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Curriculum Units by Fellows of the National Initiative
2010 Volume VII: Nanotechnology and Human Health

Introduction

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Humans can comprehend the structures of objects with an astounding range of sizes, from galaxies that we view with telescopes to sub-atomic particles. This seminar addressed two related questions: How does the size of an object influence its properties? What is special about objects that are 1-100 nm in size? The first half of the seminar addressed the first question, by exploring some of the different properties of small and large objects and how those properties influence an object's interactions with the rest of the world. To help focus this discussion, all seminar participants read the book *Why Size Matters* by John Tyler Bonner.

In the second half of the seminar, participants considered the second question by exploring the new science of nanotechnology. Nanotechnology is distinguished by the small size of the objects that are created and manipulated. Participants used their understanding of the consequences of size to appreciate the uniqueness of nanotechnology, and the technological hurdles that have been overcome to create ultrasmall components. The seminar focused on the potential role of nanotechnology in treatment and diagnosis of disease. Why is nanotechnology being suggested as the solution to so many health problems? To focus the discussion, participants concentrated on the special properties of nanotechnology that make it useful for treating and diagnosing cancer.

Specifically, the seminar covered the following topics:

1. Size and Scale
2. Structure of Matter
3. Forces and Interactions
4. Self-assembly
5. Size-dependent Properties
6. Medical Applications of Nanotechnology
7. Tools and Instrumentation
8. Scanning Electron Microscopy
9. Science, Technology, and Society

The discussions were enhanced by our reading from three books: *Why Size Matters*, John Tyler Bonner, Princeton University Press (2006); *Soft Machines*, Richard A.L. Jones, Oxford University Press (2004); *Big Ideas of Nanoscale Science and Engineering*, Shawn Y. Stevens, LeeAnn M. Sutherland, Joseph S. Krajcik, NSTA Press (2009).

The Fellows prepared curriculum units that covered a breadth of information on nanotechnology. The material

presented in the units assembled in this volume span an impressive range and are designed for use in classrooms from upper elementary (fifth grade) through high school.

Most of the units focused on material that is appropriate for high school students. Eric Laurenson prepared a unit called "Nanotechnology and Quantum Mechanics: Bringing High School Physics into the 21st Century," which is designed for use in high school physics classrooms. The unit provides an introduction to some of the key concepts of quantum mechanics, in the context of nanotechnology. Conchita Austin prepared a unit titled "The Relative Nature of Size in Biological Sciences: Let's Start Small and Work Our Way Up." Using biological examples, the unit discusses the influence of size on function. It also discusses biotechnology, which depends on biological machines that are nanometer-sized. Mary Whalen prepared a unit called "Health and the Invisible World," which discusses viruses, nanometer-sized biological objects that can cause disease. Ram Bhagat prepared a unit called "Nanotechnology and Clean Water: How Safe Is Our Drinking Water?" This unit describes the challenge for consumers of identifying the best sources of clean water, and the range of nanotechnologies that can now be used to purify water. Nancy Rudolph prepared a unit called "If You Can See It, It's Not Nano: Working with Numbers at the Extremes." This unit uses concepts derived from nanotechnology to help introduce essential math topics of high school students, including scientific notation and exponents.

Two of the units are addressed to middle school classrooms. Sharon Mott prepared a unit called "The Size of Matter: Why Properties Change at the Nanoscale." This unit describes how the effects of physical forces can differ for small objects, and relates these changes to the chemical structures of the nanomaterials. Stephen Griffith contributed a unit called "Teeny Tiny Wonders: Nanotechnology and Machines." This unit concentrates on the physics of small objects and the use of nanotechnology for making consumer and medical products.

Finally, one unit is addressed to elementary school classrooms. Doriel Moorman contributed a unit called "Nanotechnology for Enhancing Math, Science, and Language Arts in the Elementary Grades: How Small Is Your Future?" This unit introduces the concepts of nanotechnology to fifth-grade students, providing an introduction to the structure of matter and how this can be manipulated to create nanotechnologies.

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