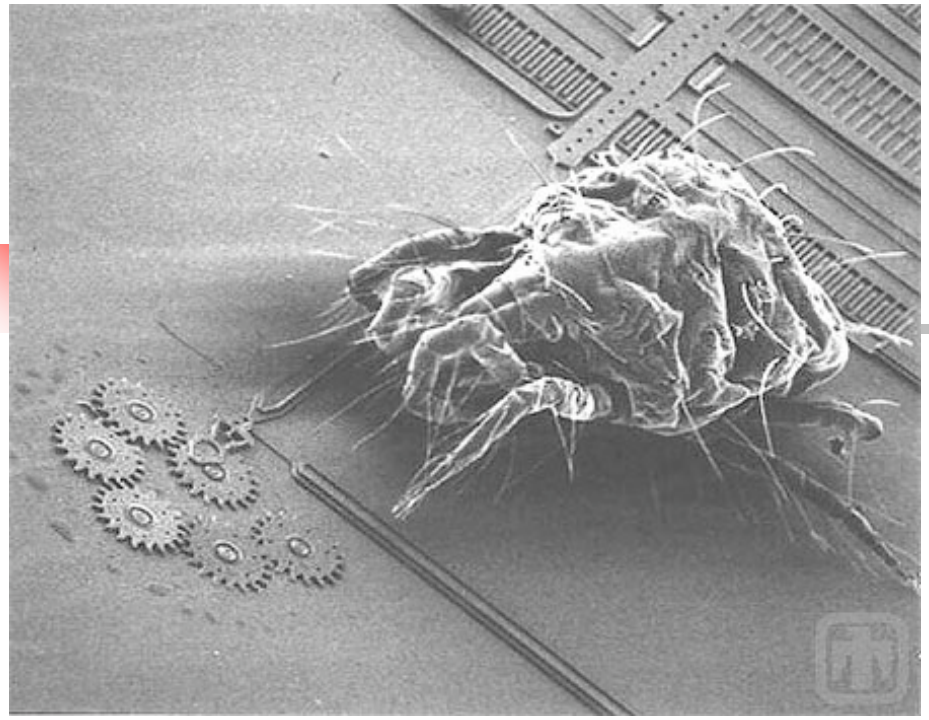
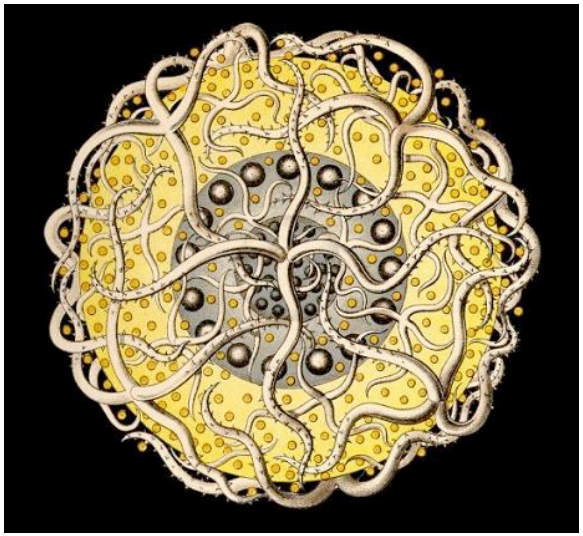
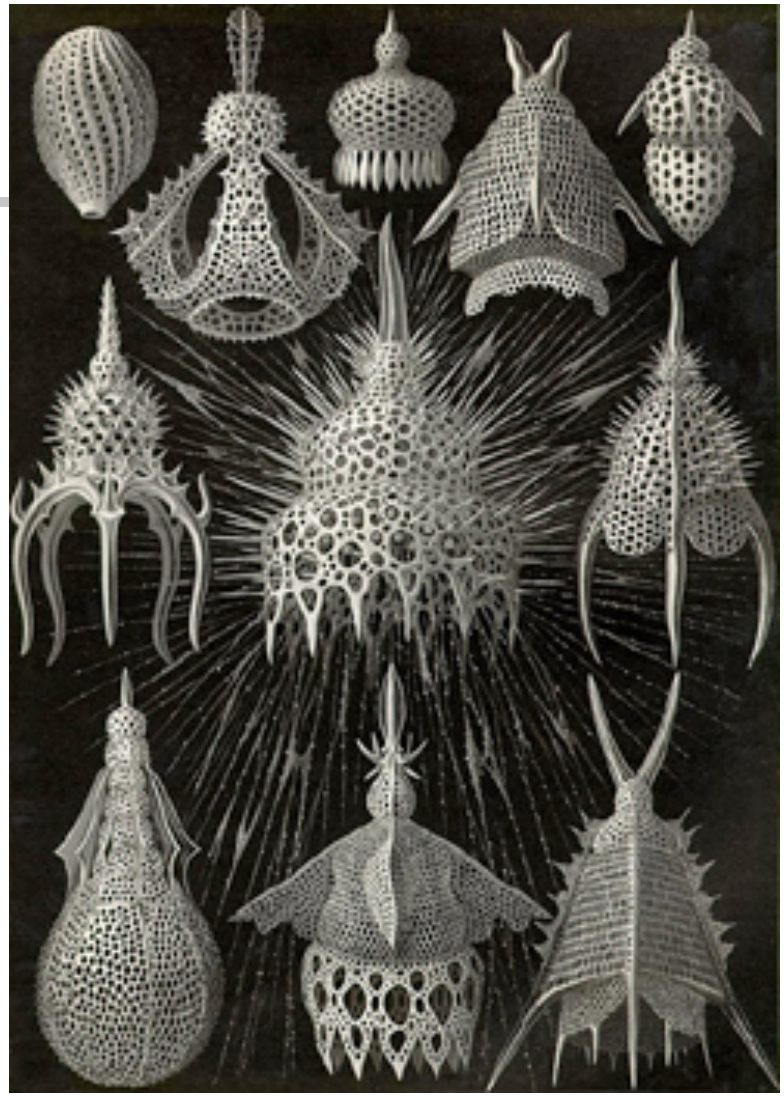
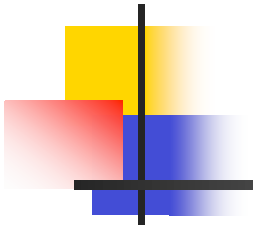








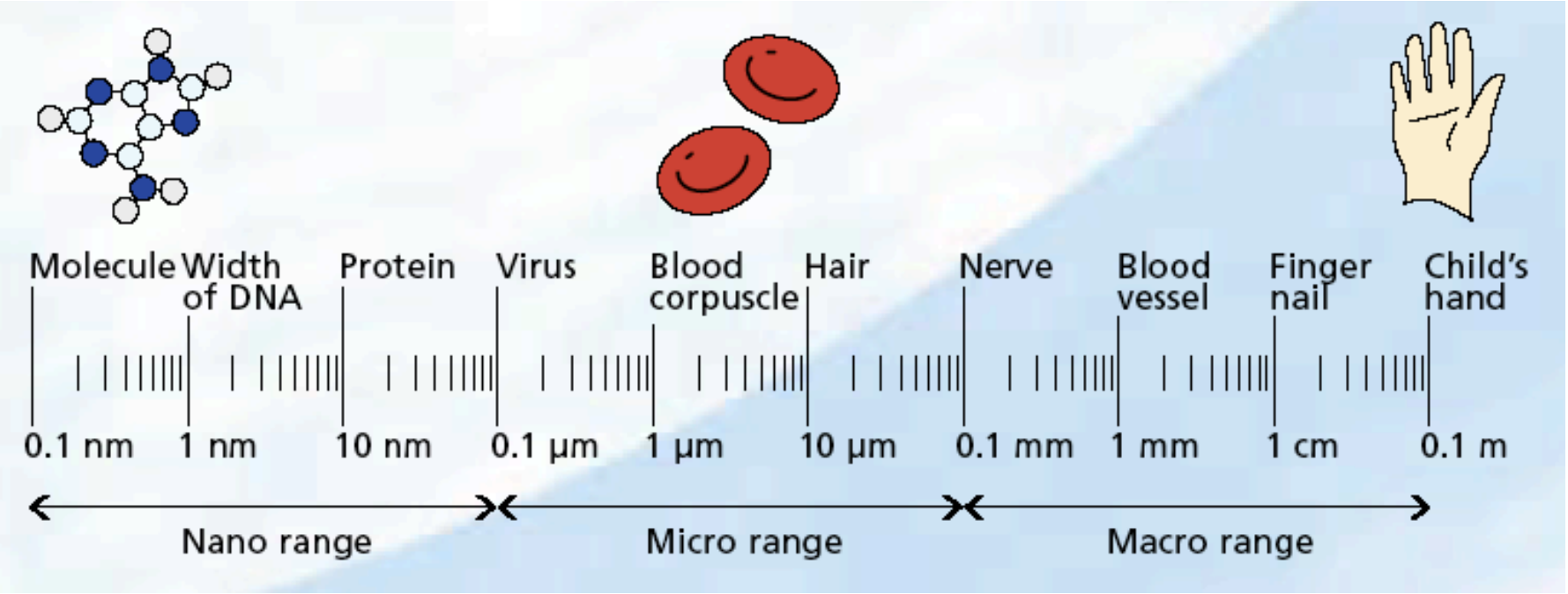
Course Web Pages

http://www.cs.duke.edu/education/courses/spring06/cps296.5/

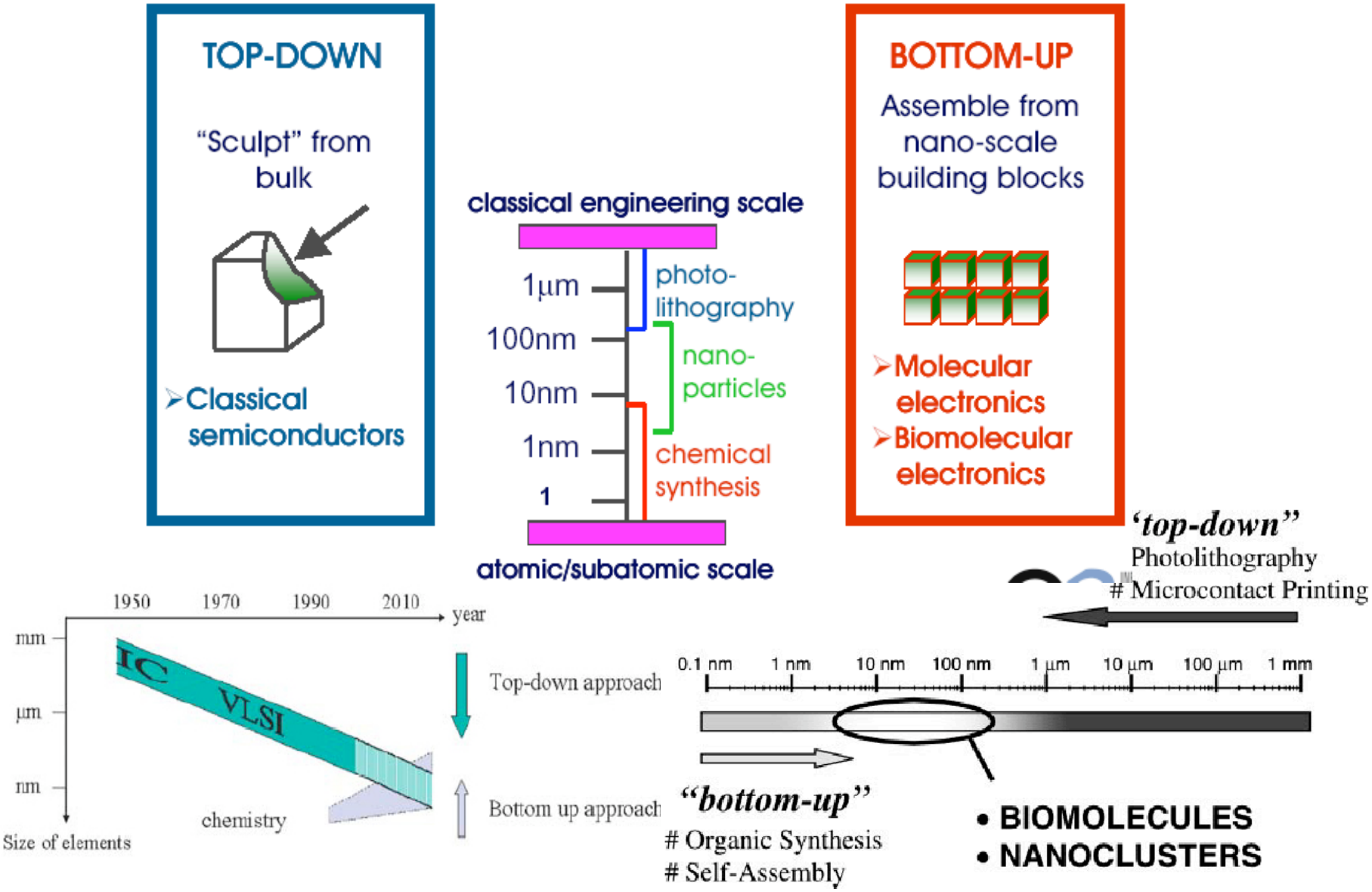
COMPSCI 296.05 (Spring 06)

- Background Nanotechnology, What is BioNanoTech?
- Biomacromolecules (Nucleic acid and protein structure, MAGE)
- Methods and Instruments: Molecular biology, chemistry, microscopy (AFM, TEM, SEM, STM, etc.)
- NanoMaterials (nanoparticles, nanotubes, nanowires, nanocrystals, block co-polymers)
- DNA Engineering. DNA-Based Nanofab. Algorithmic Self-Assembly.
- DNA-Based Computing. RNA Nanotech.
- Protein & Peptide Design & Engineering. In vitro evolution.
- Molecular Robotics. Molecular Diagnostics. Molecular Electronics.
- BioNano with Protein, Virus, Cell Building Blocks.
- Impacts: biosensors, molecular theraputics, nanoelectronic, nanooptical, nanochemical, molecular manufacturing.

Length Scales

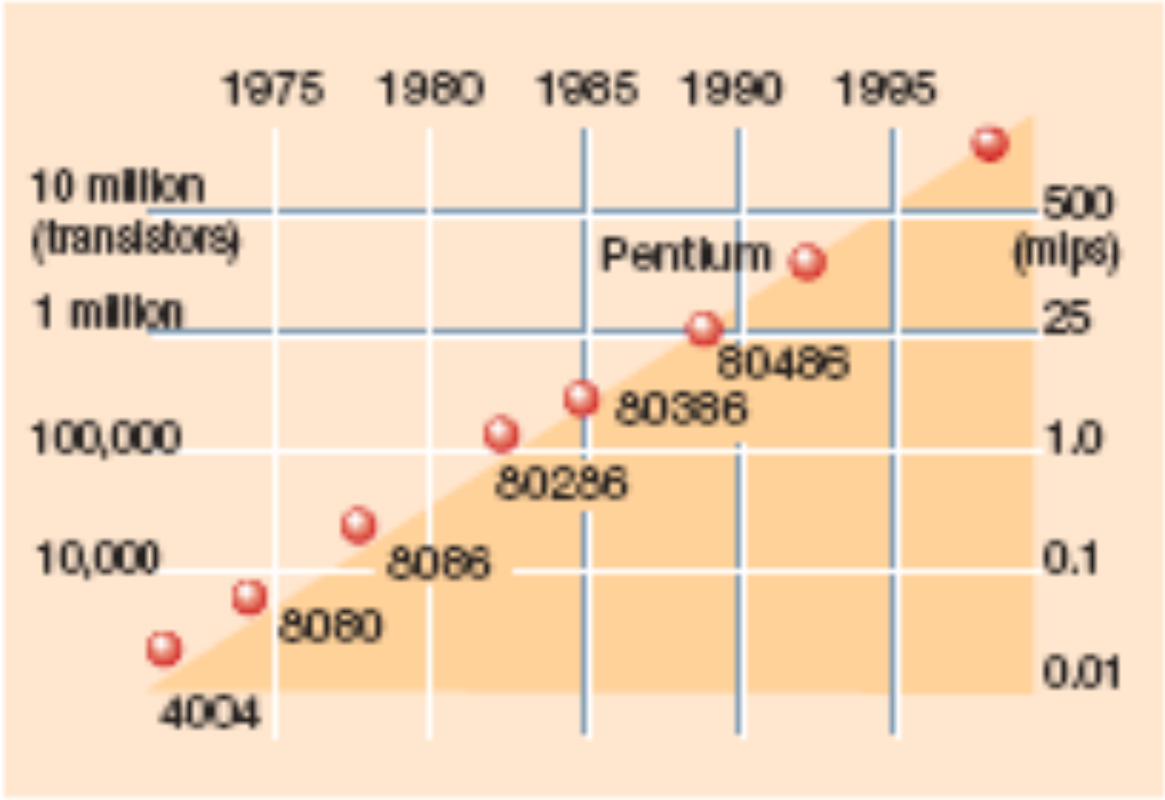


B. Top-Down and Bottom-Up



Picture credit: (top) Felice, Lancaster (2003) (bottom, left) F. Dewarrat, Univ. of Basel (2002), (bottom, right) C. Niemeyer [Angew. Chem. Int. 40,4218-4158 (2001)]

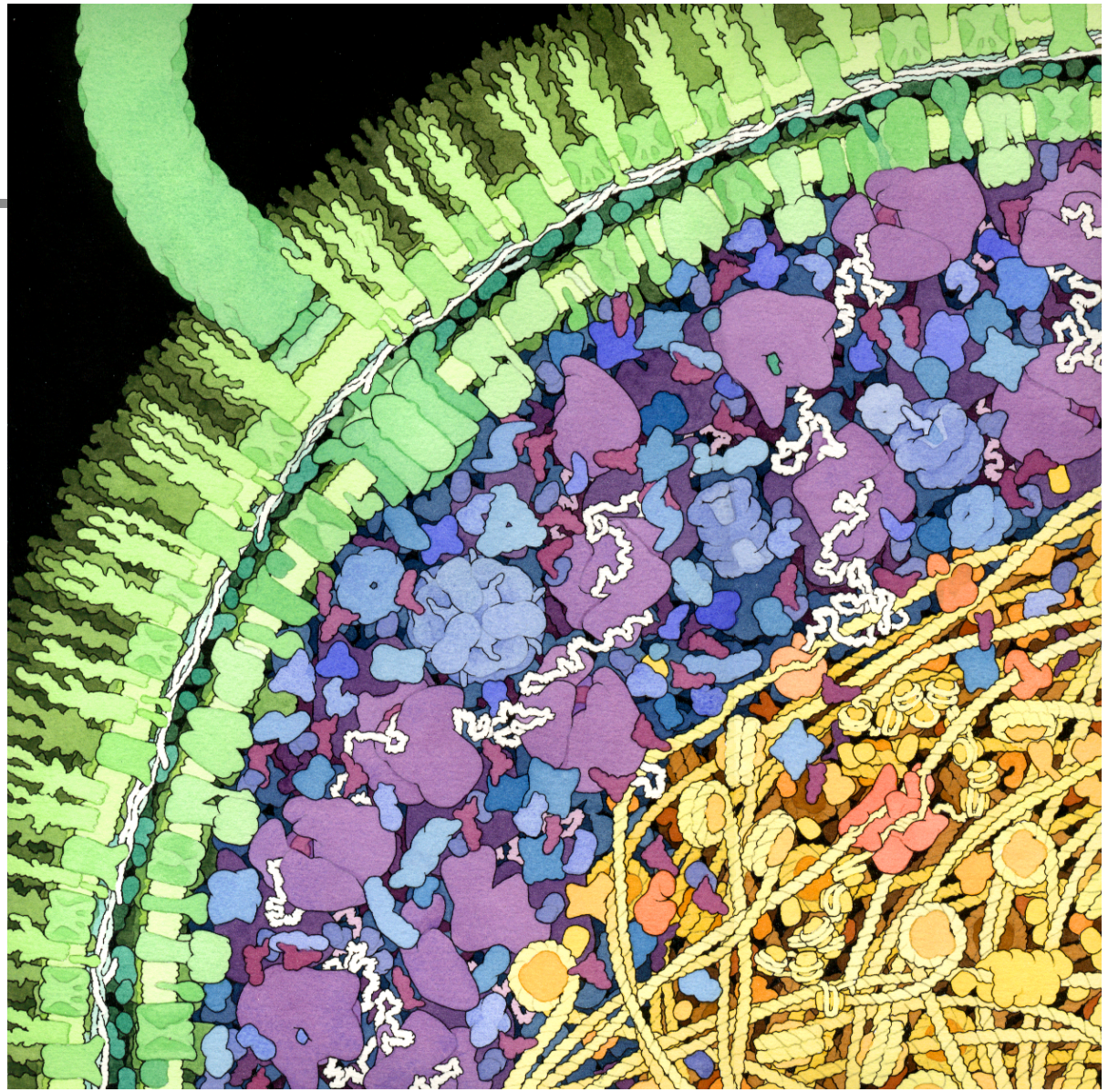
Moore's Law Motivation



Moore's Law: the growing power of silicon chips, measured in millions of instructions per second.

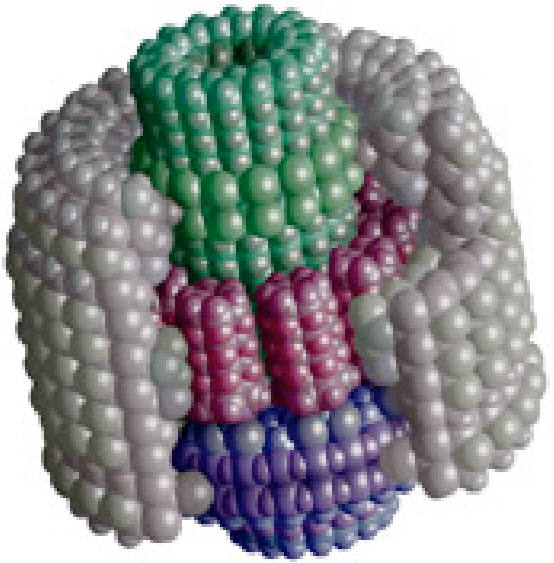
Goodsell, cellular machinery

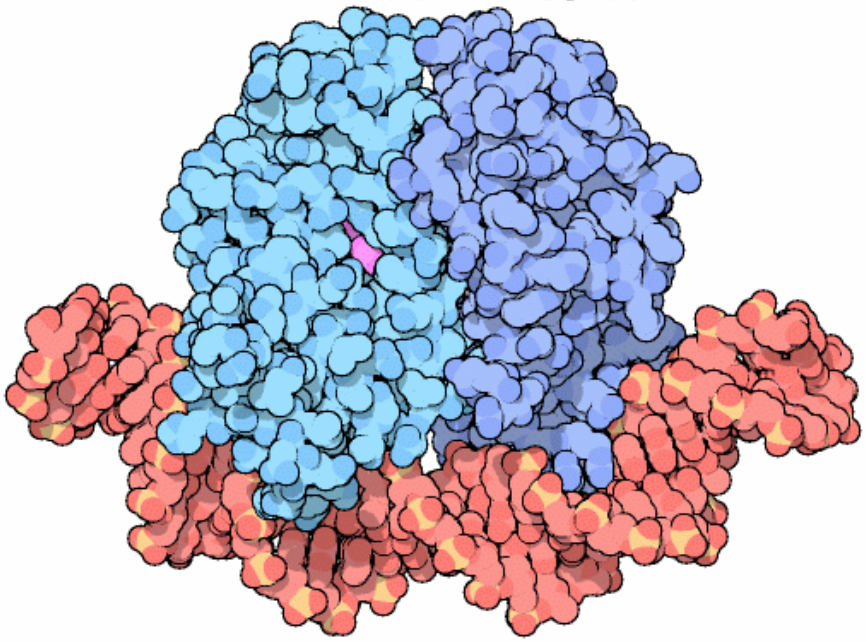
- Molecular machines
- Bioinspired engineering



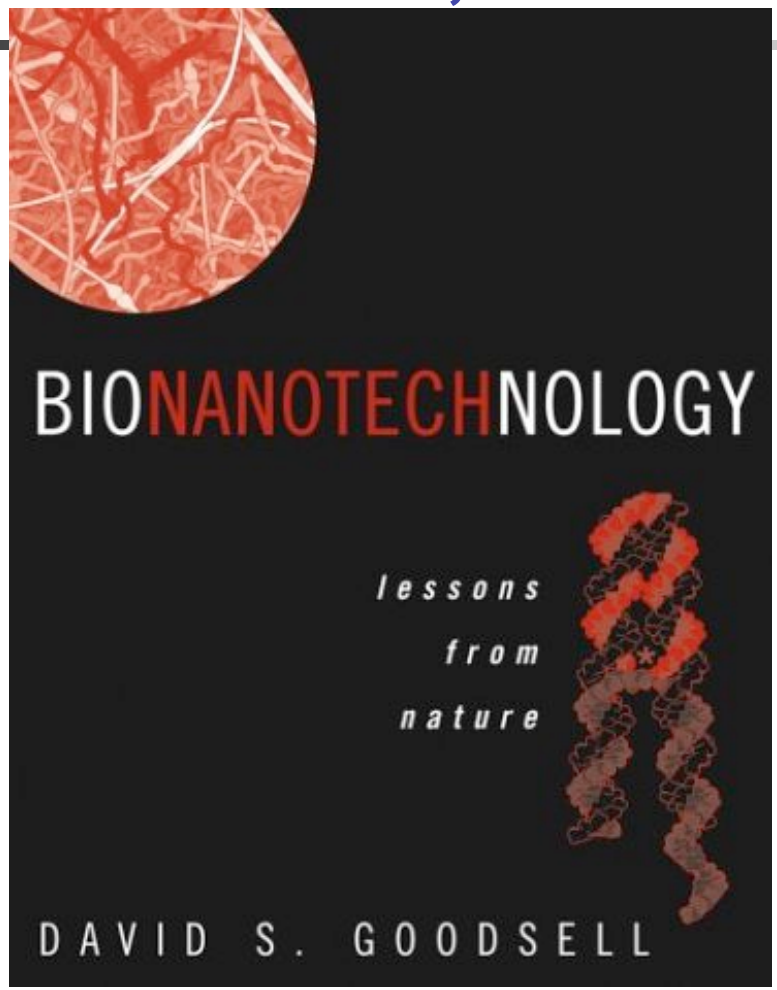
Nano and BioNano

- Nanotech--atomic control of matter
- Bionanotech--control of matter on low nanometer scale with inspiration, principles, or materials borrowed from biology.



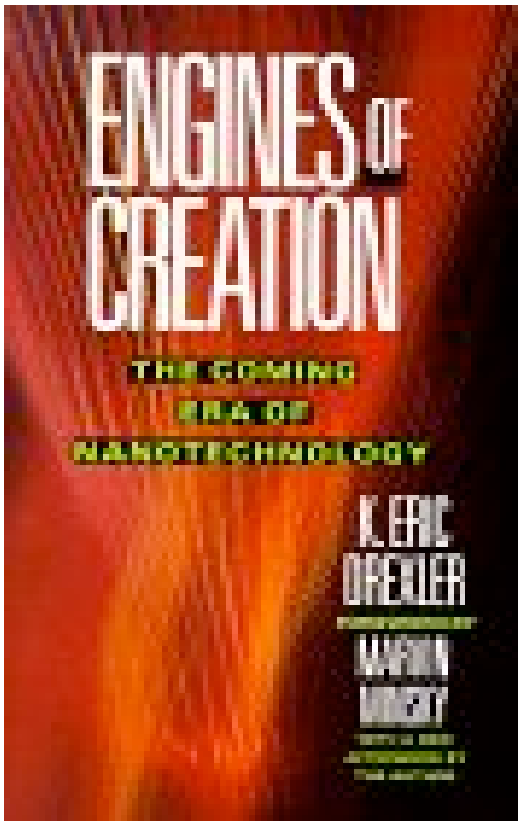


Goodsell, Bionanotech (Jan.04)



- The Quest for Nanotechnology.
- Bionanomachines in Action.
- Biomolecular Design and Biotechnology.
- Structural Principles of Bionanotechnology.
- Functional Principles of Bionanotechnology.
- Bionanotechnology Today.
- The Future of Bionanotechnology.

Drexler, Engines of Creation (1986)

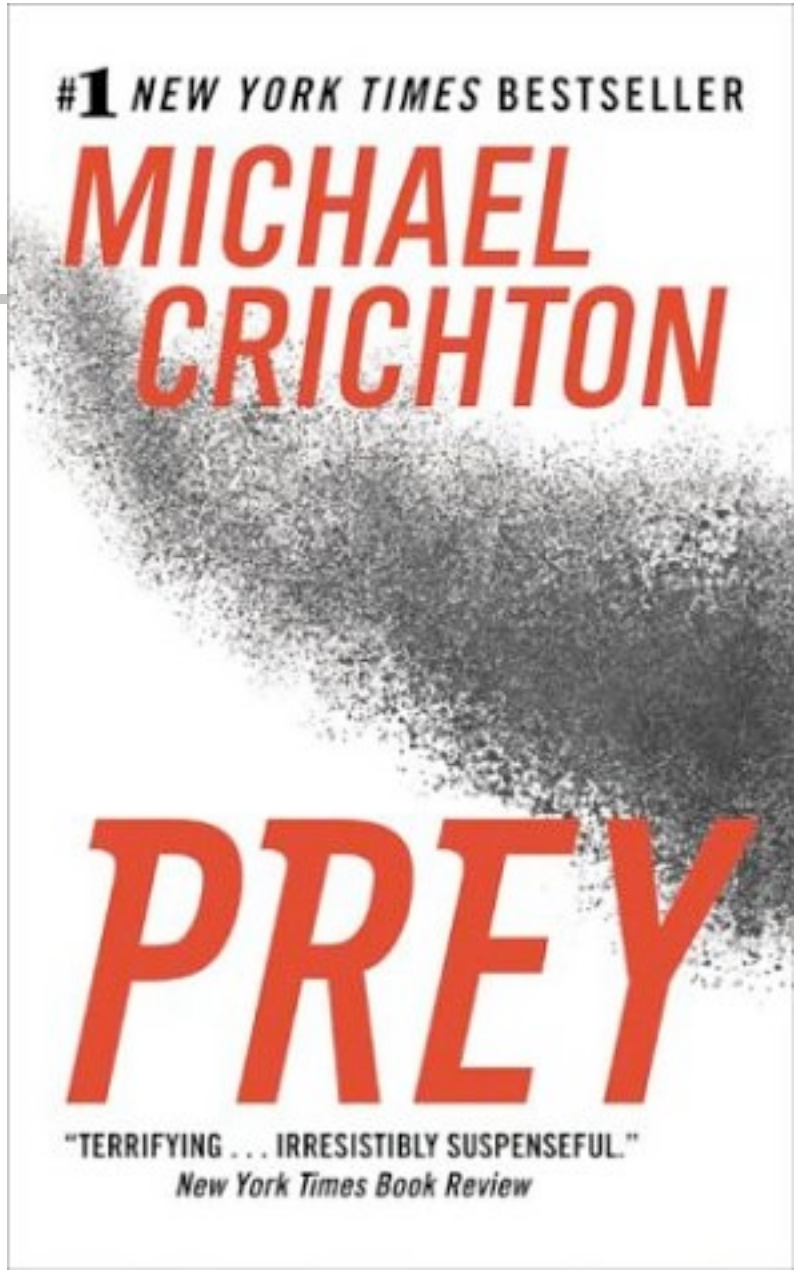


- Engines of Construction
- Engines of Abundance
- Engines of Destruction

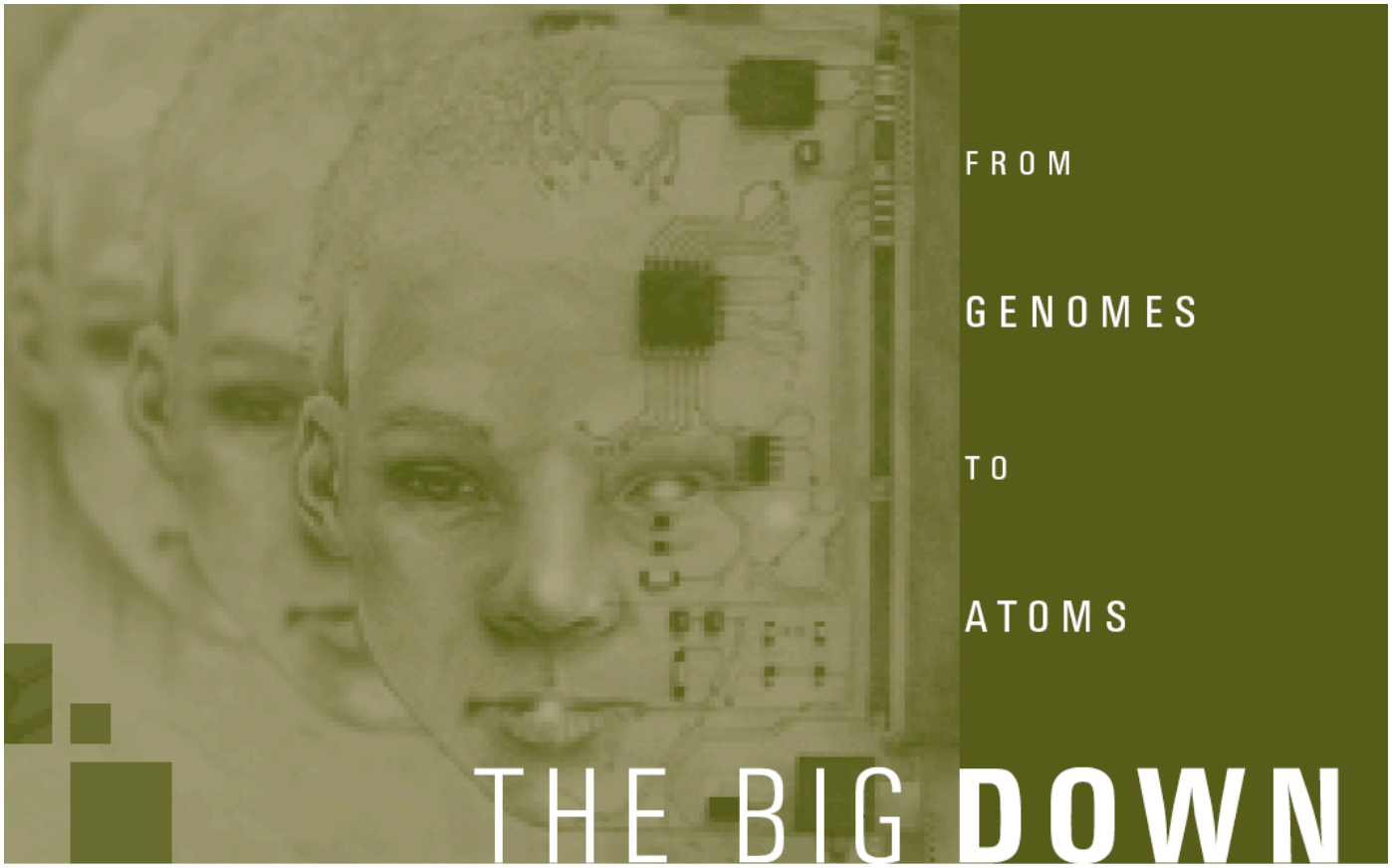
  "gray goo problem"

Nay-Sayers

- Nano OOC scenario
- Evolutionary-group-chaos-theory-alife
- BioNano-back-to-bio
- Far-fetched but based on sound science…



Nay-Sayers: ETC group



NBIC Convergence

Nanotechnology, Biotechnology, Information Technology, and Cognitive Science

NBIC CONVERGENCE 2004

Converging Technologies for Improving Human Performance

February 25-27 • New York Marriott Financial Center • New York, NY

Infocast is pleased to announce the dates of February 25-27, 2004, for the 2nd Annual NBIC Convergence conference, to be held at the New York Marriott Financial Center in New York City.

The prospect of unparalleled improvements in human health and performance, as well as the unification of science, were the over-arching themes at Infocast's first NBIC (Nanotechnology + Biotechology + Information Technology + Cognitive Science) Convergence conference held in February 2003, at UCLA in Los Angeles, CA.

Stepping Down: Some Major Milestones in Atomtech

1959 Nobel Prize-winning physicist Richard Feynman gives his now-famous speech, "There's Plenty of Room at the Bottom," describing the future possibility of atomic engineering.

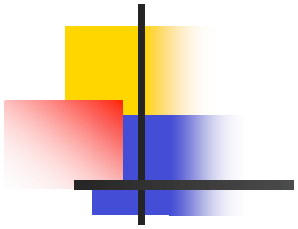
1964 Glenn Seaborg, Nobel Prize Laureate for Chemistry, wins two US patents on elements he discovered–Americium #95 and Curium #96–a little known milestone that sets a dangerous precedent for the patenting of elements and atomically-engineered matter.

1974 Norio Taniguchi of Tokyo Science University first uses the word "nanotechnology."

1981 Gerd K. Binnig and Heinrich Rohrer at IBM's Zurich Research Laboratory invent a scanning tunneling microscope that enables researchers to see and manipulate atoms for the first time. The researchers won a patent on the microscope in 1982 and a Nobel Prize in Physics in 1986.

1981 Eric Drexler publishes the first technical paper on molecular nanotechnology in the *Proceedings of the National Academy of Sciences.*

Sources: Gary Stix, "A Few 10-9 Milestones," in Scientific American, September 2001, p. 36 and CMP Cientifica, Nanotech: The Tiny Revolution, and Douglas Mulhall, Our Molecular Future, Prometheus Books, 2002; and ETC Group.



1985 Robert F. Curl Jr., Harold W. Kroto and Richard E. Smalley discover Buckminsterfullerenes (buckyballs) measuring approximately 1 nanometer wide.

1989 IBM physicists manipulate atoms precisely by spelling the letters I-B-M with thirty-five xenon atoms.

1991 Sumio Iijima, a physicist at NEC Research Labs in Japan discovers multi-wall carbon nanotubes.

1993 Warren Robinett of the University of North Carolina and R. Stanley Williams of the University of California create a virtual reality system connected to a scanning tunneling microsope that enables researchers to "see" and touch atoms.

1993 Rice University establishes the first laboratory dedicated to nanotechnology in the USA.

1996 Curl, Kroto and Smalley win Nobel Prize in chemistry for discovering buckyballs.

1997 The first nanotechnology venture capital company established in the USA.

1998 Researchers at the Delft University of Technology (Netherlands) create a transistor from a carbon nanotube.

2000 Lucent and Bell Labs, working with Oxford University, create the first DNA motors, demonstrating the convergence of biotech and nanotech.

Sources: Gary Stix, "A Few 10-9 Milestones," in Scientific American, September 2001, p. 36 and CMP Cientifica, Nanotech: The Tiny Revolution, and Douglas Mulhall, Our Molecular Future, Prometheus Books, 2002; and ETC Group.

Milestones 3/3

2001 Researchers at both IBM and Delft University use carbon nanotubes to develop nanometer-sized logic circuits–the components that perform processing in computers.

2001 Mitsui & Co. of Japan announce plans for mass-manufacture of carbon nanotubes.

2002 In June IBM's nanotechnologists demonstrated data-storage density of 1 trillion bits per square inch, equal to a 100-gigabyte hard-drive–enough to store 25 million printed textbook pages on a surface the size of a postage stamp.

2002 In August IBM announces the development of a new electron microscope with resolving power less than the radius of a single hydrogen atom.

Sources: Gary Stix, "A Few 10-9 Milestones," in Scientific American, September 2001, p. 36 and CMP Cientifica, Nanotech: The Tiny Revolution, and Douglas Mulhall, Our Molecular Future, Prometheus Books, 2002; and ETC Group.

Feynman, 1959

- **There's Plenty of Room at the Bottom**
  - **Encyclopaedia Britanica on the head of a pin requires only 25,000 fold reduction**
  - **Read- stamp, evaporate, shadow, EM**
  - **Write- focused ion beam, lithography**
  - **Atomic info: 2D surface, 3D atomic crystal**
  - **Biological information density**
  - **Need better EM**
  - **Physical arrangement of atoms -> chemistry**
  - **Miniturize computers (heat, power, speed)**
  - **Miniturize machines (smaller->smaller->smaller)**
    - **Parallalism**
  - **Molecular electronics**
  - **Mechanical tolerance**

Only TOP-DOWN view [no self-assembly]

Drexler vs Smalley

- Drexler
  - Molecular assemblers will provide atom-by-atom manufacturing
- Smalley
  - “fat fingers problem”
  - “sticky fingers problem”