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CHAPTER 1: INTRODUCTION

INTRODUCTION

The nanoscale is extremely small, in fact, so small that light waves are too big to observe objects at this level. In order to conduct research and development at the nanoscale scientists and engineers need tools that can work with better precision than ever before.

Students may be very far removed from the idea that there exist things so small that they are beyond standard tools of manipulation, thus this introduction will serve to give them a taste of what it is like working at a smaller scale with tools that are too large to function optimally. This introduction will also stress why nanotechnology is so significant – it is precise to a degree that even microscale tools are too big. This idea will be further developed in the Ideal Tools section in the Measurements Chapter.

BACKGROUND: AT THE NANOSCALE

After Richard Feynman's 1959 speech *There's Plenty of Room at the Bottom*, scientists have been seeking for a way to see and work with smaller and smaller objects. However, the process was difficult and inefficient due to the lack of extremely precise instruments. Light Microscopes and Electron Microscopes were only able to take scientists so far, and the ability to see atoms was still out of the reach. In 1981, physicists Gerd Binnig and Heinrich Rohrer created the first Scanning Tunneling Microscope, which gave scientists the ability to image atoms for the first time in history. Since then, many microscopes have been modeled using the same probe technology, giving rise to the name Scanning Probe Microscopy (SPM). Along with the ability to image atoms, these microscopes can also move them around and create pictures like the one seen to the right.

In addition to being able to move atoms around, scientists have also created a scanning tunneling microscope that can use voltage to get electrons to tunnel through the barrier between the probe and surface. If enough voltage is applied, the STM can lift individual atoms through magnetism. The activity suggests that students can pick up and manipulate individual atoms and molecules, and with the STM this is very strong possibility. The idea of being able to pick up and manipulate individual atoms and molecules is called the top-down approach; which is manipulating nanoscale objects with macroscale tools.

In a new approach to nanofabrication, called the bottom-up approach, scientists are seeking ways to combine smaller components to create more complex objects, such as electronic circuits. This method, called self-assembly, is one in which atoms or molecules assemble without the aid of any outside sources. In some cases however, scientists are trying to encourage self-assembly by introducing other molecules, such as patterned substrates. This is given the term directed self-assembly. Directed self-assembly is not covered by the module, but may be valuable to investigate for enrichment purposes.