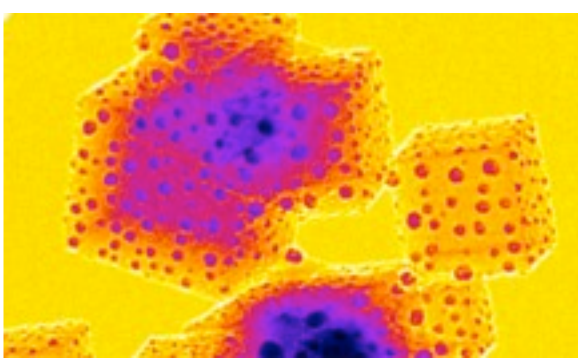
Small is Different

Nanotechnology generally deals with matter having dimensions of between one and one hundred nanometers. One reason these tiny particles are interesting is that they obey a different set of rules than the ones you and I are used to. We live at a size scale where certain physical laws apply—the laws of classical mechanics observed by Isaac Newton in the seventeenth century.

But Newton's laws no longer apply when you are dealing with nanoparticles, chunks of matter with dimensions of less than one hundred nanometers. At the nanoscale, quantum mechanics—the modern physical theory that deals with the structure and behavior of atomic and subatomic particles—comes into play. Because of quantum mechanics, nanoparticles don't act like bigger lumps of the same stuff; they look and act differently. A few atoms together in a nanoparticle just don't behave the same way they do when there are trillions and trillions of them stuck together, like in the objects we see each day.

When you're dealing with nanoparticles, the ratio of surface to volume is huge. Suppose you have a fist-sized lump of gold. The atoms at the surface of the lump are small compared to all the atoms in the lump. But if you broke that lump of gold down into gold nanoparticles, the ratio of surface to volume changes. In a cluster of 100 atoms, more than half the atoms are on the surface. The properties of a nanoparticle are really governed by surface effects.

How does that change the way matter behaves? Once again, consider that fist-sized chunk of gold. It looks gold in color and it melts at around 1948 degrees Fahrenheit (1064 degrees Celsius).



[This image shows cubes of magnesium oxide. Nanoscale particles of gold were deposited on the crystal faces to help define the surface topography.]

Compare that to particles of gold that are between one and one hundred nanometers across. These particles melt when heated to just a few hundred degrees Fahrenheit. These particles can look red, blue, or a variety of other colors, depending on the particles' sizes and distance from each other.

The ancient Romans knew how to color glass by adding gold. Initially the glass is colorless, but it becomes ruby-red when heated in a controlled fashion. The Romans knew how to make the glass turn red, but they didn't know that the color came from nanoparticles of gold.