

Science, Technology, Society: Prologue

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Some brain tumours are so unfavourably situated that they cannot be surgically removed without destroying surrounding tissue and with it the patient's personality. The Charité Hospital in Berlin is currently developing a method that could help resolve such dilemmas. Tumour cells are hungry for iron. Magnetized iron particles a thousand times smaller than red blood cells and minute enough to pass through the tiniest blood vessels are fed into the cancerous growth, where the tumour cells, mistaking them for food, greedily gobble them up. The head of the patient with the glioma – a fast-growing malignant brain tumour – who is receiving treatment is then placed between two magnets. Constantly switching their polarity so agitates the minuscule iron particles that they heat up from 45 to 47° C – a rise in temperature sufficient to kill off the tumour cells without doing any further damage.

Material particles such as these are called nanoscale particles, meaning that they measure between one and one hundred nanometres (nm) in diameter. A nanometre is defined as one billionth of a metre, one millionth of a millimetre, or one thousandth of a micrometre, which puts it beyond, far beyond the range of human perception. Special instruments and methods such as scanning tunnelling microscopy (STM) are required to view such particles. A comparison may help us to visualize the relative sizes we are talking about here: a single human hair is between 20,000 and 180,000 nm thick, most bacteria cover an area of 200 to 2,000 nm, and viruses are between 10 and 400 nm in size. The DNA helix containing the complete genome of a given organism is just 2 nm in diameter on average.

The targeted manipulation of material in the nanoscopic, or even atomic or molecular range opens up hitherto undreamed of possibilities for the generation and utilization of new material properties and new areas of application, such as in electronics or the life sciences. Significantly, the first American nanotechnology program initiated in 1999

was called 'Shaping the World Atom by Atom'. What makes nanotechnology so fascinating is that many materials change their properties in the nanoscopic range, even though chemically they remain the same. The reactions that these changed properties trigger, however, whether in the environment or in living organisms such as the human body, can be either positive – and hence desirable – or negative, unforeseen, and even toxic. The possibilities opened up by nanotechnology are offset by the as yet unknown and hence unquantifiable risks, which is why it is such a double-edged sword.

Nanotechnology is not only a key technology of the twenty-first century, but also a cross-sectional discipline that involves physics, chemistry, biology, and engineering. Subdisciplines such as solid-state physics and bio-informatics are especially important and together with the applied sciences are giving rise to new interfaces and areas of overlap. Significant innovations are therefore expected in nanomaterials' key areas of application such as information science and communications (nanoelectronics), the life sciences (nanobiotechnology), and medicine (nanomedicine).

Many vital processes take place in the nanoscopic range, that being the scale on which critical components such as proteins exist. Nanobiotechnology will pave the way to the creation of artificial life, or at least to the technical modelling of life. Nanotechnology, in other words, will make biological processes controllable. The classical divide between the technical and the organic will become blurred. Molecular 'factories' (mitochondria) and 'transport systems' such as those that are crucial to the metabolism will have a key role to play and will serve as models for the biological nanomachines (bionics) of the future.

The fusing together of biotechnology, nanotechnology, neurosciences, and information technology, for which nanotechnology provides a sure basis, opens up completely new possibilities for the human body. People's sensory organs, for example, could be 'enhanced' or new man-machine interfaces created by hooking up the brain or nervous system to information-processing equipment. Human life expectancy could also increase. The 'naturalness' of the human body itself will no longer be an immutable given. There can be no doubt that the society of the

future will be shaped by technology. And nanotechnology, alongside genetic engineering, reproduction technology, space travel, information and communication technology, will have a central role to play in this development.

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