

Benchmarks for Science Literacy Grades Kindergarten through Second Science Descriptions

The Universe

During these years, learning about objects in the sky should be entirely observational and qualitative, for the children are far from ready to understand the magnitudes involved or to make sense out of explanations. The priority is to get the students noticing and describing what the sky looks like to them at different times. They should, for example, observe how the moon appears to change its shape. But it is too soon to name all the moon's phases and much too soon to explain them.

The Earth

There are many ways to acquaint children with earth-related phenomena that they will only come to understand later as being cyclic. For instance, students can start to keep daily records of temperature (hot, cold, pleasant) and precipitation (none, some, lots), and plot them by week, month, and years. It is enough for students to spot the pattern of ups and downs, without getting deeply into the nature of climate. They should become familiar with the freezing of water and melting of ice (with no change in weight), the disappearance of wetness into the air, and the appearance of water on cold surfaces. Evaporation and condensation will mean nothing different from disappearance and appearance, perhaps for several years, until students begin to understand that the evaporated water is still present in the form of invisibly small molecules. Teaching geological facts about how the face of the earth changes serves little purpose in these early years. Students should start becoming familiar with all aspects of their immediate surroundings, including what things change and what seems to cause change. Perhaps "changing things" can be a category in a class portfolio of things students observe and read about. At some point, students can start thinking up and trying out safe and helpful ways to change parts of their environment.

The Structure of Matter

Students should examine and use a wide variety of objects, categorizing them according to their various observable properties. They should subject materials to such treatments as mixing, heating, freezing, cutting, wetting, dissolving, bending, and exposing to light to see how they change. Even though it is too early to expect precise reports or even consistent results from the students, they should be encouraged to describe what they did and how materials responded. Students should also get a lot of experience in constructing things from a few kinds of small parts ("Tinkertoys" and "Legos"), then taking them apart and rearranging them. They should begin to consider how the properties of objects may differ from properties of the materials they are made of. And they should begin to inspect things with a magnifying glass to discover features not visible without it. No effort to introduce energy as a scientific idea ought to be organized in these first years. If children use the term energy to indicate how much pep they have, that is perfectly all right, in that the meaning is clear and no technical mischief has been done. By the end of the 2nd grade, students should be familiar with a variety of ways of making things go and should consider "What makes it go?" to be an interesting question to ask. Once they learn that batteries wear down and cars run out of gasoline, turning off unneeded appliances can be said to "save on batteries" and "save on gas." The idea that is accessible at this age is that keeping anything going uses up some resource. (Little is gained by having children answer, "Energy.")

Motion and Forces

From the outset, students should view, describe, and discuss all kinds of moving things—themselves, insects, birds, trees, doors, rain, fans, swings, volleyballs, wagons, stars, etc.—keeping notes, drawing pictures to suggest their motion, and raising questions: Do they move in a straight line? Is their motion fast or slow? How can you tell? How many ways does a growing plant move? The questions count more than the answers, at this stage. And students should gain varied experiences in getting things to move or not to move and in changing the direction or speed of things that are already in motion.

Presumably students will start "making music" from the first day in school, and this provides an opportunity to introduce vibrations as a phenomenon rather than a theory. With the drums, bells, stringed and other instruments they use, including their own voices, they can feel the vibrations on the instruments as they hear the sounds. These experiences are important for their own sake and at this point do not need elaboration.

The focus should be on motion and on encouraging children to be observant about when and how things seem to move or not move. They should notice that things fall to the ground if not held up. They should observe motion everywhere, making lists of different kinds of motion and what things move that way. Even in the primary years, children should use magnets to get things to move without touching them, and thereby learn that forces can act at a distance with no perceivable substance in between.

Diversity of Life

All students, especially those who live in circumstances that limit their interaction with nature, must have the opportunity to observe a variety of plants and animals in the classroom, on the school grounds, in the neighborhood, at home, in parks and streams and gardens, and at the zoo; but observing is not enough. The students should have reasons for their observations—reasons that prompt them to do something with the information they collect. The reason can be to answer the students' own questions about how organisms live or care for their young. Some students may enjoy displaying, with drawings, photographs, or even real specimens, all the living things they can find where they live. The point is to encourage them to ask questions for which they can find answers by looking carefully (using hand lenses when needed) at plants and animals and then checking their observations and answers with one another.

The anthropomorphism embedded in most animal stories causes some worry. One suggestion is to ignore it. Stories sometimes give plants and animals attributes they do not have, but promoting student interest in reading is more important than giving students rigidly correct impressions in their reading. Students can be guided toward making distinctions between stories that portray animals the way they really are and those that do not. Differences among students over the correctness of the portrayal of animals or plants in books should lead the students to reference works, which are another source of information that students must start learning to use.

Heredity

Teachers should lead students to make observations about how the offspring of familiar animals compare to one another and to their parents. Children know that animals reproduce their own kind—rabbits have rabbits (but you can usually tell one baby rabbit from another), cats have kittens that have different markings (but cats never have puppies), and so forth. This idea should

be strengthened by a large number of examples, both plant and animal, that the children can draw on.

Cells

Emphasis should be placed on examining a variety of familiar animals and plants and considering things and processes they all need to stay alive, such as food and getting rid of wastes. Students should use hand lenses to make things appear 3 to 10 times bigger and more detailed and should be encouraged to wonder what they might see with more powerful lenses.

Interdependence of Life

Students should investigate the habitats of many different kinds of local plants and animals, including weeds, aquatic plants, insects, worms, and amphibians, and some of the ways in which animals depend on plants and on each other.

Flow of Matter and Energy

Children should begin to be aware of the basic parts of the food chain: Plants need sunlight to grow, some animals eat plants, and other animals eat both plants and animals. The key step that plants make their own food is very difficult for elementary students and should be saved for middle school.

An awareness of recycling, both in nature and in human societies, may play a helpful role in the development of children's thinking. Familiarity with the recycling of materials fosters the notion that matter continues to exist even though it changes from one form to another.

Biodiversity

Students should begin to build a knowledge base about biological diversity. Student curiosity about fossils and dinosaurs can be harnessed to consider life forms that no longer exist. But the distinction between extinct creatures and those that still live elsewhere will not be clear for some time. "Long ago" has very limited meaning at this age level. Even as students make observations of organisms in their own environments, they can extend their experiences with other environments through technology.