WHAT is NANOSCIENCE ?

Most people are familiar with the enormous changes wrought in the last 4 decades around the world, by the miniaturization of basic components in electronic technology- in communication systems, computers, information storage, etc. These changes were a big surprise, even to the people working in the relevant industries- witness the following quotes:

'Computers in the future may weigh no more than 1.5 tons'
-Popular Mechanics, forecasting the relentless march of science, 1949.

'I think there is a world market for maybe five computers'
-Thomas Watson, Chairman of IBM, 1943.

The components of early computers were enormous- a single memory element was the size of a sugar lump (over 1 cm^3 in volume), and consumed large amounts of power. The basic memory elements in a modern laptop (Dec 2005) are ~ 1 μm^3 in volume, ie., 10-100 times smaller than a bacterium, and roughly a trillion (10^{12}) times smaller than those in 1955- quite a change after 50 yrs. The decrease in size with time has roughly followed 'Moore's law', ie, a decrease by a factor of a little less than 2 each year, giving an exponentially decreasing size with time.

It makes perfect sense to extrapolate this decrease: by the year 2050, the entire present computing power of the world should be containable within a single sugar lump, with individual components the size of atoms or molecules. There will be concomitantly huge increases in the speed of information processing. Even this conservative scenario predicts vast technological changes in the next few decades, along with sweeping social changes and challenges. However, such forecasts make no allowance for any radically new innovations, which is of course a serious mistake, in the light of 20th century history- we saw above how limited the imagination of even the experts was in the 1940's! Thus we have good reason to expect that future developments will be far more radical than our simple 50-year extrapolation indicates. We can already discern 2 very important changes on the horizon. The 1st has just begun to have an impact- the combination of new technologies coming from the fusing of methods from physics, chemistry and biology at the nanoscale. This development is essentially driven by new fabrication and manipulation techniques, working at this scale. The 2nd big change will come with a new generation of devices called '*quantum devices*'. Almost all technology until now has relied on the *classical* behaviour of components, described by a combination of classical electromagnetism and simple solid state physics- the big changes have come essentially from miniaturization, with no fundamentally new kinds of hardware. Quantum devices, on the other hand, will operate in an essentially quantum-mechanical way, employing interference, quantum coherence, and entanglement as part of their basic operation. This will lead to huge changes in the nature of devices- indeed, in the whole way we think about technology.

We thus see there are 2 kinds of nanoscience- 'classical nanoscience', and 'quantum nanoscience'. The applications of this to make devices and other products are usually described as 'nanotechnology'. Nanotechnology is of course a result of research in nanoscience, but it is important to separate the two. In 2 larger documents on this site, the reader will find (i) a brief introduction to Classical Nanoscience, and (ii) a somewhat longer introduction to Quantum Nanoscience. Both are intended for the non-scientists, or for beginning students.

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