Big book explores a small world: Professor debuts first complete guide to nanoscience

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ASU’s Stuart Lindsay has released the first comprehensive nanoscience textbook ever assembled, guiding readers through a tiny world 1 million times smaller than a single grain of sand.

Stuart Lindsay, Arizona State University Regents' professor and director of the Biodesign Institute's Center for Single Molecule Biophysics, has just released the first comprehensive guide to a tiny world a million times smaller than a single grain of sand. *Introduction to Nanoscience* (published by Oxford University Press) provides readers with an overview of an emerging discipline which has in recent years, produced remarkable achievements in areas as varied as DNA sequencing, molecular machinery, nanocrystals and microscopy.

n discussing the impetus for the book, Lindsay notes that his far-flung research has always been coupled with a passion for teaching biophysical concepts to talented students. Introduction to Nanoscience also offers researchers worldwide a first-of-its kind, all-inclusive treatment of nanoscience. The book integrates several disciplines and spans basic quantum phenomena, tools of the trade, and nanoscale applications. In the course of this overview, Lindsay returns again and again to the theme of emergent behavior—how minute fluctuations at the nanoscale level can result in the appearance of striking, often unanticipated new phenomena.

The book is an outgrowth of professor Lindsay's lectures in nanoscience, refined over many years, with invaluable input from his students. Oxford University Press learned of the course and, believing it would make a fine resource, requested that Lindsay assemble the material into a book.

"What is so striking," Lindsay insists, "is that events occurring at the nanoscale have implications for chemistry, biology, physics, materials science, engineering, you name it." Nonetheless, the nanorealm lacked a textbook that could draw together the field's disparate elements. "It's sort of remarkable that the knowledge was not there in a collected way. I put together a course that was very comprehensive, starting with physics and ending with biology," he says.

Given the breakneck pace of scientific advance, particularly in nanoscience, Lindsay faced a daunting challenge. "I knew that some current issues in the field would become obsolete by the time my fingers left the keyboard." Hoping to produce a work that could remain relevant, Lindsay chose to include a wealth of fundamental principles that would be broadly applicable, regardless of the novel conditions students were likely to encounter in the future.

The book is divided into three parts. Part I (The Basics) is a selfcontained introduction to quantum mechanics, statistical mechanics and chemical kinetics, requiring only basic college calculus. Part II (The Tools) covers microscopy, single molecule manipulation and measurement, nanofabrication and self-assembly. Part III (Applications) covers electrons in nanostructures, molecular electronics, nano-materials and nanobiology. "If you wander around the lab," Lindsay says, "you'll see dog-eared copies of the Xeroxed version of the book at students' desks—it's really a compendium of everything I think they need to know in nanoscience."

Life in the nanoworld can be disconcerting to the uninitiated, so distinct are its workings compared with conditions of everyday experience. A nanometer is roughly 10,000 times smaller than the diameter of a human hair. Chance fluctuations dominate the scene and, as Lindsay stresses, provide vital raw material on which Darwinian selective processes operate. "The more I study the components of biology, the more I would say that fluctuations aren't just a nuisance to be lived with—they actually are the story of biology."

This leitmotif runs throughout the book, uniting many distinct areas of nanoscience. One such startling illustration of this central theme occurs near the end of the text, where Lindsay reviews important research into neural development in the fruit fly. Random fluctuations in gene expression and splicing serve to shuffle the genetic deck to produce an enormous number of variants of sticky-ended proteins, which are essential for proper neural assembly. When the number of these splicing variants in a particular gene was reduced from roughly 30,000 to 20,000, the creatures were unable to form proper brains. "The evolution of a neural network in a brain involves the interaction between an incredibly diverse and randomly put together Darwinian dice throw of neural connections and an environment acting selectively on the results," Lindsay says.

Introduction to Nanoscience is a vital contribution to one of the most dynamic fields, geared toward inspiring a new type of young investigator—one steeped in a multidisciplinary scientific culture. "This differently trained and diverse group of talented young people are not only going to produce scientific breakthroughs in their own rights," Lindsay says, "they're also the people who are going to start the next generation of companies that generate wealth and drive the national economy and they're going to create new things with their brains because they've learned new ways to think."

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