Preface

Nanotechnology is defined as technology that deals with particles having dimensions in the range 1–100 nm. Nanoparticles were available in nature before the advent of the human race, in the form of nano-dimensioned particles in the atmosphere, proteins, DNA, RNA, and cells in the human body. All the objects in this size range represent the nano world. In order to realize the nano world, scientists around the globe adopt a "top-down" or a "bottom-up" approach. In the top-down approach, large particles are crushed to nanoscale dimensions. In the bottom-up approach, particles or devices are created by joining single atoms or molecules together via cohesive/adhesive forces.

Major utilizers of such small devices are biotechnologists, physicists, or those working in the electronics field. It started with microelectronics and now we have moved on to nano-electronics. The Nobel Prize in physics was given in 1956 to William Bradford Shockley for the invention of the transistor. This amplification device at that time used a trio whose dimensions can never be reduced, and it consumed a large amount of energy. Today, however, we have developed transistors using nanotechnology that have dimensions of less than 100 nm.

Research at the laboratory scale can go even smaller. The rules obeyed at the atomic scale are quite different from those at the macroscale. For example, when we talk about integrated circuits working at the electronic dimension, quantum tunneling effects dominate on account of the dual wave–particle nature of electrons.

Technological development across the globe started to happen only after the development of various characterization techniques. Initially it was difficult to measure the dimensions of particles in the nanoscale range, but now we have scanning electron microscopy that studies the surface morphology of a sample at nanoscale and transmission electron microscopy to study ultra-thin samples. We can even visualize individual atoms using scanning tunneling microscopy. IBM has written its name using individual atoms of Fe_3O_4 by manipulating individual atoms: they can be moved left and right or up and down.

Now, LEDs are being replaced by quantum dot technology. Quantum dots are particles of nanoscale dimensions (range 4–10 nm) that are made of 10–20 atoms in total. These particles have gained so much popularity in recent times as their loss of energy is almost zero. In the near future, quantum dot technology will rule the television industry based on its picture quality and performance.

Nanoparticles are known for their high surface-area-to-volume ratio or aspect ratio. They can be spread over a large area without any depth, which leads to minimal loss of energy. As per recent studies, nano materials are quantized in particular directions, giving them different shapes like wires, films, dots, or particles. Materials that are not quantized in any direction are free to move along all three dimensions and form nanoparticles. If nanoparticles are quantized from one direction and allowed to move along two directions they form two-dimensional nanoparticles such as thin films. Particles quantized from two directions and allowed to move in only one form one-dimensional nanoparticles, nanowires. Particles that are quantized from all three

directions and not allowed to move along any direction form zero-dimensional nanoparticles or quantum dots.

Recently nanotechnology has also made advancements in the field of biotechnology leading to a new merger popularly known as nano biotechnology. It provides advanced and more efficient methods of drug delivery, disease diagnosis, and therapy. Thus, the study of nanotechnology involves a multidisciplinary approach combining various domains.