

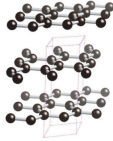
NBICS Technologies

Alexander Aksentyev

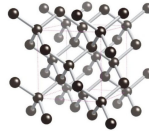
National Research Institute “MEPhI”

Carbon allotropes

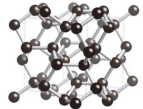
Allotropy is the property of some chemical elements to exist in several different geometries (known as *allotropes*) in the same physical phase.



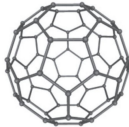
graphite



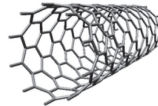
diamond



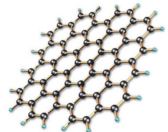
BC8



fullerene



nanotube



graphene

The Buckyball

- ▶ The Buckminsterfullerene (named after inventor Richard Buckminster Fuller) was one of the first nanoparticles to be discovered (1985)
- ▶ Number of atoms: 20 to over 100; the most common type (C₆₀) contains 60 carbon atoms
- ▶ Modifying a buckyball by adding or replacing an atom in order to change the

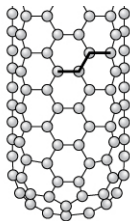


Uses

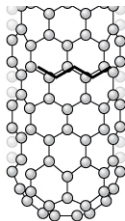
- ▶ **Armor.** Hard as diamonds, buckyballs are potentially useful within armor
- ▶ **Medicine.** Functionalized buckyballs can be made soluble by body cells, and hence find the following medical applications:
 - ▶ As antioxidants, because of their ability to absorb electrons in free radicals
 - ▶ In targeted drug delivery. The buckyball encases a minute dose of a particular drug. By controlling the functionalization of the buckyball the drug is absorbed only by the necessary cells
- ▶ **Fiber optics.** Because of their perfect spherical shape, buckyballs are able to transmit light

The nanotube

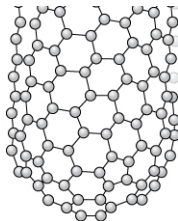
- ▶ Diameter < 1 nm
- ▶ A few nano- up to a millimeter in length
- ▶ Symmetry: armchair, zig-zag, chiral
- ▶ Single/multiple wall CNTs
- ▶ Compared to steel:
 - ▶ $100 \times$ more difficult to tear apart
 - ▶ $5 \times$ as elastic
 - ▶ a quarter density
- ▶ High thermal conductivity
- ▶ Metallic/semi-conductive contingent on symmetry



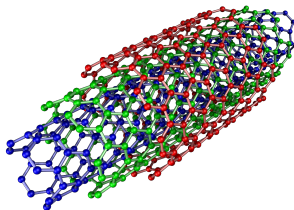
Armchair



Zigzag



Chiral

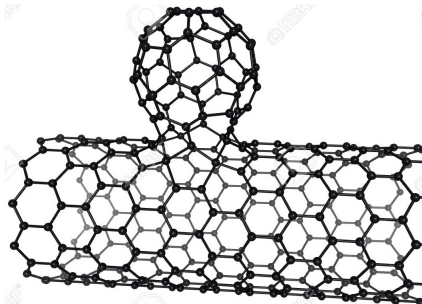


Uses

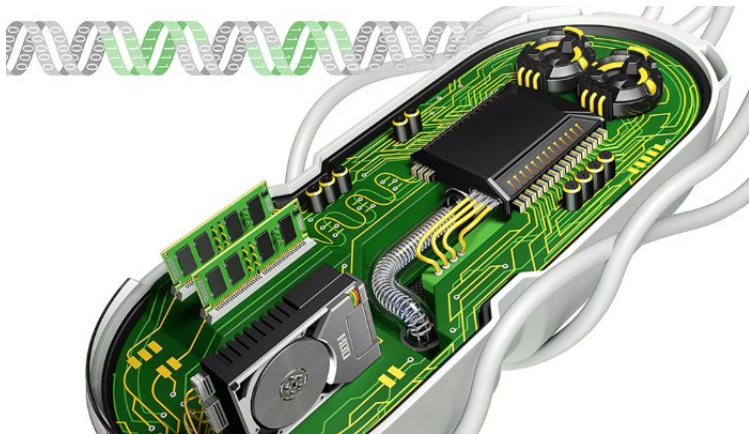
1. **Medicine:** functionalization, as well as their natural fluorescence, enable the use of CNTs as chemical sensors; they have also been shown to fuse well with bone, which could be used to diminish the implant rejection rate
2. **Conductive plastics:** CNTs are the best known conductive fillers because of their high aspect ratio
3. **Energy storage:** good battery electrodes due to high surface area ($\sim 1000 \text{ m}^2/\text{g}$), good electrical conductivity, and linear geometry; the high surface area and thermal conductivity also make them useful as electrode catalysts in fuel cells
4. **Molecular electronics:** their geometry, electrical conductivity, and the ability to be precisely derived, make CNTs invaluable connectors between switches at the nanoscale; their properties as semiconductors also make them usable as switches themselves

The nanobud

- ▶ A nanotube with a fullerene ball attached to it
- ▶ As chemically reactive as the fullerenes, as electrically conductive as the nanotubes
- ▶ The fullerene buds serve as additional anchors, modifying the mechanical properties of the whole structure
- ▶ Efficient field emitters, with the emission threshold $0.65 \text{ V}/\mu\text{m}$ (a third of that of the nanotubes)
- ▶ Highly scalable production processes, therefore applications of industrial importance



Synthetic biology



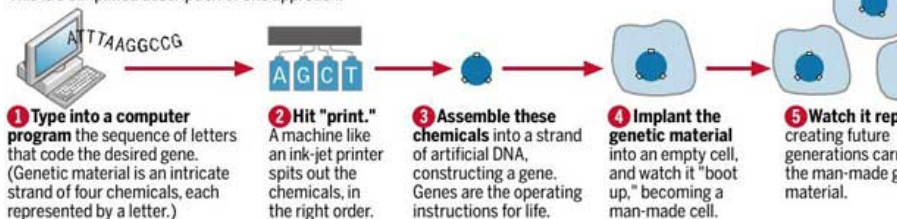
A set of technologies to construct living organisms with desired phenotypes.

- ▶ Systems biology studies complex biological systems as integrated wholes
- ▶ Synthetic biology studies how to build such systems for engineering applications
- ▶ Living systems provide a rich medium for controlling and processing
 - ▶ information
 - ▶ materials
 - ▶ energy
- ▶ Bacteria are the simplest known natural objects capable of replicating

How bacteria are made

One way synthetic biologists make cells

Synthetic biologists are trying several strategies to design and build communities of one-celled organisms. This is a simplified description of one approach.



Source: J. Craig Venter Institute

KARL KÄHLER/BAY AREA NEWS

Uses

- ▶ **Materials.** DNA synthesis and DNA sequencing have enabled the construction of microorganisms with specially engineered metabolic cycles. This is used in a variety of production processes: Biolsoprene, BioAcrylic, “Green Chemicals”
- ▶ **Vaccines.** Bio Technologies provide tools to formulate vaccines via molecular engineering and DNA sequencing
- ▶ **Fuel.** Sugars from non-food biomass can be used to manufacture biofuels and renewable chemicals that are currently produced from expensive and price-volatile petroleum feedstocks
- ▶ **Waste disposal.** Bioplastics made from fermented sugars can be biodegraded by microbes already existing in soil and water environments