Content Sequencing in Foundation Science

Many educational reports discussing science education in the 21st century stress the importance of a coherent curriculum, one in which conceptual understanding builds over time and content is connected rather than being a diffuse smorgasbord of facts. The flow of the curriculum in *Foundation Science*, beginning with the unit on ecology followed by cell biology, molecular biology, and genetics units, and ending in the evolution unit, is based on two schools of thought. First, although ecology is actually a very complex science, starting at the macro level with students can engage them more effectively than plunging into the cellular, biochemical and molecular level. In addition, the principles involved in ecosystems in the biosphere can help students better under the cell as a micro ecosystem, making the transition to the biochemical and molecular level easier. Second, to develop a deep understanding of evolution, a student needs to acquire knowledge about ecology, molecular biology and genetics.

In Foundation Science, the flow of a unit such as genetics is also predicated on first introducing the topic broadly, and then going deeper into specific concepts as students progress through the unit. For example, one of the more difficult concepts for students to grasp is the relationship among DNA, genes, proteins and traits. In the Foundation Science genetics unit, students first explore the nature of the genetic material, how it was identified, and how it stores information in the cell. They then move to understanding how information is translated from DNA to protein and how proteins can result in traits.

The relationship among genes, proteins, and traits is explored more deeply in the next learning experience about genetically modified organisms, and then students construct an understanding about where all this happens in the cell by examining the structure and function of chromosomes, where they also learn about meiosis and the formation of sex cells and zygotes. From there, students have the content needed to understand genetic variation and Mendelian and non-Mendelian genetics. Some of the thinking about the genetics flow is based on the work of Duncan, Rogat, and Yarden (*Journal of Research in Science Learning*, 2009), who discuss the importance of developing three levels of conceptual understanding in genetics: the *molecular model* that describes mechanisms for connecting genes to traits; the *meiotic model* that relates cellular process to recombination, sorting, variation, and transfer of information from one generation to the next; and the *genetic model* that describes patterns of inheritance and probability of traits.

Each Learning Experience (LE) also has a specific content flow. Students gather information from various sources such as readings, investigations, and discussions within the LE. The sequence of information in the LE is presented in a carefully constructed order such that students build understanding about the concepts being addressed. For example, in LE 3 the big idea is that traits of organisms are determined by the expression of specific genes in their DNA, an idea introduced in LE 2. This new trait is the result of the protein encoded by that gene. Students make a direct observation of this by inserting a gene encoding the enzyme luciferase into bacteria which gives them a new trait, the ability to glow in the dark. Students then read about how genes can be incorporated into an organism more complex than bacteria, i.e. a plant. Using this understanding they explain how organisms can be engineered to have traits that they would not have in nature.