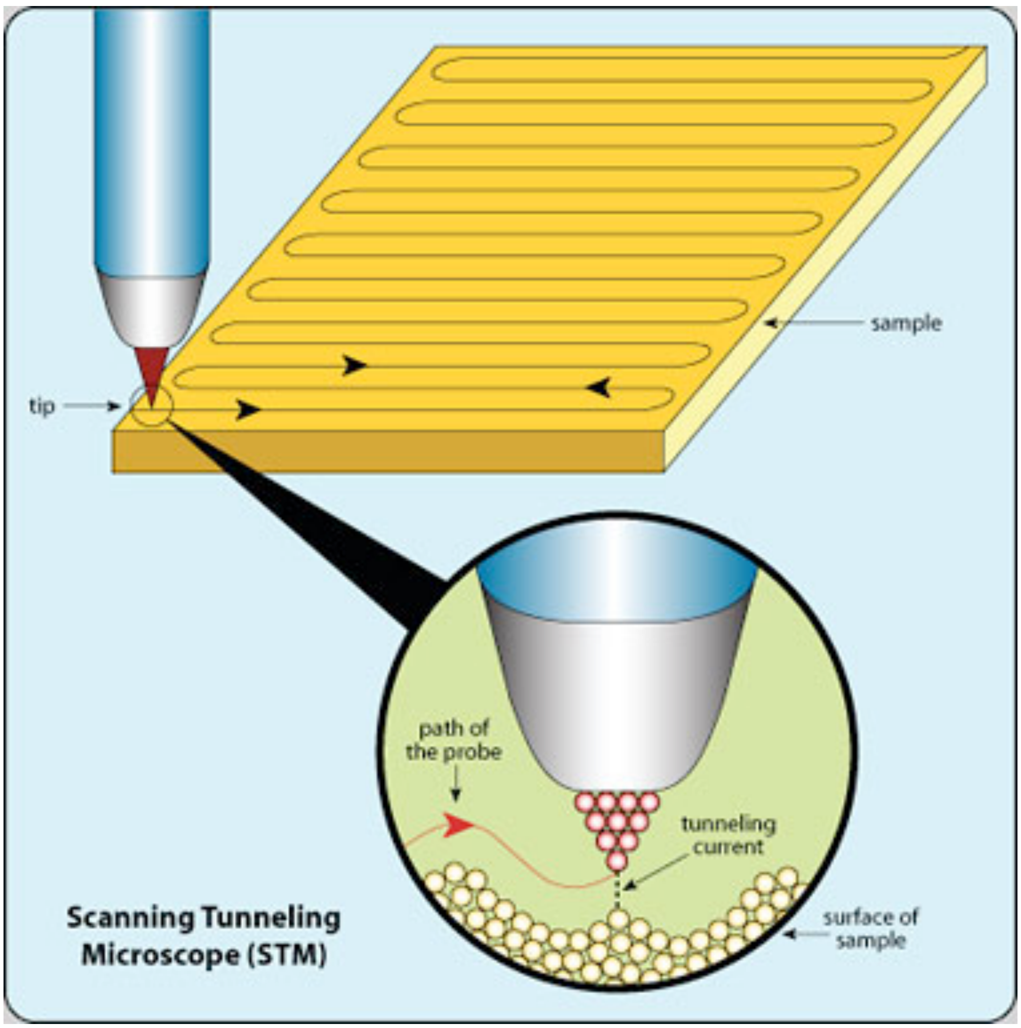
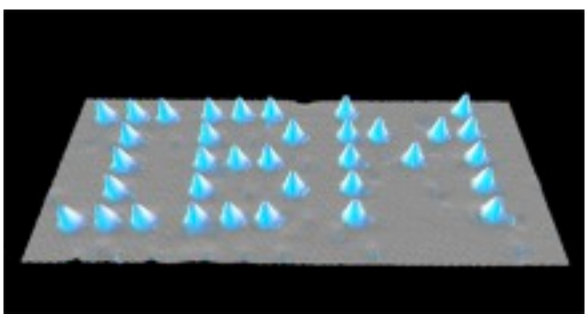
Breakthrough: The Scanning Tunneling Microscope

In 1981, Gerd Binnig and Heinrich Rohrer at the IBM Zurich Research Laboratory in Switzerland developed a significantly superior tool for observing surfaces atom by atom: the scanning tunneling microscope (STM). (Binnig and Rohrer would share the 1986 Nobel Prize in Physics with Ernst Ruska, designer of the electron microscope.)



Here's the basic concept: The STM has a metal needle that scans a sample by moving back and forth over it, gathering information about the details of the surface. Imagine closing your eyes and running your finger along the top of a row of books—you could easily identify the changes in height. Now imagine replacing your finger with a needle that has a tip tapering down to a single atom, and you can understand how the tip can follow the smallest changes in the contours of a sample.

The needle doesn't touch the sample, however, but stays about the width of two atoms above it. The STM takes advantage of what's called the tunnel effect: If a voltage is applied to the tiny distance between the needle and the sample, electrons are able to tunnel, or jump, between the needle and the sample, creating an electric current. A computer receives the electrical signal and directs the needle to move up or down to keep the current constant—which keeps the distance between needle and sample constant. The path of the needle is recorded, and the computer can display that information as a grayscale image or topographical map. Scientists can add color to make the image easier to interpret. (See the Quantum Corral for more about creating images.)



[IBM in Xenon Atoms: In 1989, Eigler and Schweizer spelled "IBM" by positioning thirty-five xenon atoms on a nickel surface.]

The result is a visual way to learn about the sample—but it's not a picture, in the traditional sense, of the atoms on the surface. For example, the atoms appear to have solid surfaces in STM images, but in reality they don't. The nucleus of an atom is surrounded by electrons that are in constant motion. What appears to be a solid surface is actually a haze of electrons. The STM shows the positions of atoms—or more precisely, the positions of some of the electrons. It doesn't show the atoms themselves.