The academic nanotechnology research landscape—the UK in a global context

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What is nanotechnology?

- technology at the nanoscale
- engineering with atomic precision
- atomically precise technology
- design, characterization, production and application of materials, devices and systems by controlling shape and size of the nanoscale *(NanoDictionary, 2005)*

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What is the nanoscale?

- **1 to 100 nm**
- phenomenologically-based nanoscale-defining lengths

Domain	**Defining length**	**Typical value/nm**
Surfaces	Geometry	5
Nucleation	Critical nucleus size	5
Optics and electronics	Bohr radius	10
Magnetism	Single domain size	50
Mechanics	Griffith length	50

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What is nanotechnology (2)?

- a group of emerging technologies in which the structure of matter is controlled at the nanometer scale to produce novel materials and devices that have useful and unique properties *(US Foresight Institute)*

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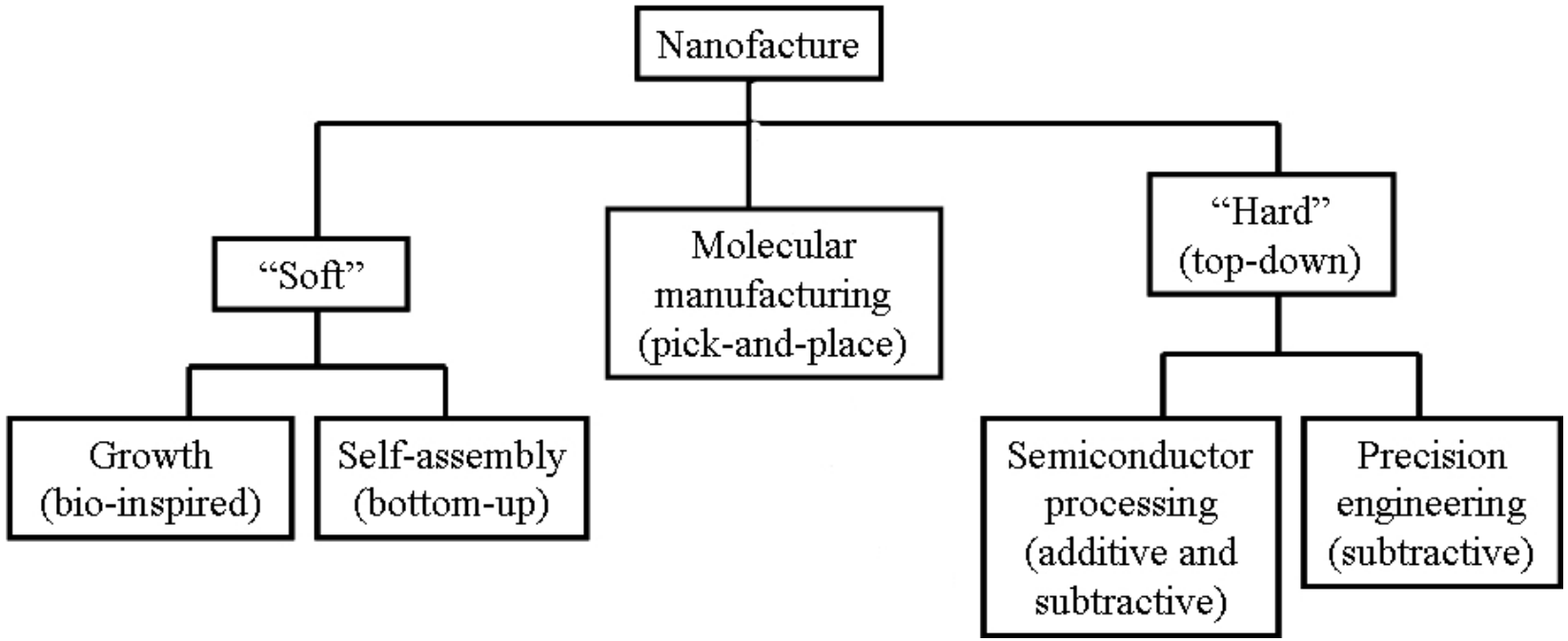
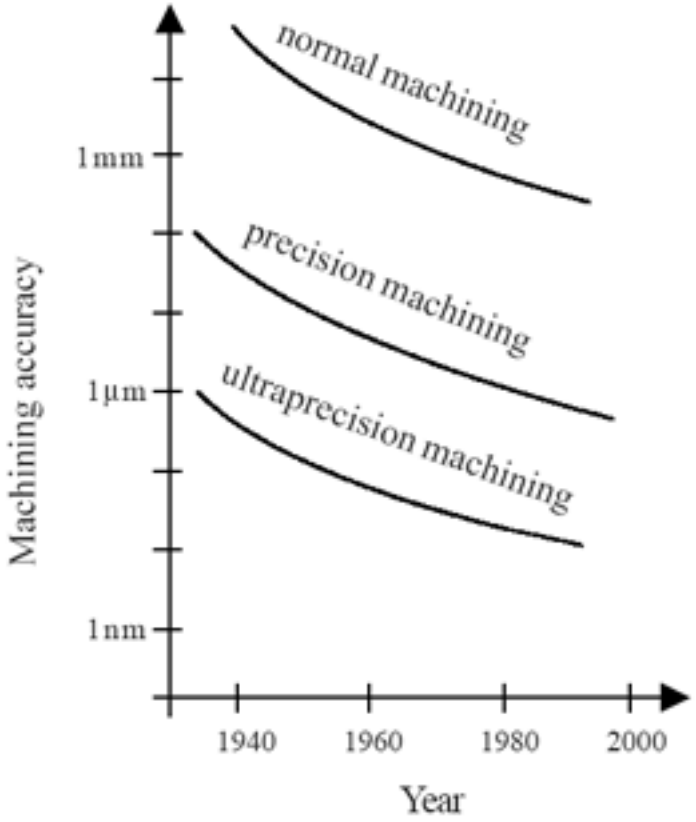
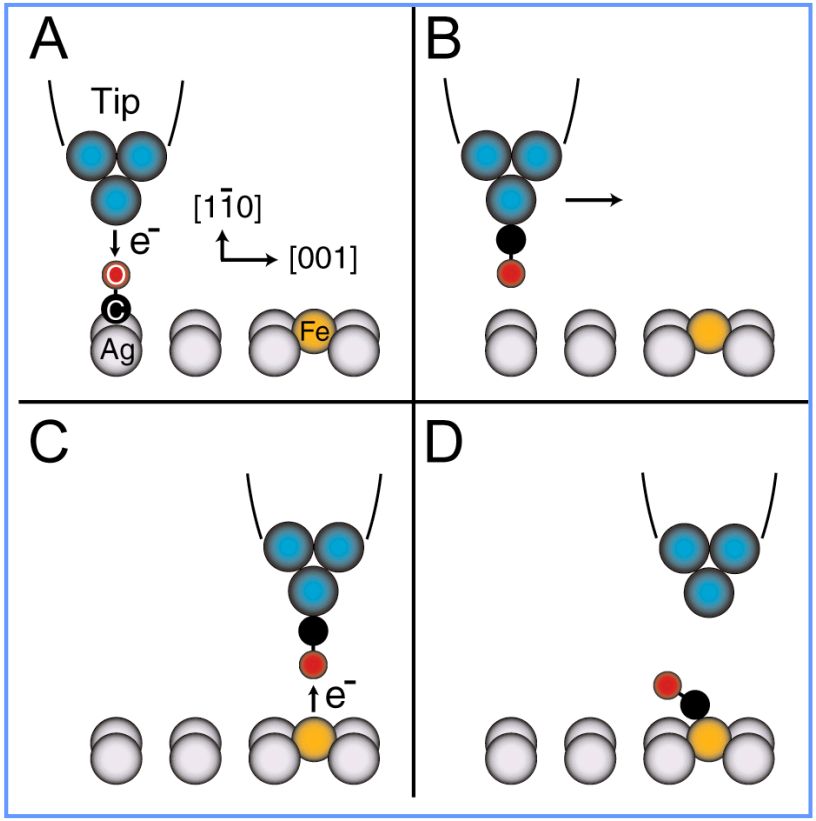
What is nanotechnology (3)?



What is nanotechnology (3a)?





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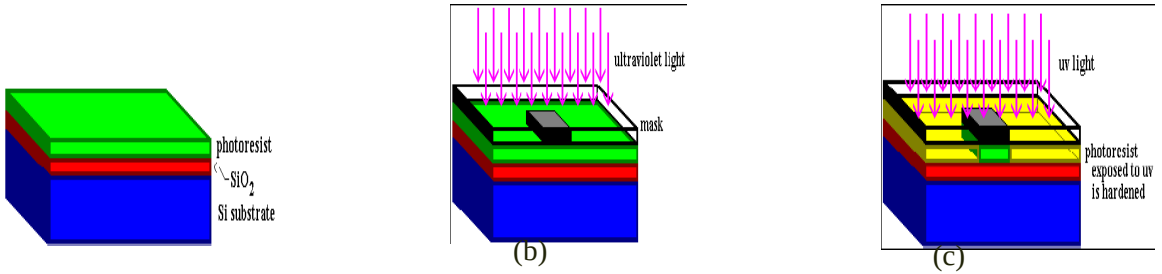
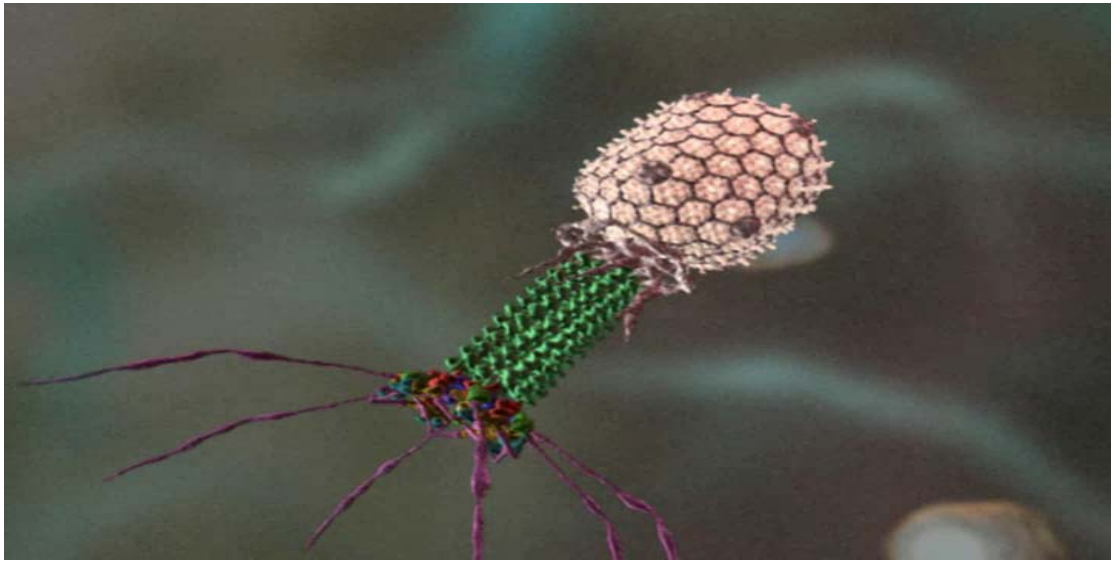
Assembler

- a mechanism for guiding chemical reactions by positioning reactive molecular tools by moving its tool-holding end in 3 dimensions like an industrial robot arm (K.E. Drexler, *Bull. Sci. Technol. Soc.* 24 (2004) 21–27)
- cf. “Put the atoms down where the chemist says, and so you make the substance.” (R.P. Feynman, *There’s Plenty of Room at the Bottom*, 1959)

What is nanotechnology (3b)?





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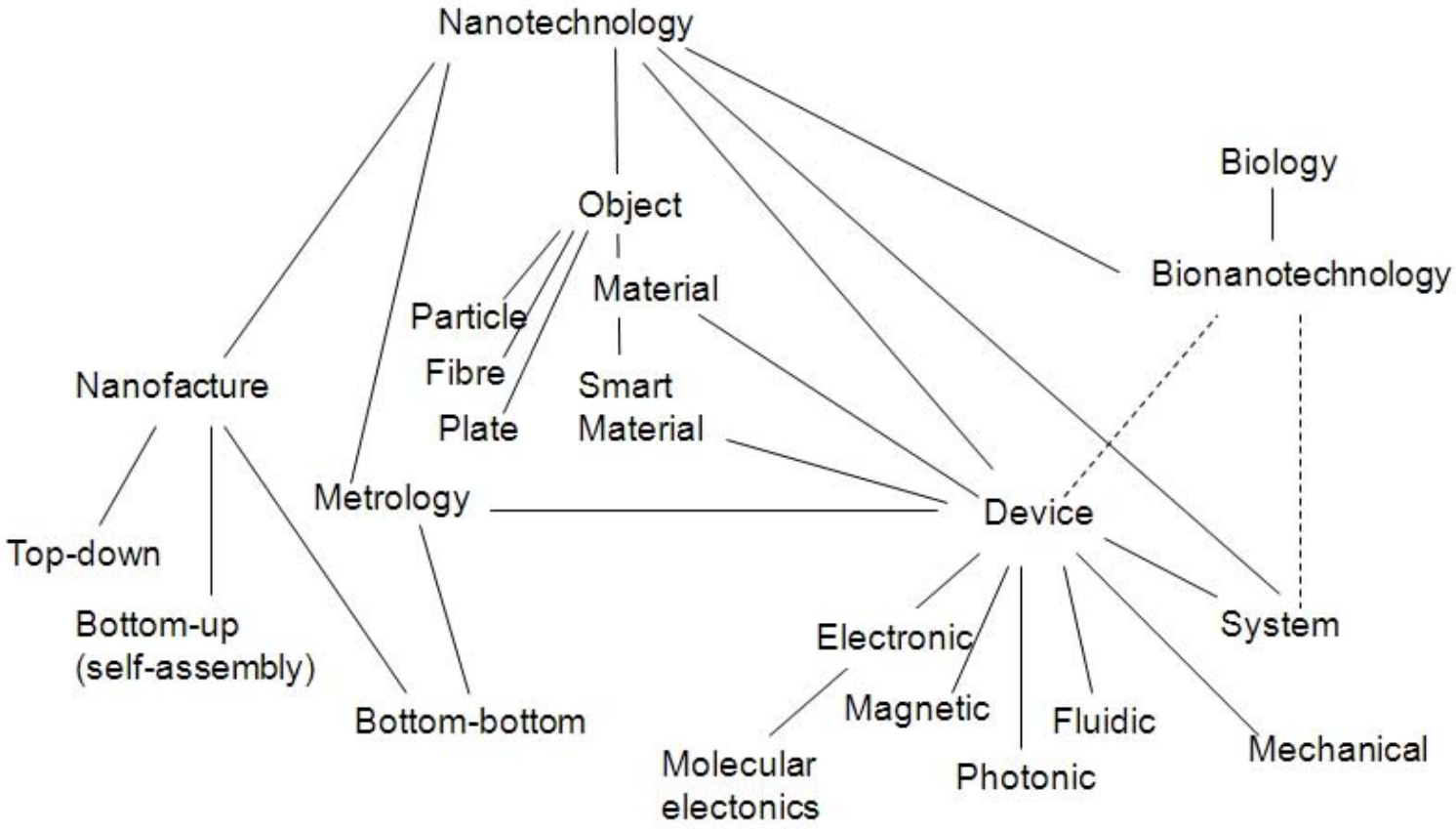
Nanotechnology concept system



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Vision obscured (Drexler)

- roots of the word “nanotechnology” let it fit any nanoscale technology no matter how old or mundane
- examples (S.I. Stupp, 2003): “pigments in paints; cutting tools and wear-resistant coatings; pharmaceuticals and drugs; nanoscale particles and thin films in electronic devices; jewelry, optical and semiconductor wafer polishing.”
- “Any connexion between this miscellany of technologies and a research program inspired by the Feynman vision is almost imperceptible.”

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Nanotechnology in the UK

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Nanotechnology in the UK

- UK has potential to play a globally leading role
- Research budgets are presently minuscule—“survival minimum” rather than “what can be usefully spent”—scope for a tenfold increase
- Industry base is very small

Global context

Research in nanoscale technologies is growing worldwide:

- USA: despite implicit assertions to the contrary from program administrators, there is a lack of strategic focus
- Japan: solid advances with heavy industrial involvement
- EU: bogged down in bureaucracy; more effective use of funds in small nonmember states such as Switzerland
- Russia: impressive (although criticized) intentions; has yet to show results; probably some time before the Soviet legacy is matched

Global context (2)

- China: exponential growth in papers published in English, probably due to a switch of publication strategy rather than an exponential growth in the volume of work
- India: tremendous activity on a solid base; possibly rather uncoordinated
- Brazil: what activity (if any) there is has a low profile
- Developing world: lack of coordination (e.g., disbanding of Commonwealth Science Council)

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Dialogue

- The journal *Nanotechnology Perceptions: a Review of Ultraprecision Engineering and Nanotechnology*

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Global context (refs)

- R.N. Kostoff et al., The growth of nanotechnology literature. *Nanotechnology Perceptions* **2** (2006) 229–248
- T. Toth-Fejel, When China develops Productive Nanosystems. *Nanotechnology Perceptions* **4** (2008) 113–132