. It also stands as a potential resource for the design of informal environments for science learning. (pp305-6)

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