NANOTECHNOLOGY:
SCIENTIFIC OR ETHICAL REVOLUTION?

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- Nanotechnology: truly a new science?
- Nanotechnology as an economics phenomenon
- The ethical debate on nanotechnology
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Materials and civilization

Technology eras

- Stone age
- Gold/silver age and the creation of empires
- Steel age and creation of modern industry
- Silicon age and the technology-oriented society
- Nanotechnology age

Nanotechnology: truly a new science?

nanoscale

- centimeter 0.01 m
- milimeter 0.001 m
- Micrometer (MICRON) 0.000001 m
- Nanometer 0.000000001 m
-

- Typical distance among atoms or melecules in a material 0.1 to 1 nm

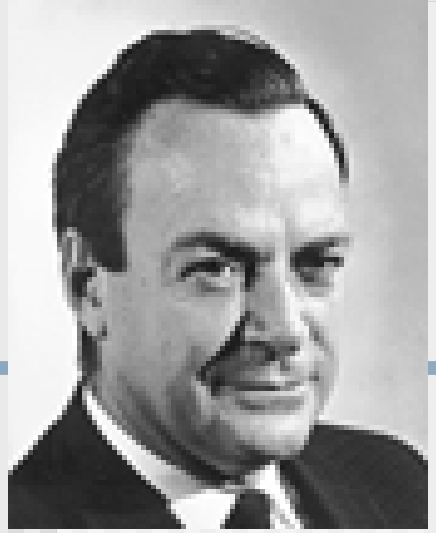
modern history

- **There's Plenty of Room at the Bottom**

  An Invitation to Enter a New Field of Physics

  by Richard P. Feynman

- This transcript of the classic talk that Richard Feynman gave on December 29th 1959 at the annual meeting of the American Physical Society at the California Institute of Technology (Caltech) was first published in the February 1960 issue of Caltech's Engineering and Science, which owns the copyright. It has been made available on the web at http://www.zyvex.com/nanotech/feynman.html with their kind permission.

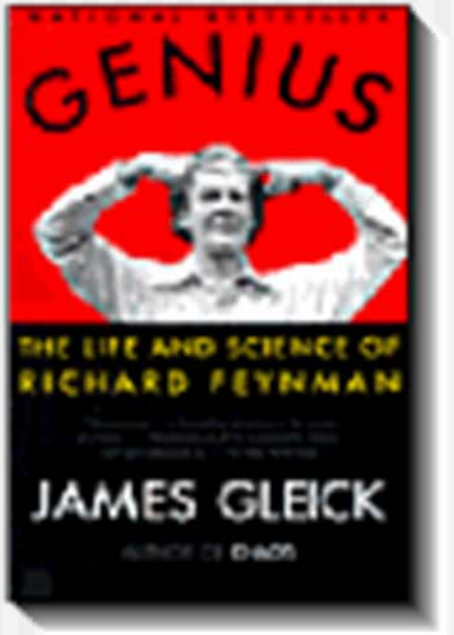


RICHARD PHILLIPS FEYNMAN

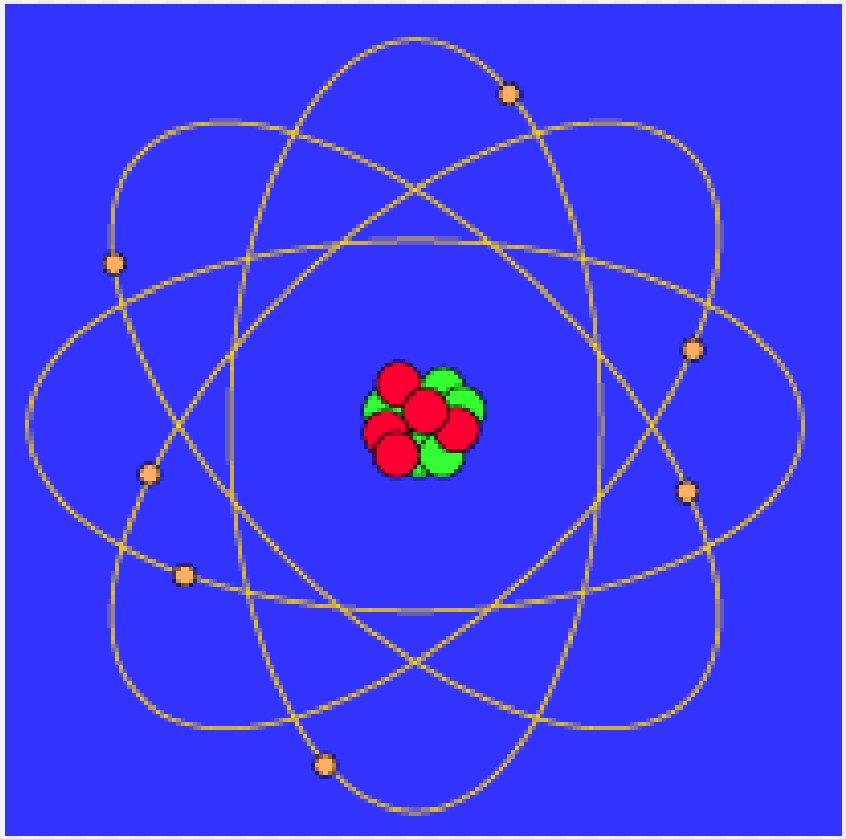
(1918-1988)

GENIUS

The life and science of
RICHARD FEYNMAN

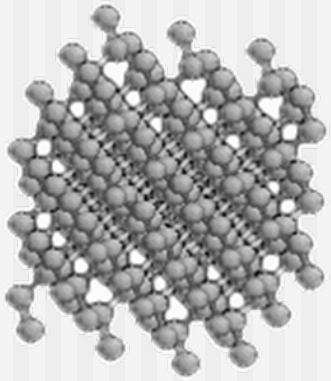


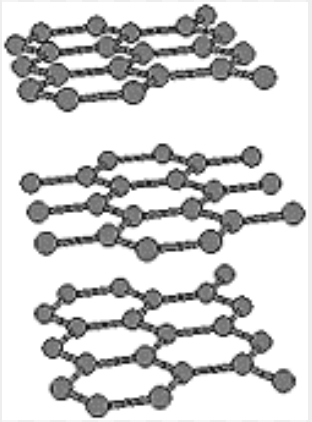
Atomic nucleus vs. Distance to the first electron

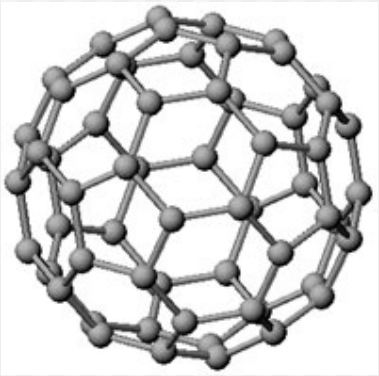


- Imagine:
- nucleus = 1 mm
- Then the nearest electron would be at 100 m!!!

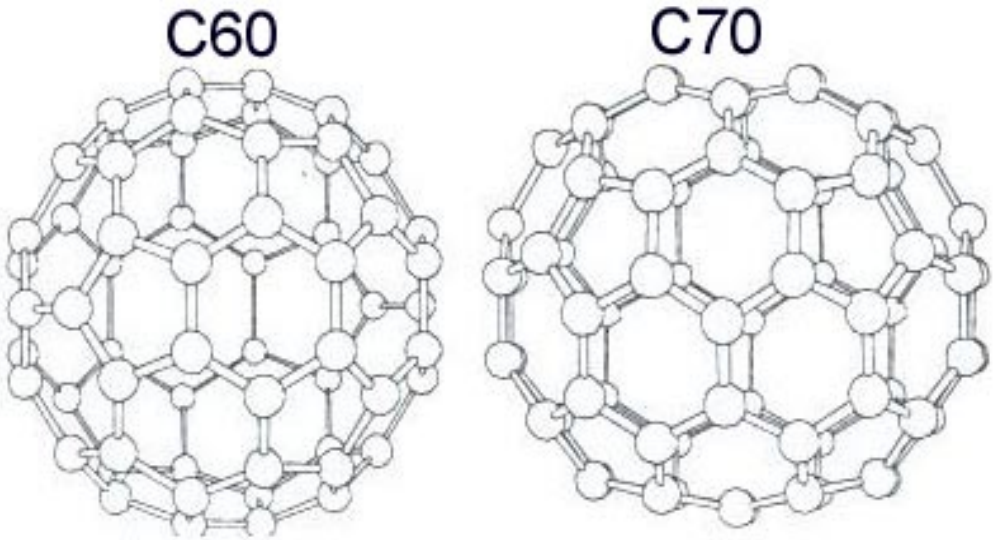
History of carbon



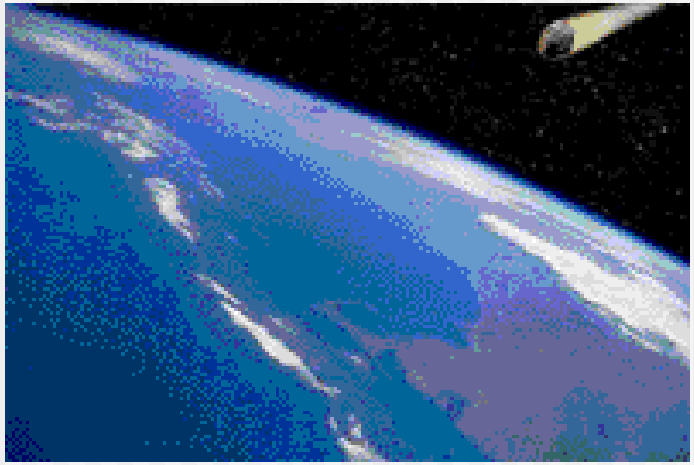


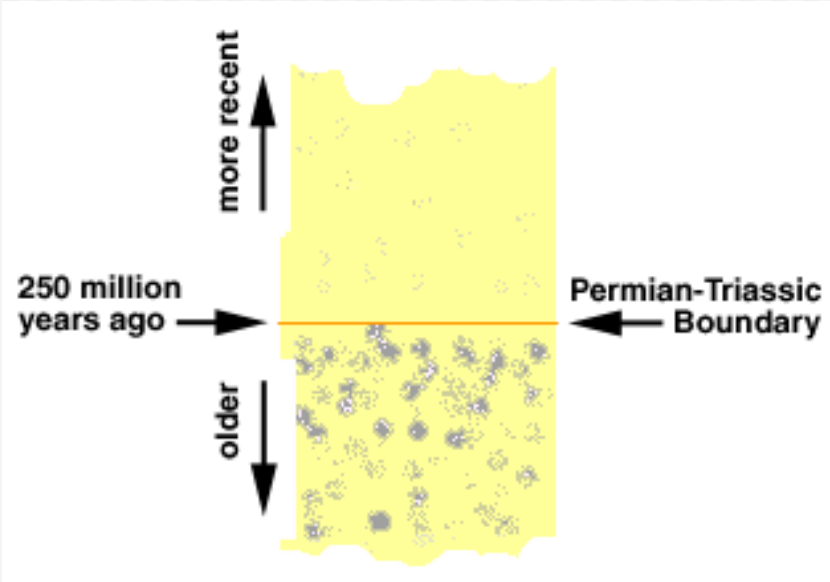


Harold Kroto, James Heath, Sean O'Brien, Robert Curl, Richard Smalley
1985

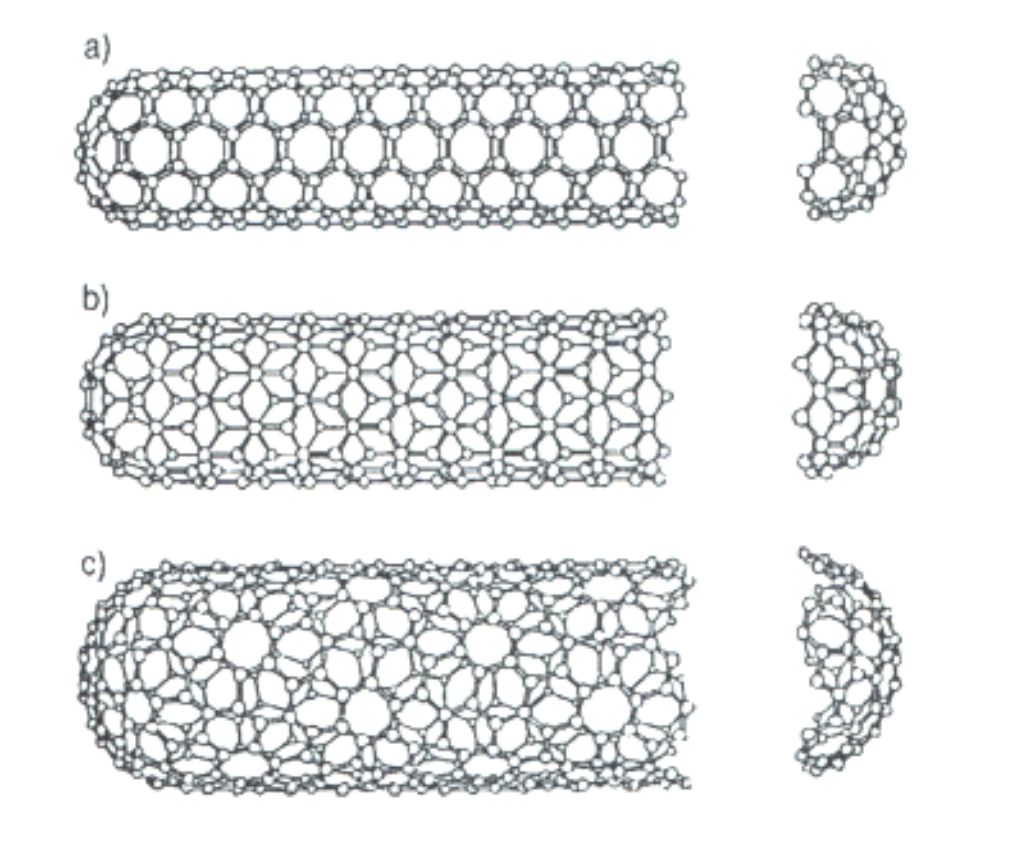


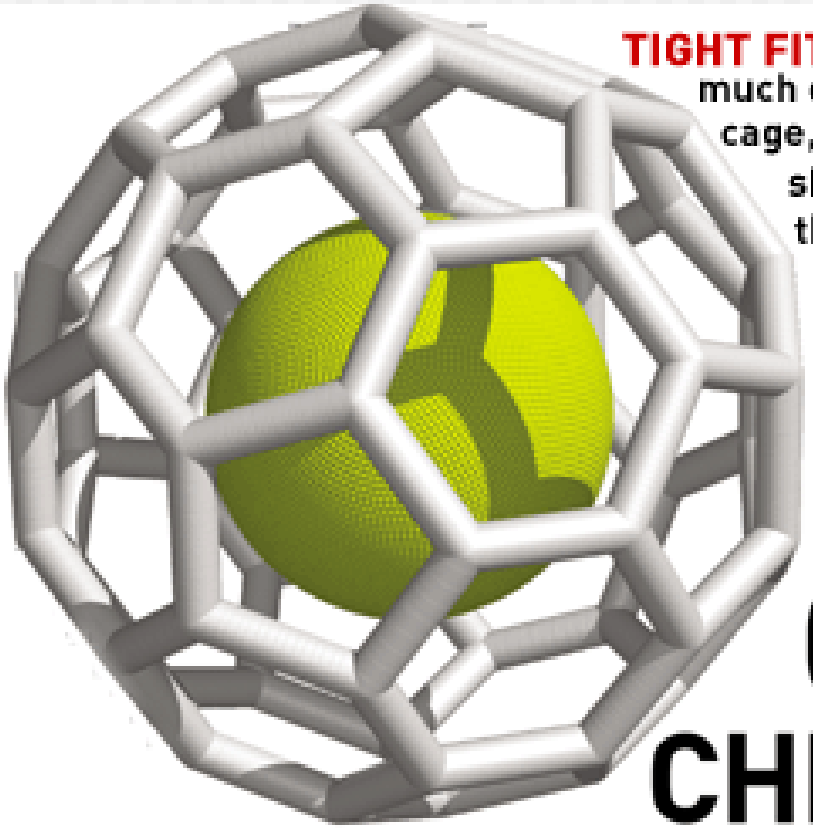
METEORITES AND NANOTECHNOLOGY





CARBON NANOTUBES



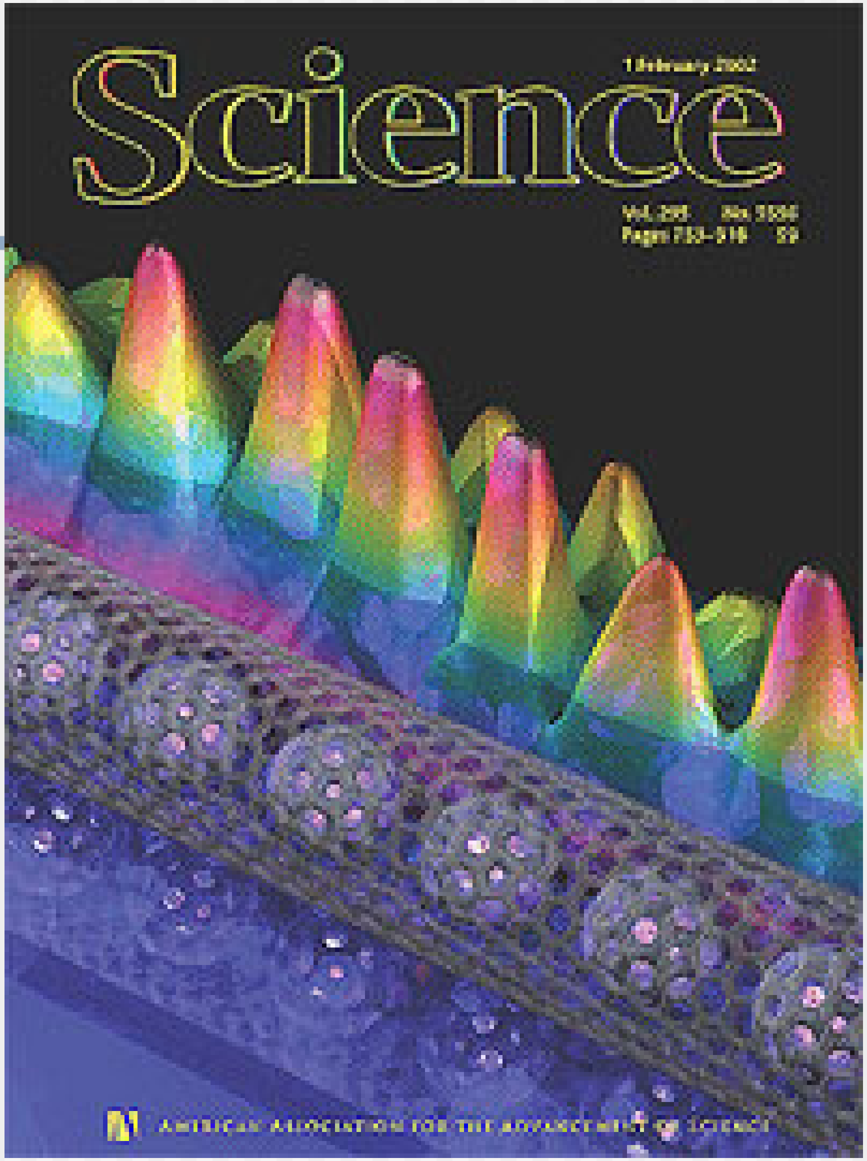


TIGHT FIT A xenon atom occupies much of the cavity inside a C_{60} cage, and its ^{129}Xe NMR chemical shift has been measured for the first time.

CAGEY CHEMISTRY

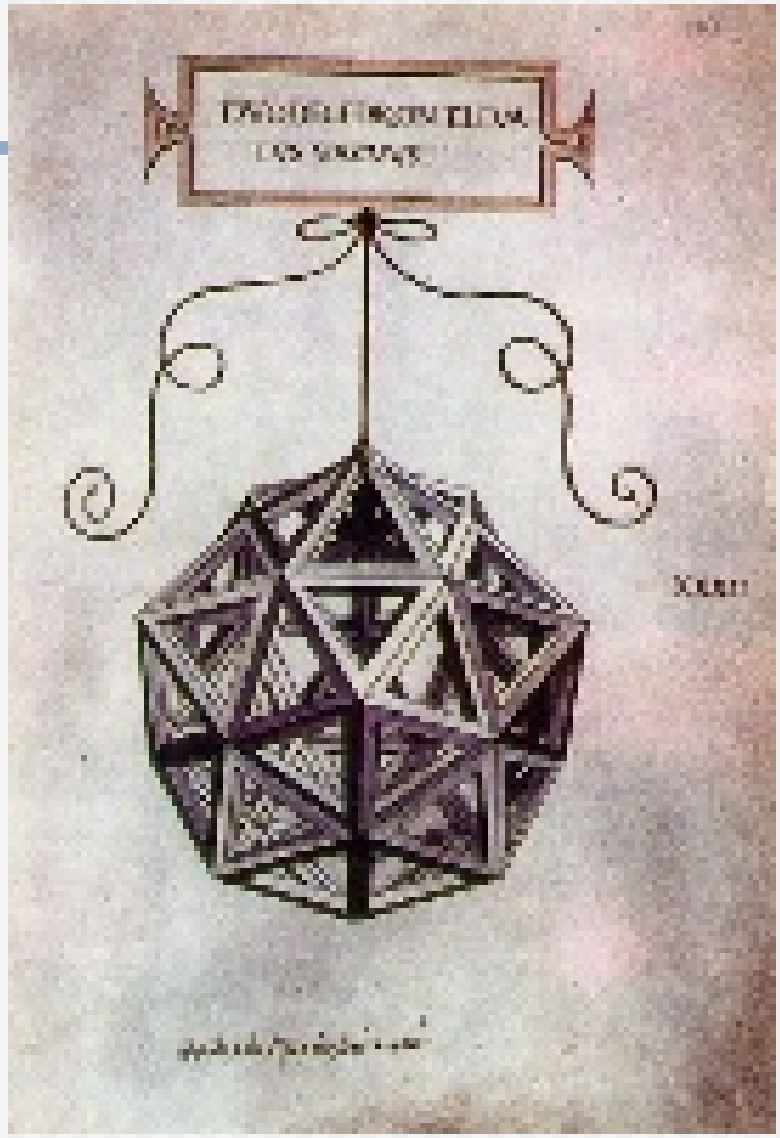
Scientists are making headway in exploring and exploiting the unique properties of endohedral fullerenes

IMAGE BY DENIS OSTROVSKY


Science
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

LEONARDO Da VINCI (1452-1519)

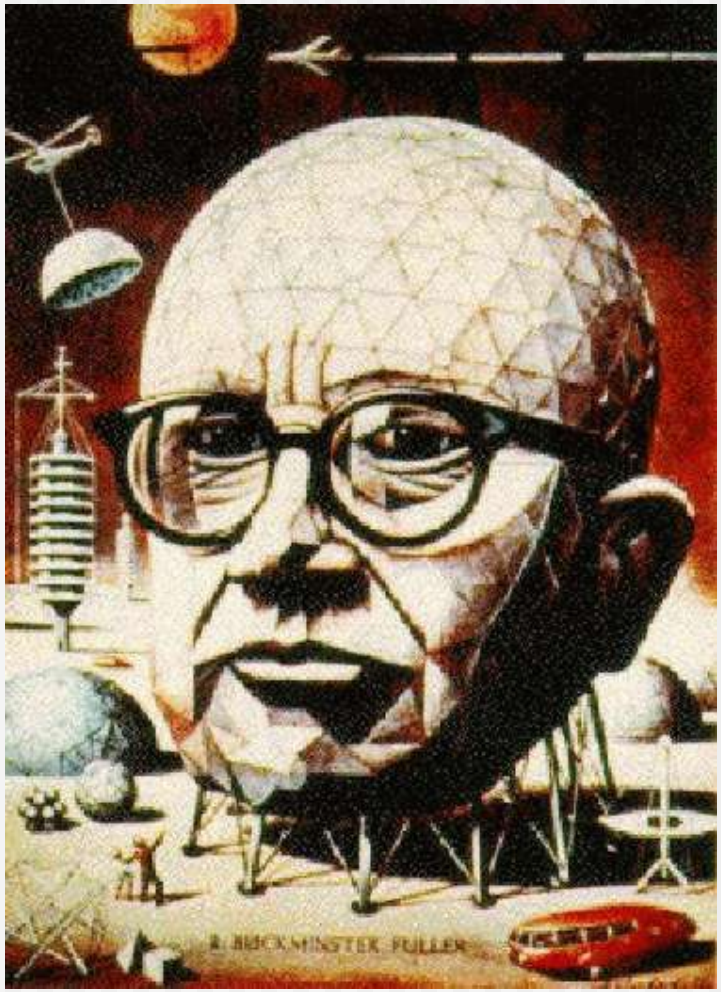
Duodecendron elevatus vacuus
Biblioteca Ambrosiana, Milan

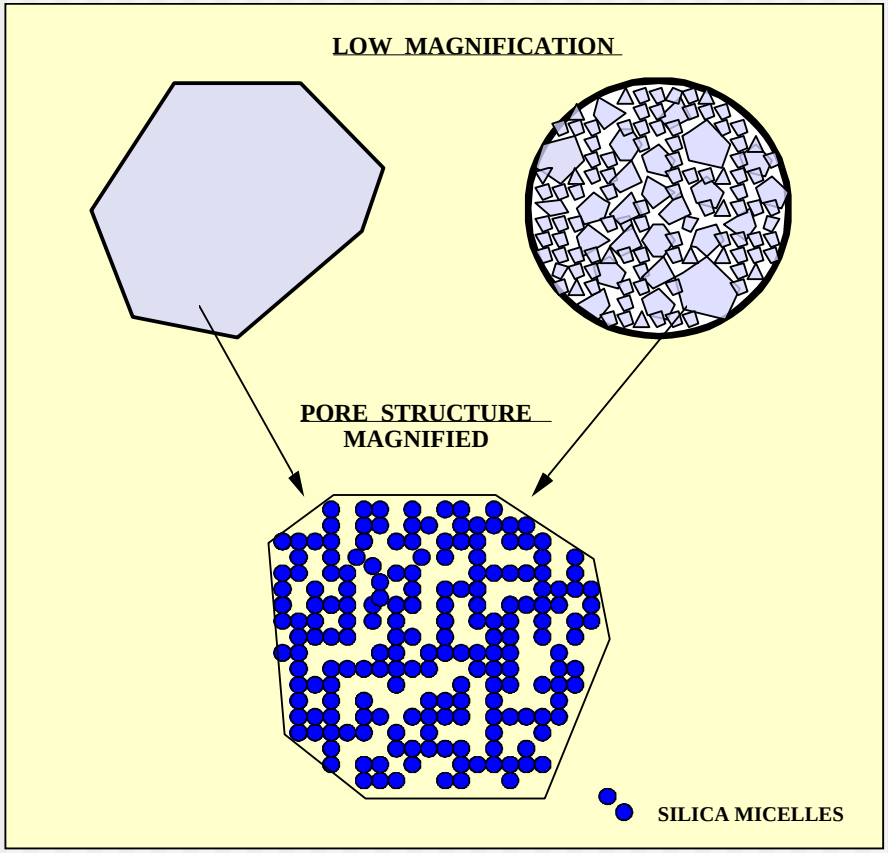


Fra Luca Pacioli (1445-1510)

Richard Buckminster Fuller

Time Magazine, January 10, 1964




LOW MAGNIFICATION
PORE STRUCTURE
MAGNIFIED
SILICA MICELLES

Nanotechnology as a economics phenomenon

FORTUNE

- May, 2004

Is nanotechnology ready for its close-up?

- (3,400 millon dollars in 2003!)

The ethical debate on nanotechnology

Embargo on nanomaterials production!
(August, 2002)

- **The Action Group on Erosion, Technology and Concentration, formerly RAFI, is an international civil society organization headquartered in Canada**

Abril 1, 2004

Nano's Troubled Waters: Latest toxic warning shows nanoparticles cause brain damage in aquatic species and highlights need for a moratorium on the release of new nanomaterials

A new study revealing that engineered carbon molecules known as "buckyballs" cause brain damage in fish is one more brick in the wall of evidence suggesting that manufactured nanoparticles are harmful to the environment and to health. The results of the study highlight the urgency to heed ETC Group's 2002 call for a moratorium on manufactured nanoparticles in commercial products and they back up last month's recommendation by the Institut für ökologische Wirtschaftforschung – in a report commissioned by the European Parliament – that nanoparticles should not be released into the environment

1997 – Titanium dioxide/zinc oxide nanoparticles from sunscreen are found to cause free radicals in skin cells, damaging DNA. (Oxford University and Montreal University)

March 2002 – Researchers from the Center for Biological and Environmental Nanotechnology (CBEN, Rice University, Houston) report to US EPA that engineered nanoparticles accumulate in the organs of lab animals and are taken up by cells. *"We know that nanomaterials have been taken up by cells. That sets off alarms. If bacteria can take them up then we have an entry point for nanomaterials into the food chain."*

2003 – Researchers from NASA/Johnson Space Center report that studies on effects of nanotubes on the lungs of rats produced more toxic response than quartz dust. Scientists from DuPont Haskell laboratory present varying but still worrying findings on nanotube toxicity. *"The message is clear. People should take precautions. Nanotubes can be highly toxic."*

May 2nd, 2003

Prince Charles' concerns about the emerging revolution in nanotechnology have catapulted tabloid headlines about "grey goo”

(and impending doom) onto front pages around the world. Industry fears that the great GMO (genetically modified organisms) debate is about to go down to the nanoscale inhabited by atoms and molecules. But the virulent attacks against the Prince may only be the latest of a series of technical and tactical mistakes made

by nanotech's over-eager proponents.

On january 28th, 2004, 5 distinguished experts in Ethics, from the University of Toronto acussed Prince Charles of “exagerating” by asking for the embargo and thus condemning poor countries to “export bananas and T-shirts”, instead of nanotechnology

Their claim is that “ethical opposition” to nanotechnology is another imperialistic action by the ruling countries

Table 1. Global growth in NT R&D [2].

Country/region	1997	2002
USA	432	604
Western Europe	126	350–400
Japan	120	750
South Korea	0	100[a]
Taiwan	0	70
Australia	0	40
China	0	40
Rest of world	0	270

[a] Per year, for 10 years (in millions of dollars).

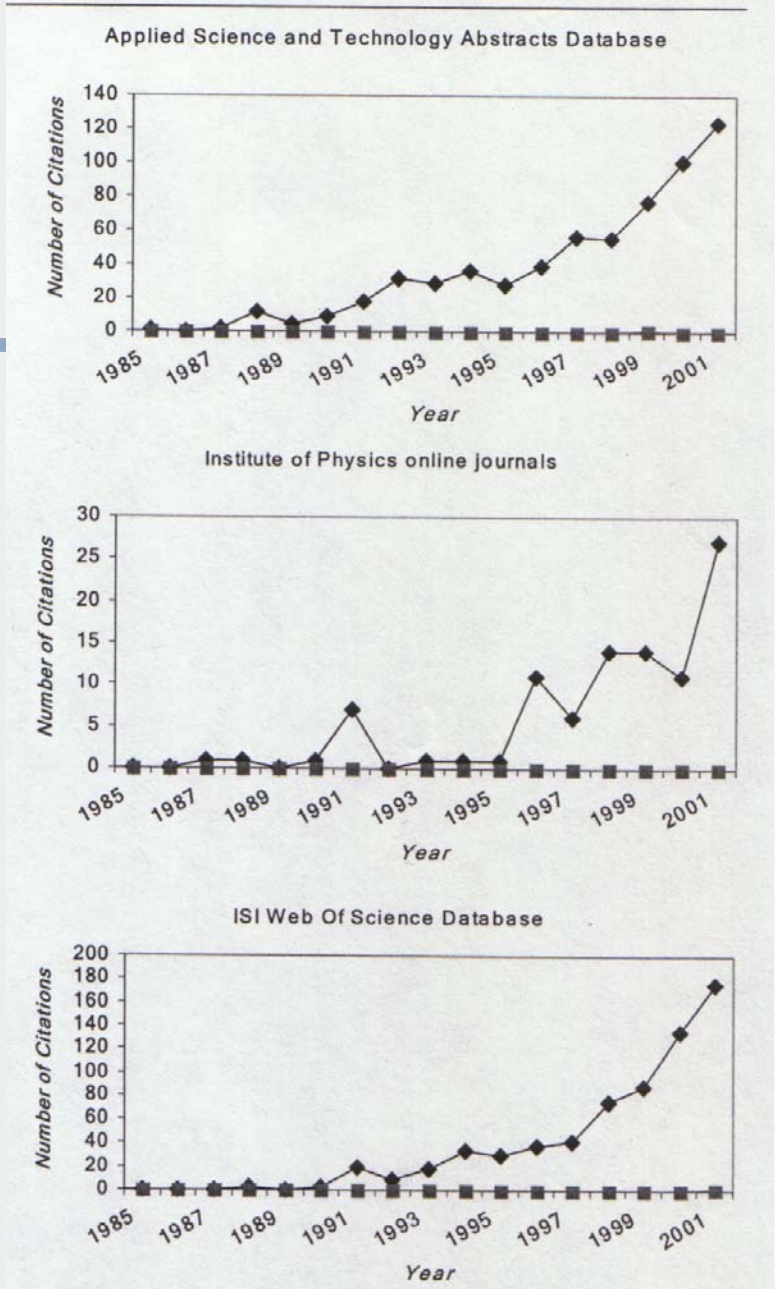


Figure 1. Citations in scientific databases on NT and on ethics or social implications of NT. ♦: NT; ■: ethics or social implications of NT.

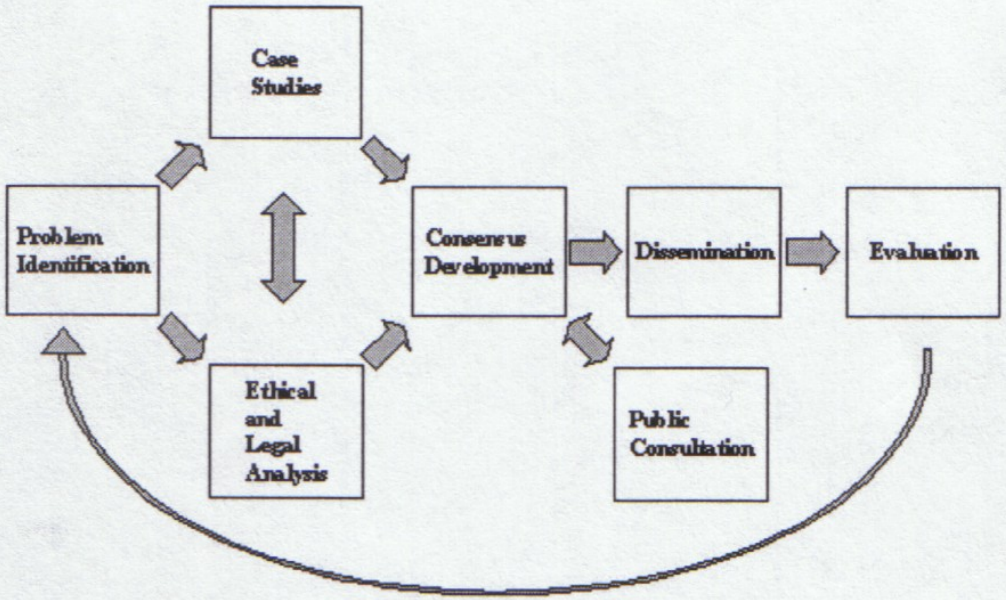


Figure 2. An example of a large-scale interdisciplinary method: the Canadian Program on Genomics and Global Health (CPGGH). The large-scale interdisciplinary platform has been designed specifically to address the deficiencies of current approaches to the study of the ethical, environmental, legal, and social implications of scientific and technological advances [23].

Concluding remarks

“Hard” vs. Social Sciences

- Nanotechnology = historical chance for joint projects
- Need of a transdisciplinary approach
- Future is here and no time for more “planning”