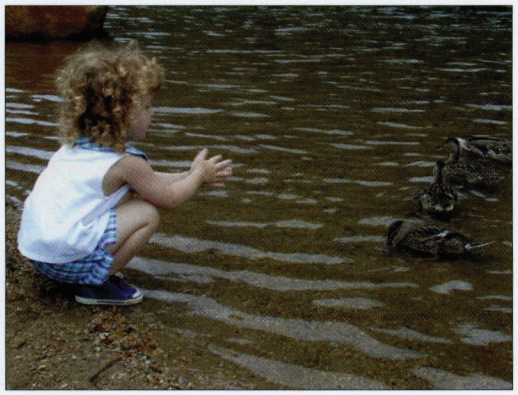
1.5 The Way Science Works

"Why" questions have been posed ever since humans have had conscious brains, and over the course of the last 300 years or so, observant, curious people scattered everywhere on Earth have, in common, devised a verifiable, self-correcting system for answering these questions. We call that systematic asking of questions and search for answers science.

Science is, in essence, organized curiosity. It is initiated by careful observation and nurtured by wonder, creativity, and skepticism. While the overall pattern of a scientific inquiry is common to scientific work, each individual explorer lays out his or her own itinerary into the unknown: observes an interesting event or phenomenon, identifies a particular aspect of it that can be stated as a problem, produces a hypothesis (an imagined scenario) that explains the event, and when possible, tests the hypothesis by experiment. In science *"one endlessly play[s] at setting up a fragment of the universe which the experiment . . . rudely correct[s]"* (François Jacob). The process is a wholly natural and active extension of the one we all use intuitively, from birth, to build our picture of reality.

Observation of and wonder at the workings of nature are what initiate "why" questions. These activities are not the sole province of scientists. In fact, they begin in childhood and are more or less developed in all of us. Throughout this book you will find observations of nature by novelists, poets, amateur scientists, and painters, done in their own ways. Science joins art as another branch on the tree of observation and wonder.

The hypotheses scientists come up with generally lend themselves to predictive statements: If I do this, that should happen. If a prediction is borne out by experiment or observation — if the predicted event happens — this outcome builds confidence in the hypothesis but cannot prove it right (since better information or new experimental techniques may come along later and indicate that it's wrong). Thus, good hypotheses are often those that suggest ways in which they can be proved false. If a hypothesis offers no way to prove itself false, it is not useful scientifically. The conclusions scientists arrive at after extensive observation or after experimentally testing many hypotheses are statements that have a greater or lesser probability of reflecting reality; they are never certainties. They gain strength as ongoing tests and accumulating evidence continue either to verify them or to prove reasonable alternative hypotheses to be false. And the better the conclusions fit with those of other experimental approaches to the same problem, the surer we are they're right. The possibility that some of our most cherished truths may someday turn out to be false can never be ruled out. *"In the growing cathedral of science, many crumbling stones at the growing points are replaced, and the more important their position, the sooner the defect is disclosed"* (B. D. Davis).



Hypotheses that are disproved by experiments have value, of course. They are signposts telling others where not to go. In science, an idea becomes substance only if it fits into a dynamic accumulating body of knowledge, a progression of understanding. Each new piece of work must fit into the bigger picture — the published work of other scientists. It is inspected, tested, tentatively accepted, modified, perhaps discarded. In the march of scientific discovery the artisans of experimentation blend into history like the builders of the great cathedrals. Scientists would have to have more than their fair share of egotism to avoid acknowledging their own expendability. This reality, as well as teaching us how little we know and how difficult what we do know was to come by, makes science a profoundly humbling experience.