

Our future lies in nanotechnology

GUEST COLUMN | President A.P.J. Abdul Kalam

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Whenever I go for a morning walk in the Mughal Garden, I see peacocks dancing with their colourful feathers during this season. When I look at the deep and beautiful colours on the feathers of the peacock, I have often wondered how even after many years, the colour of the peacock feather does not fade away. I recall as a young boy, I used to keep peacock feathers in my books. This phenomenon of long lasting original colour to the peacock has come from God's own creation of nano materials coated in a peacock's feather; and they diffract light, which gives us the rich colours.

Every thing in this universe — from giant stars to our bodies work on a molecular scale. Our hearts and lungs are big objects but all the processes take place at the molecular level. Therefore, everything in our body and in the physical universe is already based on nanotechnology. Observation of nature and the role of science in understanding it from our research in nano sciences can be converted into a technological product by using the same or similar nano materials which gave the natural colour to the peacock's feathers, as part of our shirts, sarees, fabric and apparels. It is a welcome destination for science to mature into technology and become a product of utility for society.

Throughout the last 120 centuries, unique cultures have come into existence due to advancements in technology. The first 118 centuries had a dominance of primarily stone, bronze and iron. The last two centuries have seen rapid development of the chemical age. The advancements made in material science and technology gave the impetus for both the nuclear and biological age to flourish. Succession of these technology periods has involved progression from simpler materials to more complex forms of science and engineering. We are today at the convergence of nano, bio and information technologies. This age, I feel will create a historic revolution and we must be in the driver's seat to contribute towards this societal change.

When I think of nanoscience and nanotechnology, I am reminded of three personalities. The first person is Richard Feynman, who described the concept of "building machines" atom by atom in his talk at Caltech titled "There is plenty of room at the bottom". The second person is Eric Drexler, who wrote the book titled Nano Systems, Molecular Machinery, Manufacturing and Computation. The third person is Prof C.N.R. Rao, who pioneered and fostered nano science research in India.

Since independence, the country had all along been taking recourse to technology for societal changes and economic prosperity. A nation that is alert should be sensitive to the changes that take place in the technological fabric of the world and prepare itself for the arrival of newer changes on the horizon.

As the country was acquiring the technologies of steel, agriculture, space, missiles and IT, we grew to be anywhere between the third to fifth nation in merit. In information technology we have a possibility of becoming the third knowledge power. We believe that nanotechnology would give us an opportunity, if we take appropriate and timely action to become one of the important technological nations in the world.

The world market in 2004 is for nano materials, nano tools, nano devices and nano biotechnology which put together is expected to be over hundred billion dollars. It has been noticed that the fastest growing area among these is nanobiotechnology.

Carbon nano tubes and its composites will give rise to super strong, smart and intelligent structures in the field of material science.

Molecular switches and circuits along with nano cells will pave the way for next generation computers. Ultra dense computer memory coupled with excellent electrical performance will give society low power, low cost, nano size, and yet faster assemblies.

Nano biomedical sensors will play a major role in glucose detection and endoscopic implants. Drug delivery systems will revolutionise healthcare to a large extent.

The last four decades have also affected the packaging concept. Electronics packaging of the past has given way to the present microsystems packaging and the shift in the trend is now towards futuristic nano packaging.

Today, a few countries such as USA, Germany, Japan, UK, have already taken the lead and have invested more coherently and cohesively in thrust areas of Nanotechnology. The global funding for nanoscience and technology has now risen to approximately \$ 3 billion in 2003.

Nanotechnology is a new technology that is knocking at the doors. It has wider applications compared to information technology and is likely to touch the common man. It will be the central focus for many technologies to converge and open a large number of applications. Further, this technology will have a large domestic market potential leading to a robust economy.

Rapid advances both in terms of materials and devices are taking place globally. Almost 300 novel materials and 50 devices with unique characteristics have been successfully developed around the world. Many of these inventions in materials and devices that are being created today by nanotechnology were beyond human imagination a few years back. Further, this technology will have a large domestic market potential and hence would be very robust and immune to the changes that would take place beyond our borders. The next ten years will see nanotechnology playing the most dominant role in the global business environment. It is expected to go beyond the billion US dollar estimates and cross the figure of \$ 1 trillion. Globally, it is seen that a large number of universities, academic institutions and companies have already starting making concrete efforts.

In India, modest beginnings have been made by some pioneers. Today, only a few institutions are contributing towards this pioneering research. A lot more needs to be done and we have to formulate an action plan by pooling all available national resources. Both the Government and the private sector have to join hands and form a “Nano-Tech Enterprise”.

For us to succeed in manufacturing of nano products and their deployment we need to tackle the issues of science and technology, product development and societal aspects in an integrated way. Judging by the past experience of the country in driving technology missions in aerospace, agriculture, atomic energy and IT, I am confident that, if we take up a mission mode with a clear-cut vision, the country will reap the benefits of nanoscience and technology.

The future challenges include:

- ** Reproducible mass production at kilogram levels of identical high quality CNT.
- ** Development of self-sustaining, self-replicating hybrids of CNT and silicon to perform augmentation and repair of DNA.
- ** Development of intelligent wearable systems using nano technology. Solution to cancer, Parkinson’s Disease and AIDS through biosensors, devices and drug delivery systems.
- ** Realisation of molecular sized machines. Remote sensing through nano Unmanned Aerial Vehicles and satellites

I am convinced that nano is the greatest building block for healthcare, structural material, in electronics, automation, etc, and will become the platform for new cutting edge technologies to grow for the better living of mankind.

(Adapted for HT by the President from his address to scientists and technologists in April in Delhi.)