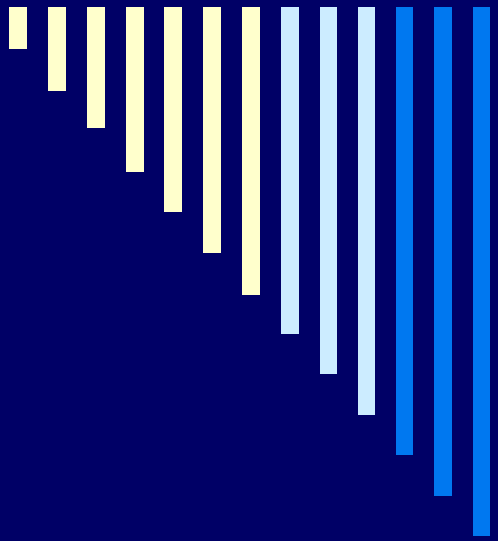

Electronics at Molecular Scale

By

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Introduction

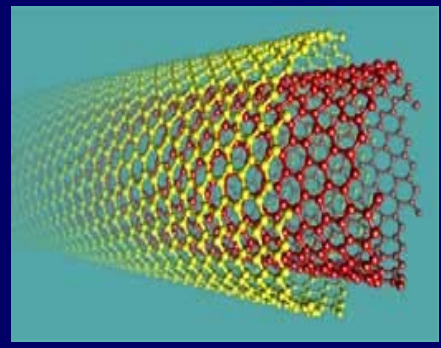
- • Nano History
- • Nano-Technology
- • Molecular Electronics
- • Advantages over Microelectronics
- • Potential Applications
- • Present research
- • Future

History of NANO

- **• Tools 2,000,000 B.C.**
- **• Metallurgy 3600 B.C.**
- **• Steam power 1764**
- **• Mass production 1908**
- **• Automation 1946**
- **• Sixth industrial revolution NOW**

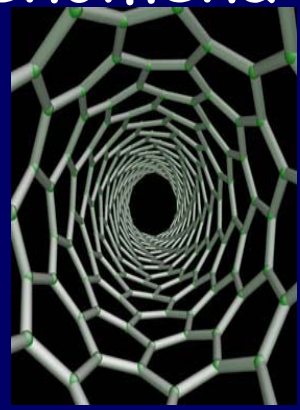
- Moving from micrometer scale to nanometer scale devices.

Nanotechnology



- Nanotechnology:

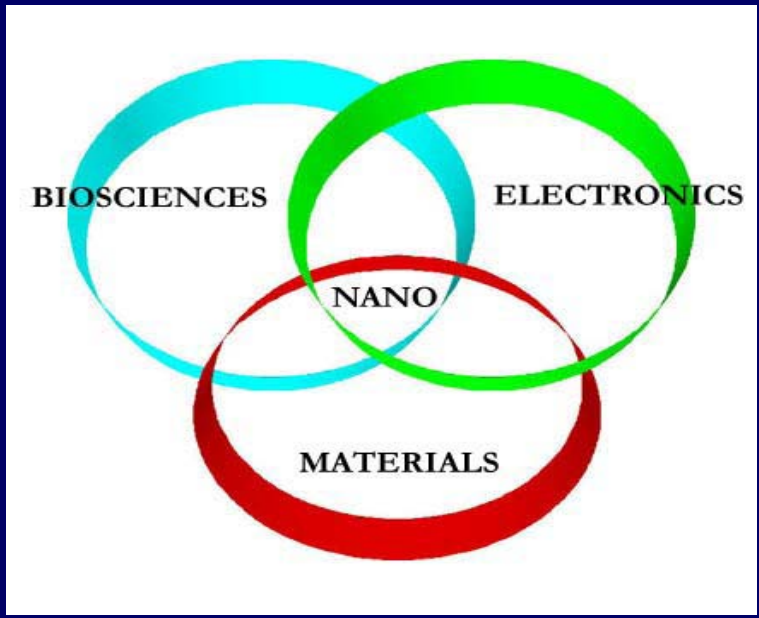
-The creation of functional materials, devices and systems through control of matter on the nanometer(1~100nm) length scale and the exploitation of novel properties and phenomena developed at that scale.



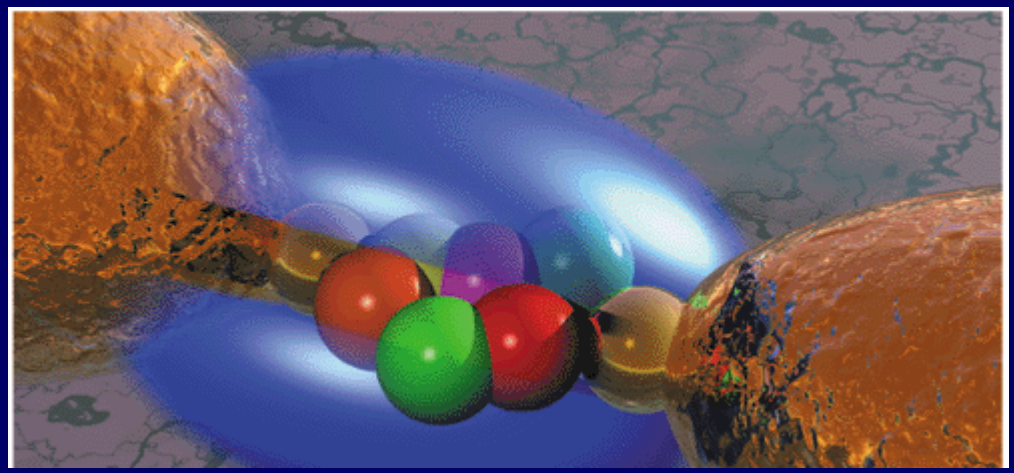
Milestone

- • **1959** R. Feynman Delivers “ Plenty of Room at the Bottom”
- • **1974** First Molecular Electronic Device Patented
- • **1981** Scanning Tunneling Microscopic (STM)
- • **1986** Atomic Force Microscopy (AFM) Invented
- • **1987** First single-electron transistor created
- • **1991** Carbon Nanotubes Discovered

Nanotechnology Components



Molecular Electronics



- Source: Reed. www.scientificamerican.com

- Definition

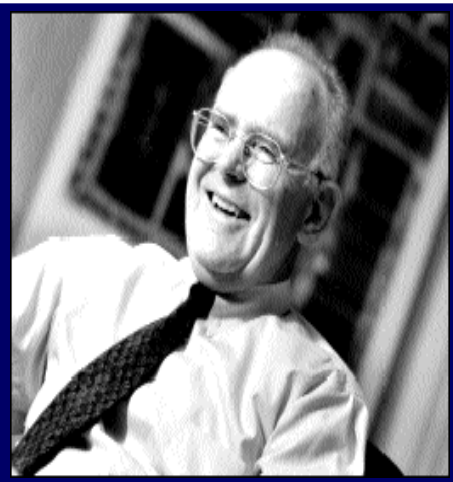
–is a field emerging around the premise that it is possible to build individual molecules that can perform functions identical to those of the key components of today's microcircuits.

Molecular Devices

Many researchers around the world have started to combine biology and electronics in the formation of molecular electronics.

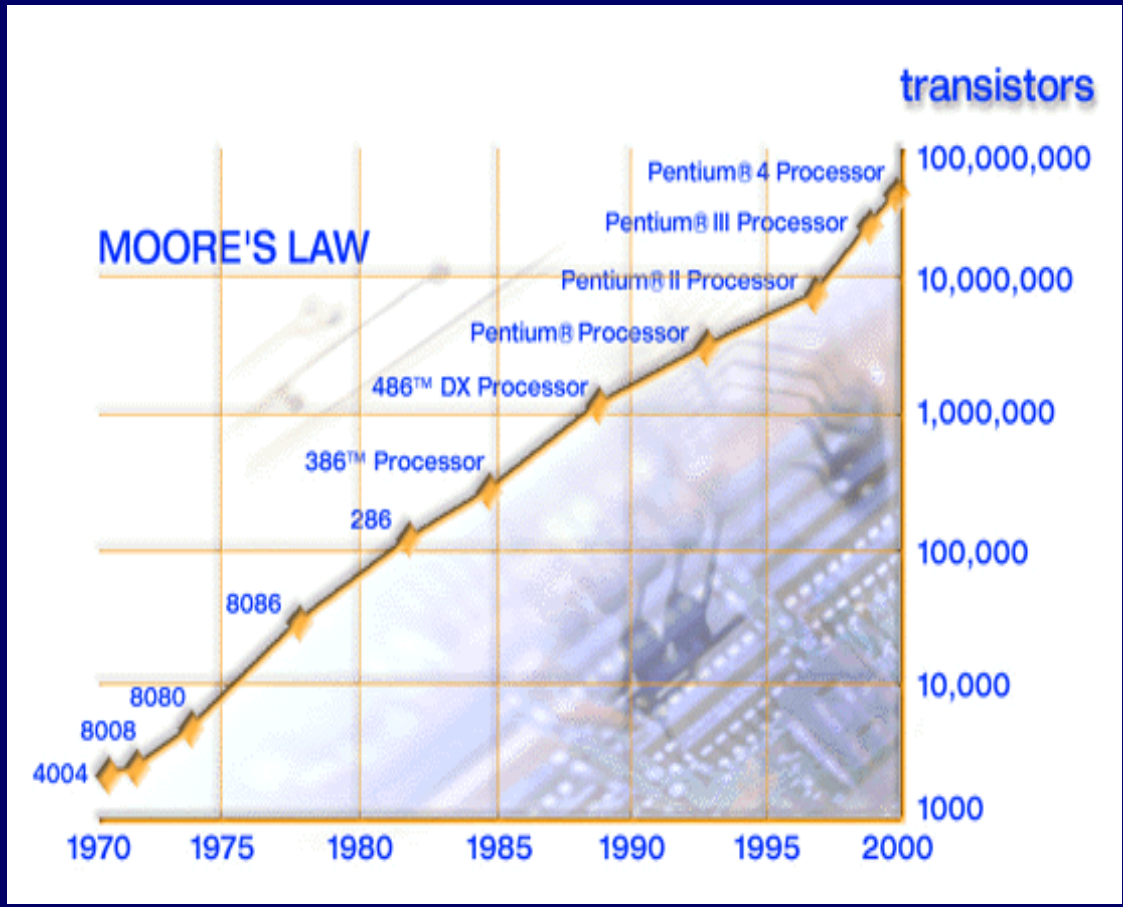
- Recent studies have shown that individual molecules can conduct and switch electric current and store information.
- Molecular Computers can be constructed from Molecular Scale Electronic Devices which are electronic devices that consist of only a few atoms and are constructed and interconnected by chemical means.

Moore’s Law



- Gordon Moore (co-founder of Intel) predicted in 1965 that the transistor density of semiconductor chips would double roughly every 18 months.
- It's not a law! It's a prediction about what device physicists and process engineers can achieve

Moore's Law Holding!



Ambitious Predictions

- • Moore's Law will have run its course around 2019. By that time, transistor features will be just a few atoms in width. But new computer architectures will continue the exponential growth of computing.
- • However, at some point, that miniaturization process collides with the physical limits of silicon.
- • Nanotechnology's ability to continually increase the amount of data that fits on a microchip, providing the industry with escalating computing speed and power, which led to even-more powerful products and a strong motive for customers to upgrade.

Why Molecular Electronics?

- Limits in microelectronics already been reached to its extreme. A further decrease in device feature will cause quantum problems.
- Stray signals on the chip.
- the need to dissipate the heat from so many closely packed devices.

Why molecular Electronics cont…

- • Nanotechnology exploits benefits of ultra small size, enabling the use of particles to deliver a range of important benefits…
- By patterning matter on the Molecular scale, it is possible to vary fundamental properties of materials without changing the chemical composition.
- – Small particles are 'invisible' :
  - • Transparent Coatings/Films are attainable
- – Small particles are very weight efficient:
  - • Surfaces can be modified with minimal material.

Approaches

- Top-down
  - Breaking down matter into more basic building blocks. Frequently uses chemical or thermal methods.
- Bottoms-up
  - Building complex systems by combining simple atomic-level components.

Self-assembly

- Definition-
  - It is the autonomous organization of components into patterns or structures without human Intervention.
  - Self-assembling processes are common throughout nature and technology.

Self-assembly

- The concept of self-assembly is used increasingly in many disciplines, with a different emphasis in each.
- Self-assembly is one of the few practical strategies for making ensembles of nanostructures. It will therefore be an essential part of nanotechnology.
- Thus, Manufacturing electronics will benefit from applications of self-assembly.

Self-assembly

- Molecular Electronic components are designed and synthesized using batch processes of chemistry and then assembled into useful circuits through the process of self-organization and self-alignment.
- If molecular electronics achieves the ultimate goal of using individual molecules as switches and Carbon Nanotubes Tubes as the wires in circuits, we can anticipate nonvolatile memories with one million times the bit area density of today's DRAMs and power efficiency one billion times better than conventional CMOS circuitry

Recent Research Recent Research

- Recent studies have shown that individual molecules can conduct and switch electric current and store information.
- July of 1999– HP and the University of California at Los Angeles build an electronic switch consisting of a layer of several million molecules of an organic substance called rotaxane.
  - Linking a number of switches - is a version of an AND gate.

Recent Research cont.

- June 2002 - Fuji Xerox biotechnology made a prototype transistor of DNA from salmon prototype sperm.
- Researchers successfully passed an electric current through the DNA transistor.
- Super smaller chip in 10 years.

Can Molecular Electronics Be Better.

Researchers are trying to develop more sophisticated forms of microelectronics or maybe "nano"-electronics. The areas of interest overlap with biotechnology, which includes DNA and cellular computing.

- DNA - It is promising to achieve super-high density memory and high sensitive detection technology. (DNA-Nanowires, DNA-SET.)
- Cell Computing.

Biological Nanodevices

- Bottom-up approach frequently used when constructing nanomaterials for use in Medicine
- Most animal cells are 10 to 20 thousand nanometers in diameter.
- Nanodevices smaller than 100 nanometers would be able to enter the cells and organs where they could interact with DNA and proteins.

Biological Nanodevices (cont)

- This could assist with the detection of disease in very small cell or tissue samples.
- Could also allow less invasive examination of living cells with in the body.

Cancer Detection and Diagnosis

- Currently done by physical examination or imaging techniques Early molecular changes not detected by these methods.
- Need to detect changes in small percentage of cells, need very sensitive technology, "enter" nanostructures.

Improvements in Diagnostics

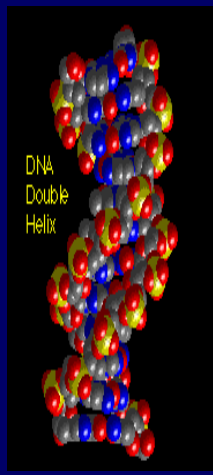
- BIO-Nanodevices could exam tissue or cell samples without physically altering them.
- Improving miniaturization will allow nanodevices to contain the tools to perform multiple tests simultaneously.
- Leading to faster, more efficient, and less sample consuming diagnostic tests.

Present and Future Applications

- Robotics and Manufacturing
  - components become smaller and conventional robotic methods will fail.
  - Self-assembly offers a new approach to the assembly of parts with nanometer dimensions.
- Microelectronics
  - Self-assembly offers a possible route to three dimensional Microsystems.

Possible Uses of DNA in Molecular-electronics.

- As the major component in a Single Electron Tunneling transistor (DNA-SET)
- As tags to connect up nano-circuitry including wires and nanoparticles (taking advantage of DNA selectivity)
- As basis for a Qubit (for quantum computation)



Cellular Computing: Goals

- To use a cell as the smallest DNA based molecular computer .
- More specifically, to mimic some or all of a cells mechanisms in order to produce a quasi molecular computer (QMC), or a true molecular computer (TMC)

Cells and Human -Made Computers

- Qualities of cells that are similar to those in computers
- Have inputs, state transitions, and outputs as indicated by their programming.
- Have a language to communicate between cells
- Have information and energy storage mechanisms.

Cell vs Human-made Computer.

Parameters	Cell	Human-made Comupter
Current carried by:	Chemicals	Wires
Reactions or processes turned on or off by:	Enzymes	Transistor
Information stored in:	Biopolymers	Capacitor
Computational programs stored in:	DNA	Software

Cells vs. Human Made Computers

Parameters	Cell	Human-made
Programmability	No - not yet	Yes
Self-Reproducibility	Yes	No - not yet

It’s a beginning……..

Thanks