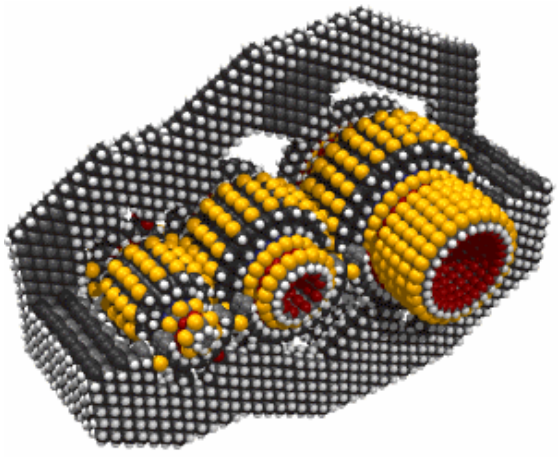
Nanotechnology

References:

Nanomaterials (Dieter Vollath)

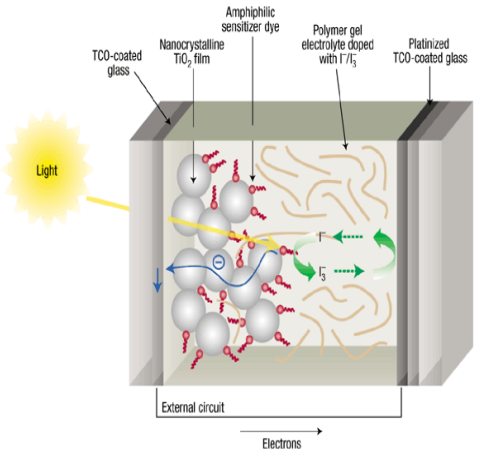
Structural nanocrystalline materials (Carl C. Koch)

Nanotechnology influences almost every facet of every day life



Typical nano-machine

Nanocrystalline Solar Cells



Access Optics

makes the lens for endoscopes and other medical devices.

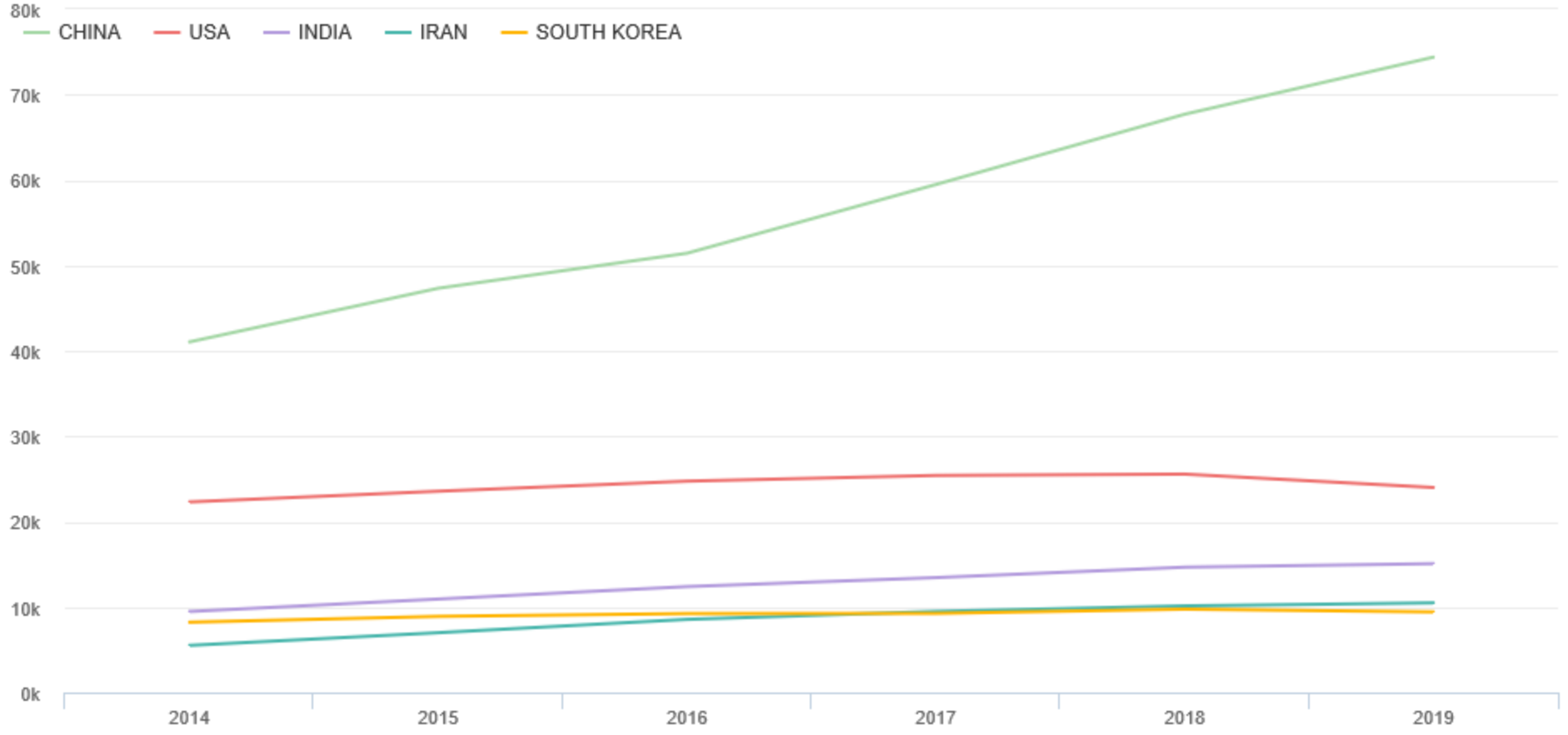
ARC Outdoors
nano silver cloth eliminating odor

Nano-Tex
stain resistance fabrics

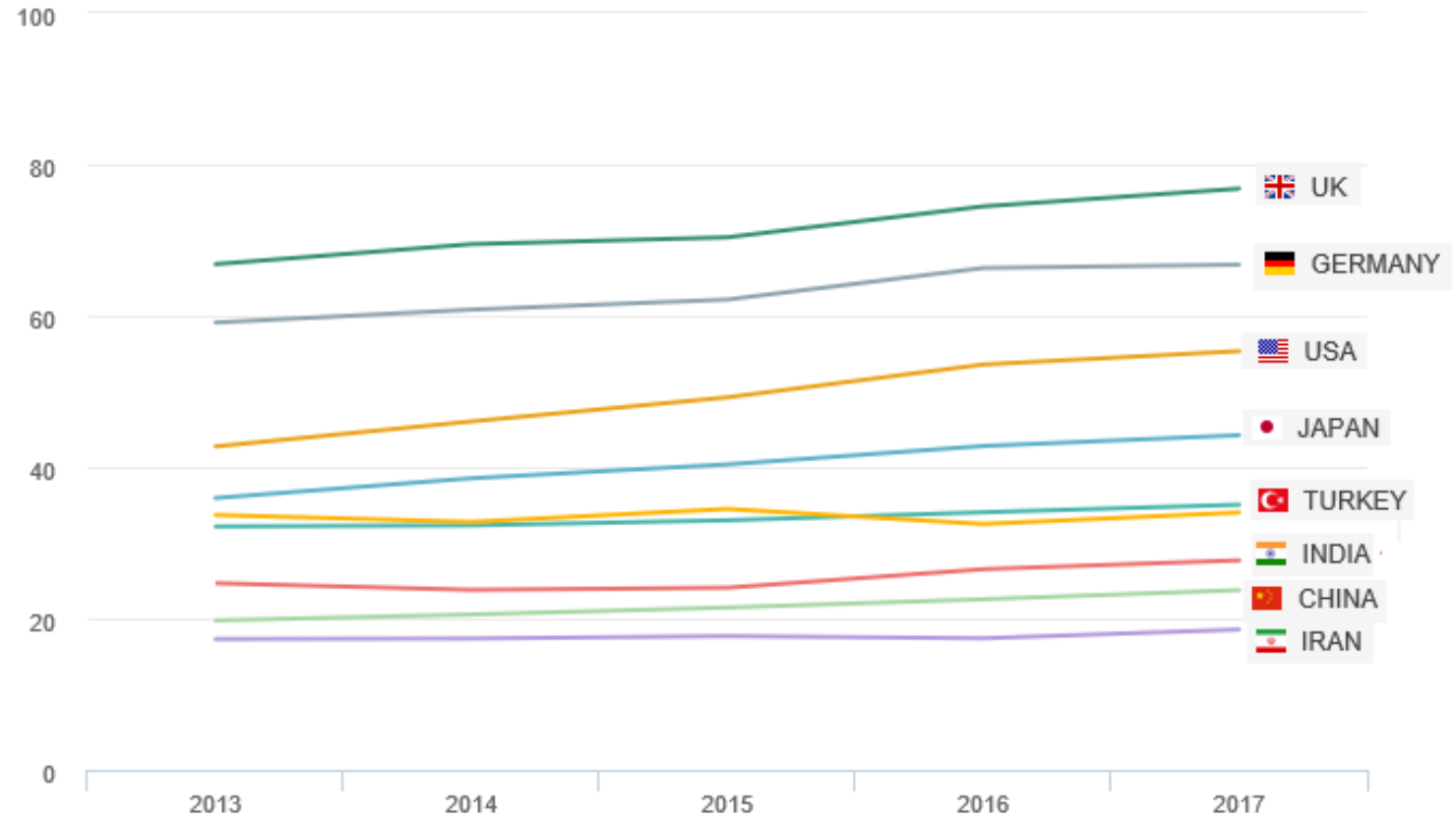
scratch resistance Paint – Mercedes-Benz

the Lycurgus Cup (4th Century B.C)

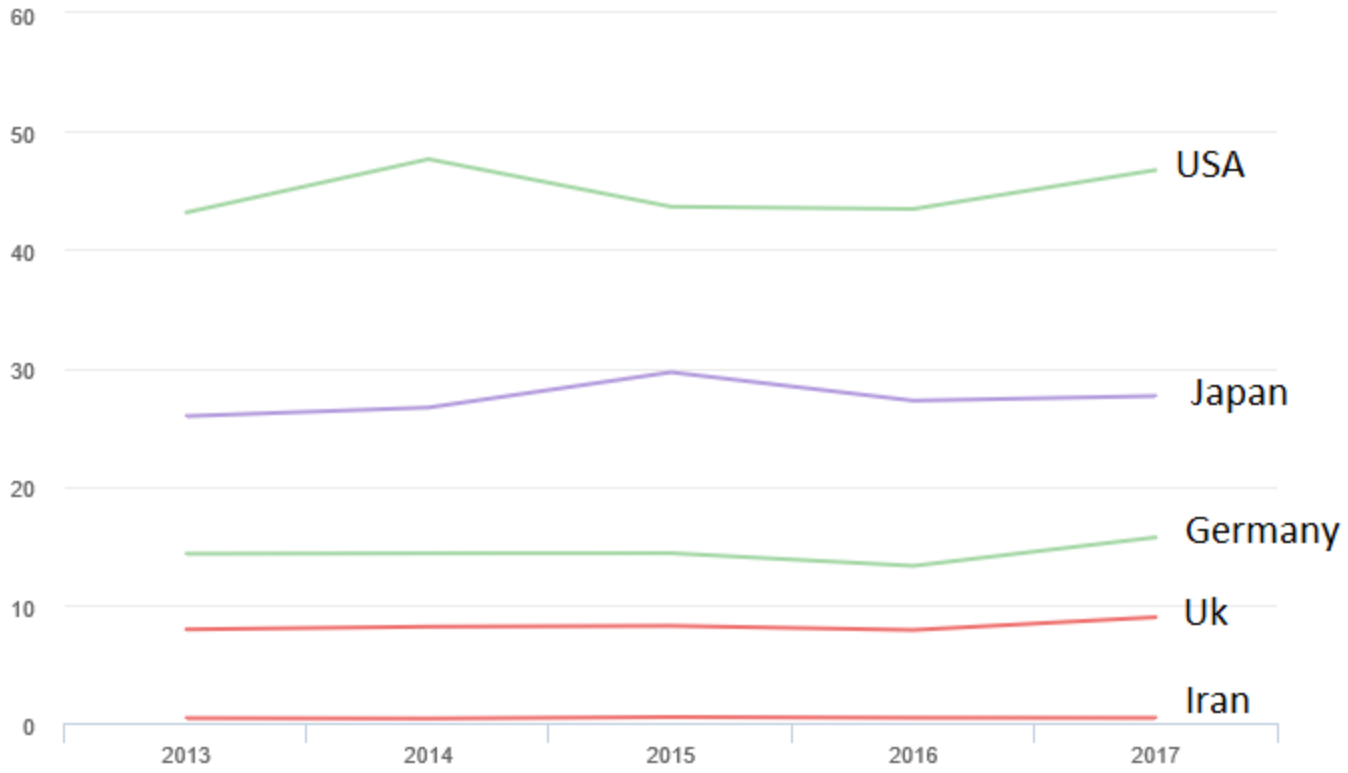
ISI indexed nano-articles (Article)



Share of international collaboration in nanoscience (Percent)



Ratio of nanotechnology patents to nano-articles (Patents per 100 articles)



Nanotechnology is the latest in a long series of technologies heralded as ushering in a new era – the “next industrial revolution”, according to some. Since 2000, nanotechnology has grown from little more than a gleam in the eyes of researchers to a technology projected to be worth $2.6 trillion in manufactured goods in 2014.

Current and future applications of nanotechnology are expected to hold immense societal and environmental benefits in regard to increased economic development and employment, improved materials using less resources and environmental remediation, along with new ways of diagnostics and medical treatments (RS & RAE 2004, Roco and Bainbridge 2005).

Defining Nanotechnology

- Research and technology development aimed to understand and control matter at dimensions of approximately 1 – 100 nanometer ;the nanoscale
- By a more generally accepted definition,today, nanotechnology is the engineering and fabrication of objects with features smaller than 100 nanometers, or one-tenth of a micron. A micron (lm) is one millionth of a meter – too small for the eye to resolve. A nanometer (nm) is 1 thousandth of a micron – that is to say, really, really tiny.

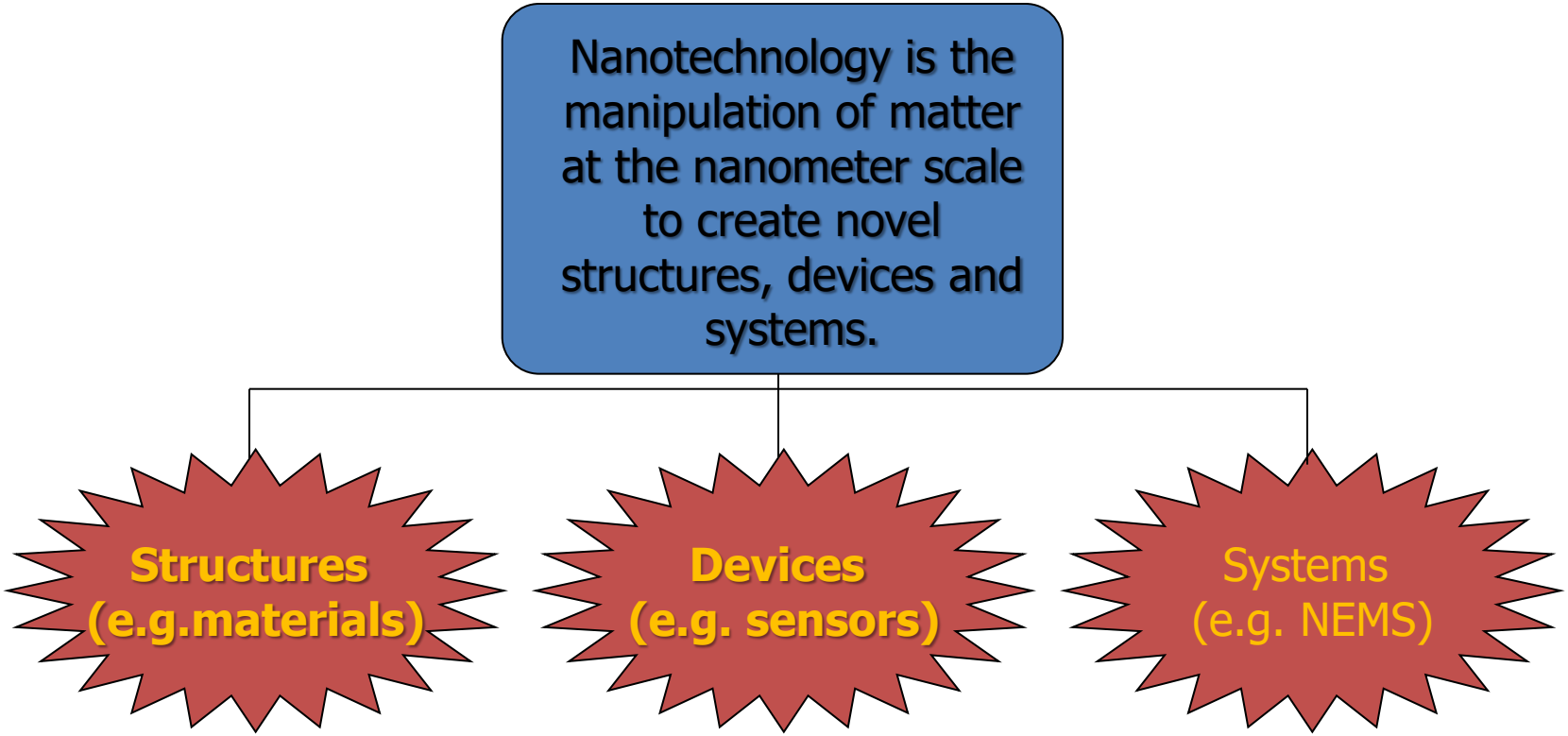
“Capability to manipulate, control, assemble, produce and manufacture things at atomic precision”

Richard Feynman
Nobel Prize in Physics 1965

The sizes of nanoscale objects: Nature versus fabrication

Object	Diameter
Hydrogen atom	0.1 nm
Buckminsterfullerene (C60)	0.7 nm
Carbon nanotube (single wall)	0.4–1.8 nm
6 carbon atoms aligned	1 nm
DNA	2 nm
Proteins	5–50 nm
CdSe Quantum Dot	2–10 nm
Ribosome	25 nm
Virus	75–100 nm
Semiconductor Chip Features	90 nm or above
Mitochondria	500–1000 nm
Bacteria	1000–10000 nm
Capillary (diameter)	8000 nm
White blood cell	10000 nm

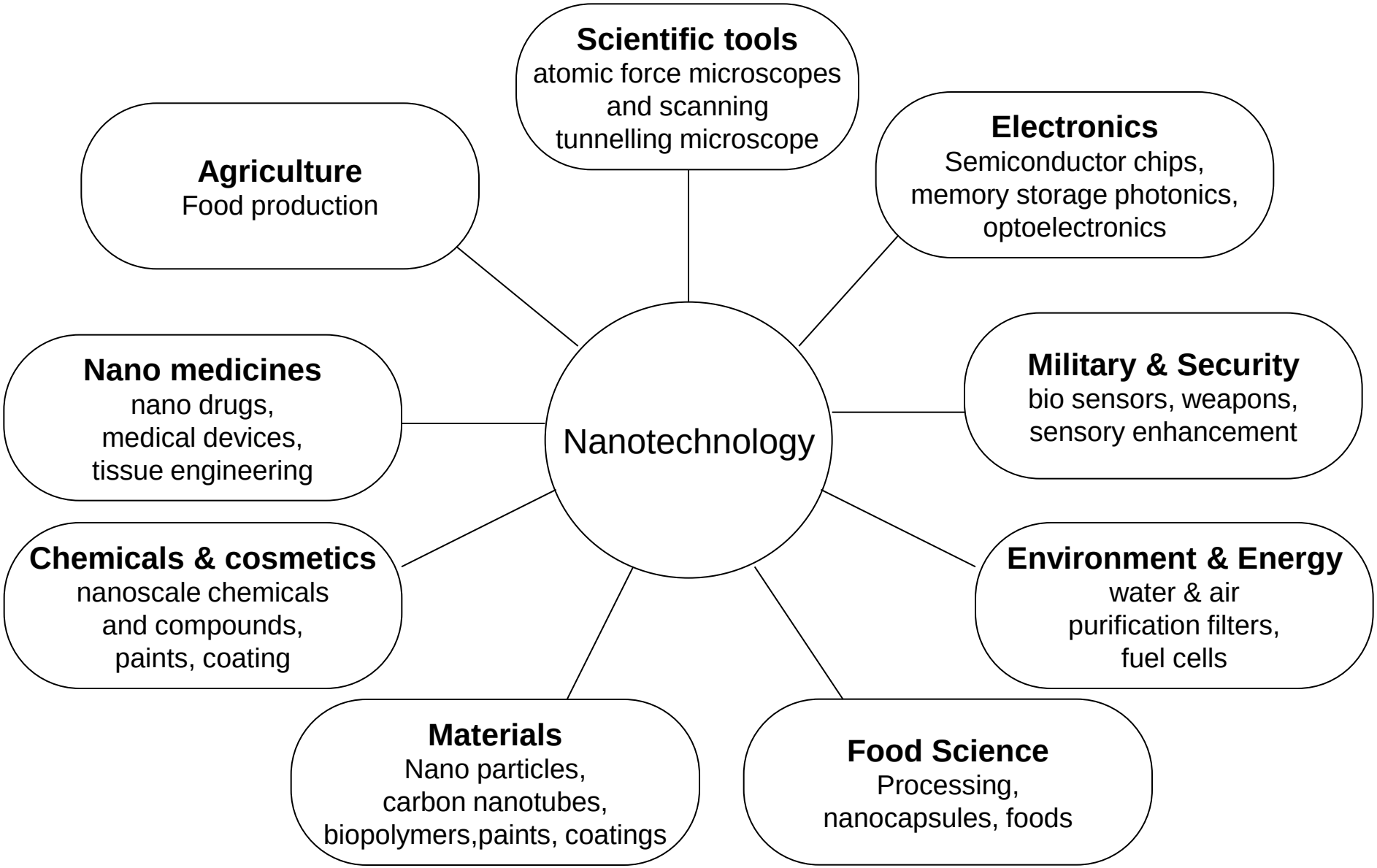
WHAT IS NANOTECHNOLOGY?



* 1 millimeter = 1,000 micrometers;
1 micrometer = 1,000 nanometers

Source: "Nanotech: The Tiny Revolution" by CMP Científica (November 2001)

Prospective first and second generation nanotechnology applications



1959 Feynman Lecture *"There is Plenty of Room at the Bottom"* provided the vision of exciting new discoveries if one could fabricate aterials/devices at the atomic/molecular scale.

• Emergence of instruments in the 1980s; STM, AFM providing the "eyes", "fingers" for nanoscale manipulation, measurement…

• Atoms and molecules are generally less than a nm and we study them in chemistry. Condensed matter physics deals with solids with infinite array of bound atoms. Nanoscience deals with the in-between meso-world

• Size-dependent properties
• Surface to volume ratio
- A 3 nm iron particle has 50% atoms on the surface
- A 10 nm particle 20% on the surface
- A 30 nm particle only 5% on the surface

Nanomaterials have a large surface area. For example, single-walled carbon nanotubes show ~ 1600 m2/g. This is equivalent to the size of a football field for only 4 gms of nanotubes. The large surface area enables:
- Large adsorption rates of various gases/vapors
- Separation of pollutants
- Catalyst support for conversion reactions

Various nanomaterials and nanotechnologies

- Nanocrystalline materials
- Nanoparticles
- Nanocapsules
- Nanoporous materials
- Nanofibers
- Nanowires
- Fullerenes
- Nanotubes
- Nanosprings
- Nanobelts
- Dendrimers
- Molecular electronics
- Quantum dots
- NEMS, Nanofluidics
- Nanophotonics, Nano-optics
- Nanomagnetics
- Nanofabrication
- Nanolithography
- Nanomanufacturing
- Nanomedicine
- Nano-bio