Molecular Biology and Micro/Nano-Scale Engineering
(MCEN4228-006/5228-006 and MCDB4100-003/MCDB6440-002)

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Integrated Circuits – Information Era

Transistor counts:
- Intel 80386, 1985, 275,000
- Intel Pentium 4, 2006, 184,000,000
- Intel i7, 2011, 2,270,000,000
Bacteria (e.coli): ~1µm diameter, 2µm length, ~1µm³ in volume; 10⁹ cells/ml in an overnight culture; 10⁷ x 10⁹ = 10¹⁶ proteins/ml.
Engineering Technology and Molecular Biology: Same Scales!
Question: Please indicate how much societal impact each of the following fields will have on the world over the next ten years. 10 = great impact on the world; 1 = no impact on the world.

- **Biomolecular engineering**: 72% Great impact (8-10), 26% Average impact (4-7), 2% No impact (1-3)
- **Nanotechnology**: 59% Great impact (8-10), 36% Average impact (4-7), 5% No impact (1-3)
- **Megacomputing**: 46% Great impact (8-10), 48% Average impact (4-7), 5% No impact (1-3)
- **Robotics**: 41% Great impact (8-10), 54% Average impact (4-7), 5% No impact (1-3)

Q1: Base = "total" (901)
Contents

• Molecular Biology
• Micro/Nano-Scale Engineering
• Case: Electronics for Biomedical Applications
• Case: Lab on a chip
• Case: Bio-fuels
• Syllabus

Synergistic integration of molecular biology and micro/nano-scale engineering
Protein: a Nano-Electro-Chemical-Mechanical Device
Millions or Billions of Proteins Working Together in a Cell
Protein Conformations

Videos on organelle movement and ATP Synthase.

Figure 6–82. Molecular Biology of the Cell, 4th Edition.
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Technology Drivers for Microsystems (Hardware)

- Mainframe computers and supercomputers
- Desktop workstations/personal computers
- Laptop computers
- Smart phones or mobile computers (data centers)
- ?
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What’s new? accelerometers, gyroscopes, proximity, pressure, temperature, humidity.
Microelectromechanical Systems (MEMS) for Sensors and Actuators

Multi-User MEMS Processes (MUMPS)

Example Design

(a) After Poly2 Deposition

(b) Released Device
Smartphone-Controlled Sensors and Actuators

- Arduino board
- Bluetooth
- Accelerometer
- Other sensors

![Image of a circuit board connected to a smartphone]
Wearable Electronics for Biomedical Applications (workshop)

The Intel Edison board features a low-power 22nm 400MHz Intel® Quark processor with two cores, integrated Wi-Fi and Bluetooth*. Upload a Windows or Android application to Intel Edison and control sensors and actuators through wireless connections.

Intel Edison announced in January 2014
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Structure Based Drug Design

Membrane Protein
Polyhedral Nanoparticles
→ Protein structure
Dialysis Chamber → Membrane Protein
Polyhedral Nanoparticles
Lab-on-a-Chip for Membrane Protein Crystals

(CU-ME: Michael H.B. Stowell (& MCDB) and Y. C. Lee and Caltech)

- Evaluation time reduced from weeks to seconds.
- Critical to increase the number of known structures from 1% to much higher.
- Basic technology to produce other biological nanoparticles and molecules.
MAY 8, 2013

DARPA is soliciting innovative research proposals to develop new high-throughput methods and tools that will elucidate in thirty days the molecular mechanism by which threat agents, drugs, biologics or chemicals affect the function of biological cells.

Years or decades → 30 days! Important to drug discovery!
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Bio-Fuel

The Clean Fuel Cycle

SUSTAINABLE ENERGY WITH NO GREENHOUSE EFFECT

Plants use the energy of the sun to grow. Plant fibre, called cellulose, is the most abundant organic molecule on earth. Logen’s EcoEthanol™ process takes cellulose and, using enzymes, turns it into fermentable sugars and subsequently into ethanol. Using CO₂ absorbing plant material as an ethanol feedstock offers environmental advantages unequalled by other feedstocks or fuels.
FOR IMMEDIATE RELEASE

Chesapeake Energy Corporation
acquires fifty percent stake in Sundrop Fuels

LOUISVILLE, COLORADO [July 11, 2011] - Sundrop Fuels, Inc., a gasification-based drop-in biofuels company, and Chesapeake NG Ventures Corp. (CNGV), a wholly owned subsidiary of Chesapeake Energy Corporation (NYSE:CHK), today announced that they have closed a transaction in which CNGV will invest $155 million, enabling Sundrop Fuels to expand operations and begin construction of a commercial demonstration facility to produce biobased “green gasoline” made from cellulosic material. Additionally, Sundrop Fuels announced that Oak Investment Partners, a current investor, has committed to invest $20 million pro rata with CNGV. The deals closed on July 11, 2011.

Contact: Steven Silvers
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Biofuel: Cellulose-Digesting Enzyme
(National Renewable Energy Laboratory)

Non-food plants ➔ Ethanol, …
DARPA: Living Foundries: 1000 Molecules

July 12, 2013 Build a scalable, integrated, rapid design and prototyping infrastructure for the facile engineering of biology. This infrastructure will enable transformative and currently inaccessible projects to develop advanced chemicals, materials, sensing capabilities, and therapeutics.
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