

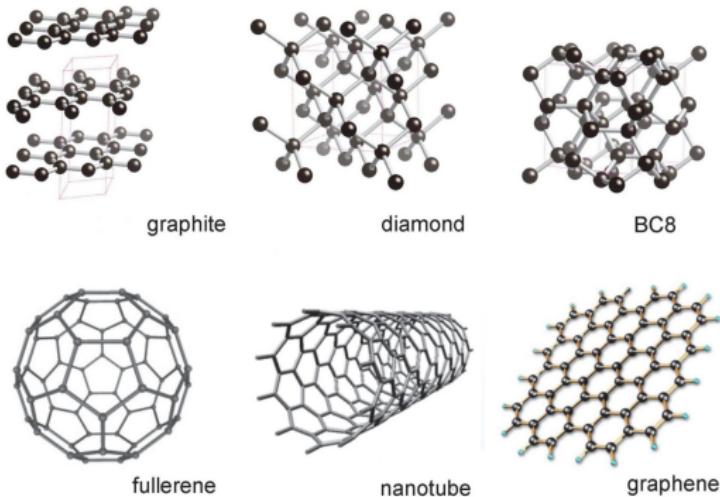
NBICS Technologies

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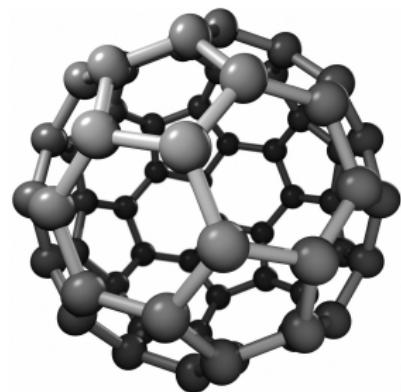
Carbon allotropes

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



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 properties of the buckyball is called **functionalization**



Uses

- ▶ **Armor.** Hard as diamonds, buckyballs are potentially useful within armor

Uses

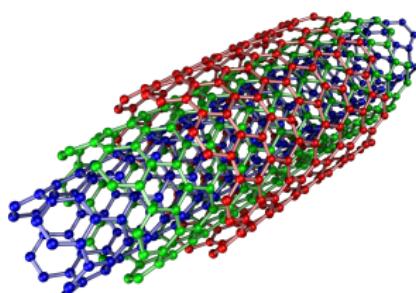
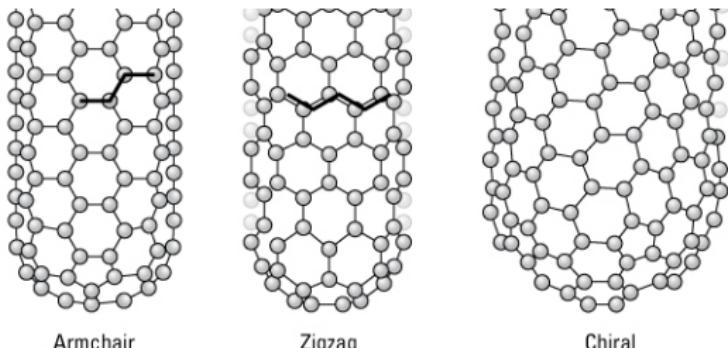
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- ▶ **Medicine.** Functionalized buckyballs can be made soluble by body cells, and hence find the following medical applications:
 - ▶ As antioxidants, because of their ability to absorb electrons in free radicals
 - ▶ In targeted drug delivery. The 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

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- ▶ **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 × more difficult to tear apart
 - ▶ 5 × as elastic
 - ▶ a quarter density
- ▶ High thermal conductivity
- ▶ Metallic/semi-conductive contingent on symmetry



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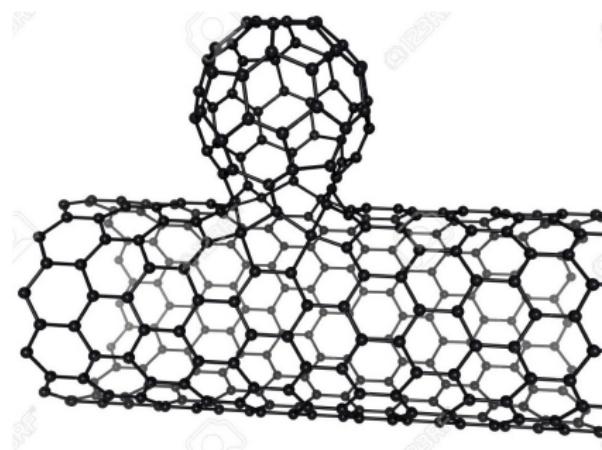
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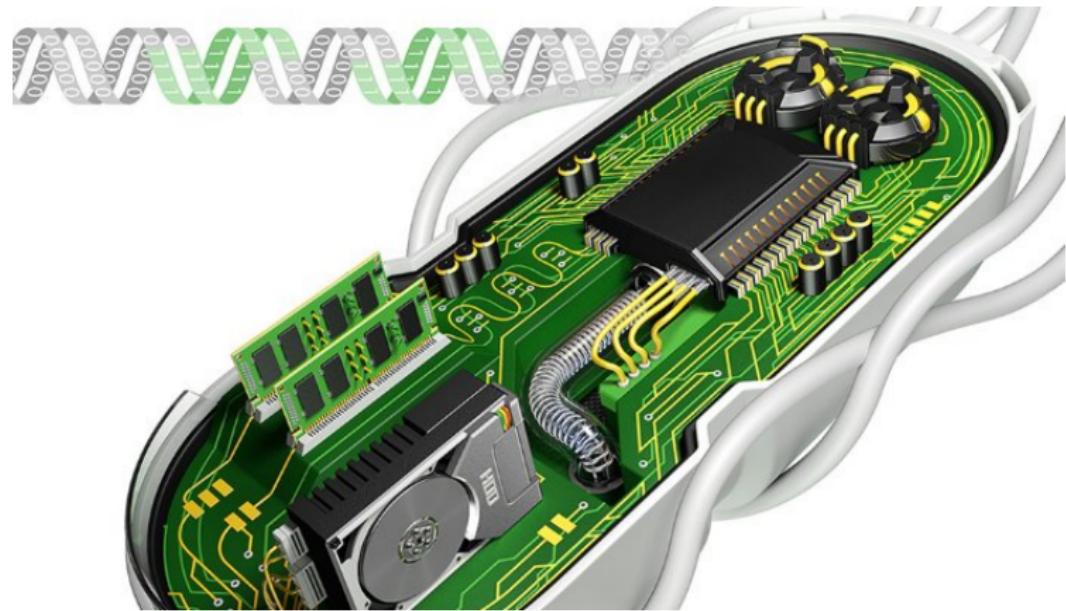
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- ▶ **Molecular electronics:** their geometry, electrical conductivity, and the ability to be precisely derived, make CNTs invaluable connectors between switches at the nanoscale; their properties as semiconductors also make them usable as switches 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

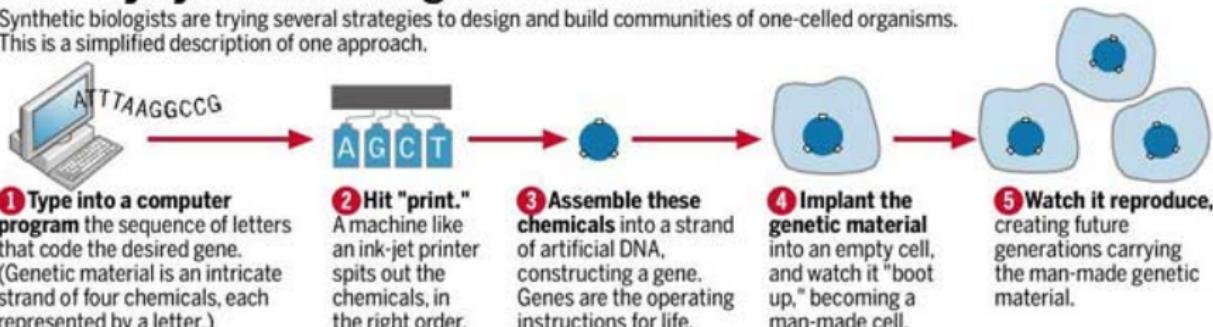


A set of technologies to construct living organisms with desired phenotypes.

- ▶ 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

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 KAHLER/BAY AREA NEWS GROUP

Enabling technologies:

- ▶ Standardization of DNA parts (BioBrick plasmids)
- ▶ DNA Synthesis
- ▶ DNA Sequencing
- ▶ Modular protein assembly

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”

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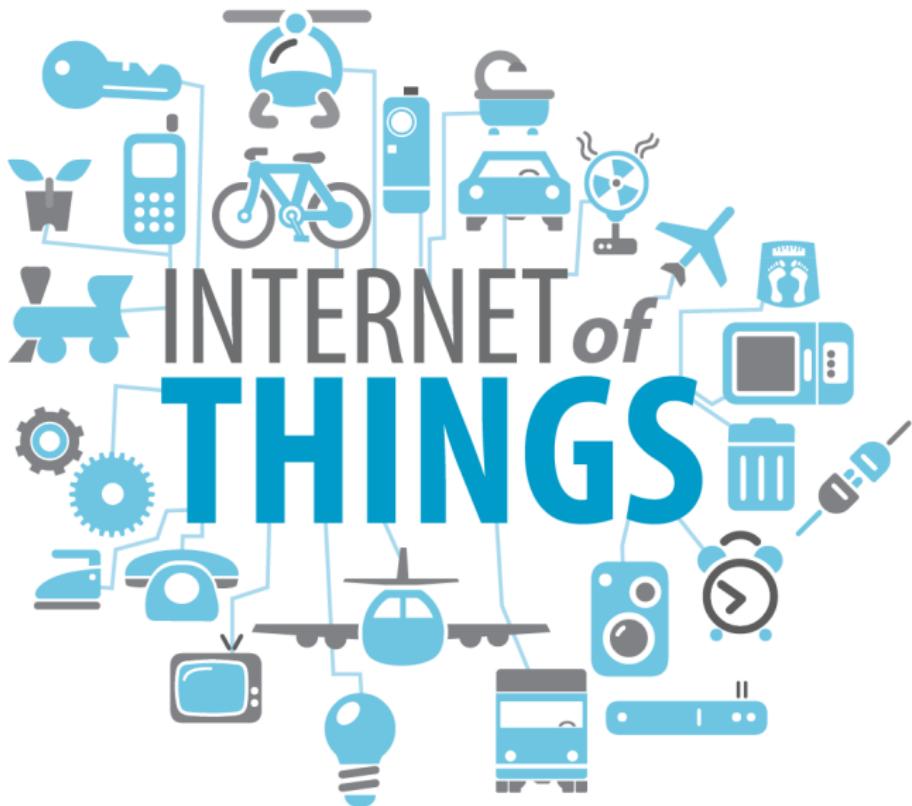
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- ▶ **Waste disposal.** Bioplastics made from fermented sugars can be biodegraded by microbes already existing in soil and water environments



- ▶ The internetworking of physical devices to allow collection and exchange of information
- ▶ An instance of the more general class of *cyber-physical systems*:
 - ▶ smart grids
 - ▶ smart homes
 - ▶ smart cities
 - ▶ intelligent transportation
- ▶ Made by equipping all physical objects with identifying devices
- ▶ By 2020 there expected to be 20 billion connected devices
- ▶ The Internet of Things will therefore depend on the adoption of IPv6 to accommodate for the large address space

Enabling technologies

Some of the top 10 IoT-enabling technologies Gartner (IT research and advisory firm) identifies as most in-demand in 2017–2018:

- ▶ **IoT security:** IoT devices are open to both information and physical attacks, and many of them lack the processors and OS to afford sophisticated security approaches
- ▶ **IoT analytics:** IoT business models require new algorithms, data structures, machine learning approaches to profit from the data that will become available
- ▶ **IoT device management:** as the devices comprising the IoT will find themselves in a variety of contexts, locations, physical states, the challenge is to develop data structures capable of learning and adapting to circumstances

- ▶ **IoT processors:** processor architecture defines the device capabilities, such as security, firmware updatability, ability to support device management agents, etc.
- ▶ **IoT OS:** traditional OS consume too much power, need fast processors, lack guaranteed real-time response, require too much memory. A range of specialized IoT OS has been developing
- ▶ **Event stream processing:** distributed stream computing platforms (DSCPs) have emerged to address the need to analyze the extremely high data rates generated by some IoT applications (telecom, telemetry) on-line
- ▶ **IoT standards:** IoT devices need to interoperate, and IoT business models rely on sharing data between multiple devices and organizations

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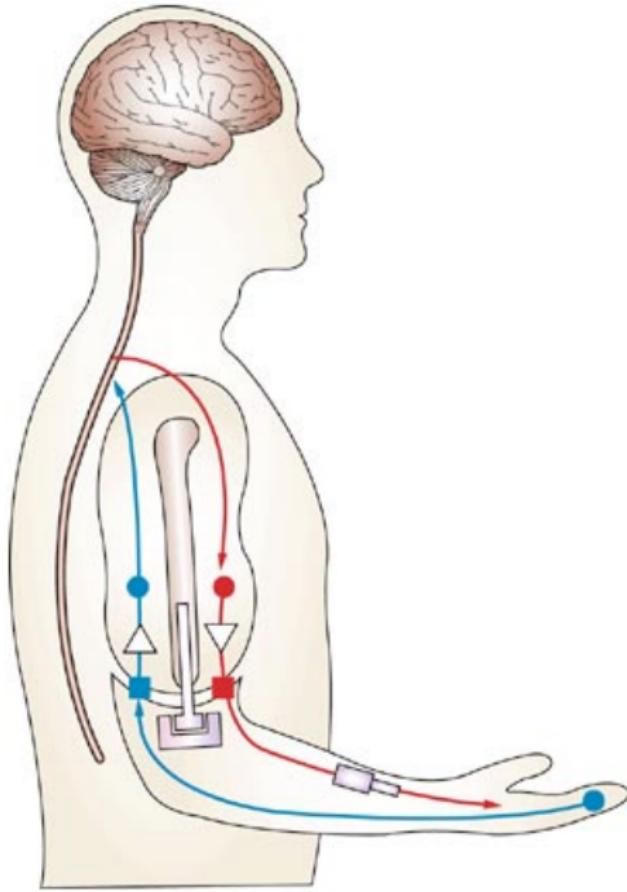
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- ▶ In transportation:
 - ▶ **on-line traffic analysis** improves logistics (smart infrastructure, smarter personal choices)
 - ▶ **on-board wi-fi, real-time video, smart ticketing, centralized operations** enhance mass transit and passenger experience

Neural interfaces

CREL'

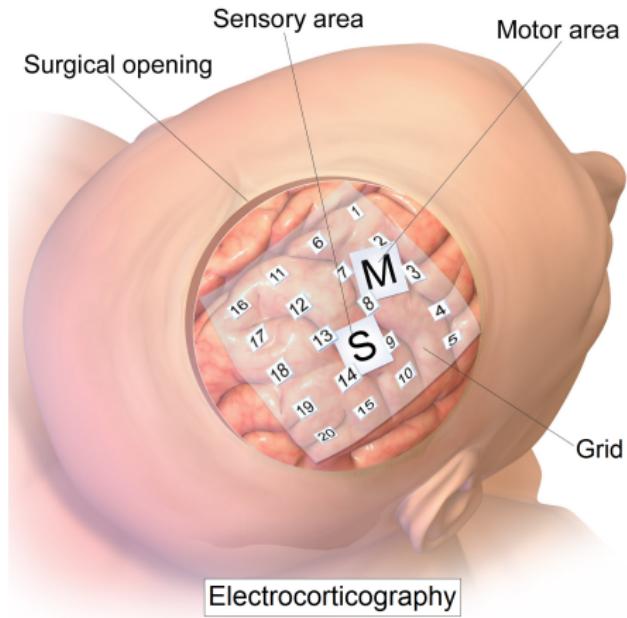




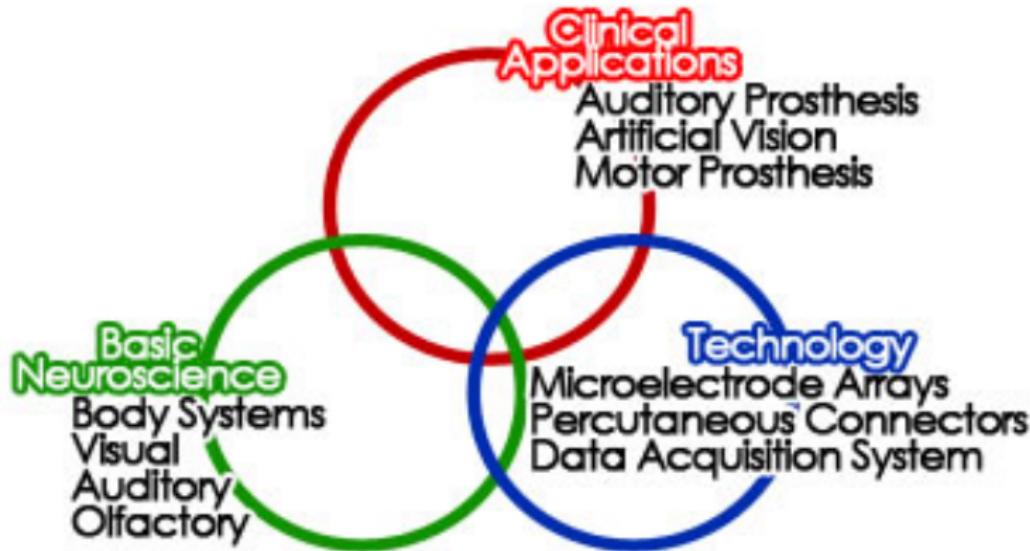
- ▶ A brain-computer interface (BCI) is a direct communication pathway between a wired brain and an external device
- ▶ Research and development are focused primarily on neuroprosthetics applications
- ▶ Was made possible by the development of *electroencephalography* (EEG)

Types of interfaces

- ▶ EEG-based:
 - ▶ Electrocorticography: electrodes embedded in a plastic pad are placed above the cortex, beneath the cranium
- ▶ Non-EEG-based:
 - ▶ Pupil-size oscillation: an eye's pupil contracts according to the brightness of the looked at object



BCI applications



Educational technology



- ▶ Learning theory
 - ▶ Behaviorism
 - ▶ Cognitivism
 - ▶ Constructivism
- ▶ Computer-based training
- ▶ Online learning
- ▶ Mobile learning

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