

S&T Survey

(Lightning version)

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- Civil and Urban Engineering
- Information, Operations, and Management Science
- Physics

S&T you should you be interested in (30-year horizon)

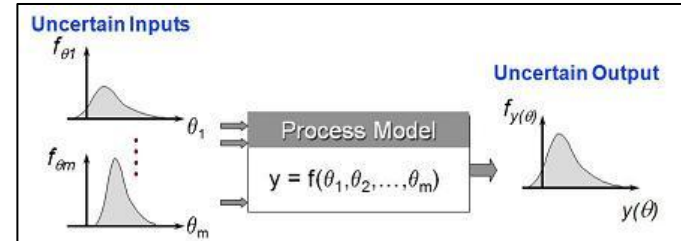
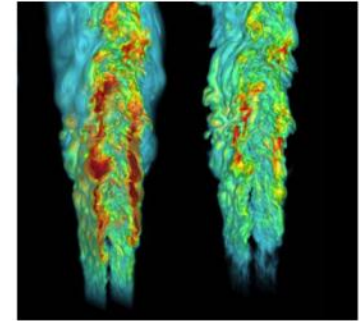
- **Foundational S&T that's moving rapidly**
 - **INFO** (= data acquisition → knowledge)
 - Enabling
 - **NANO** (= inanimate stuff)
 - Basis of physical world
 - **BIO** (= living things)
 - It's about carbon
 - **NEURO** (= neurons → societal behavior)
 - The users of energy
- **Energy systems**
 - Transport, power, efficiency



INFO

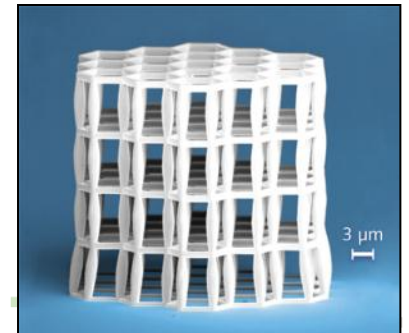
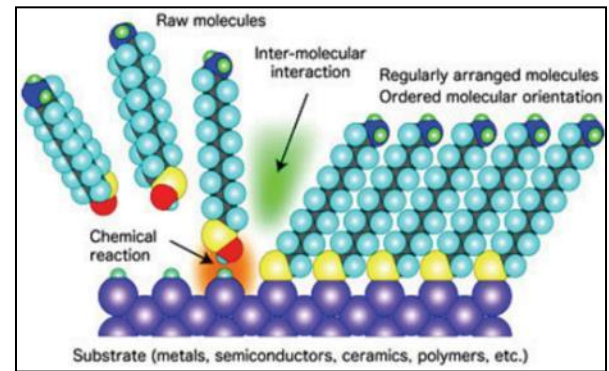
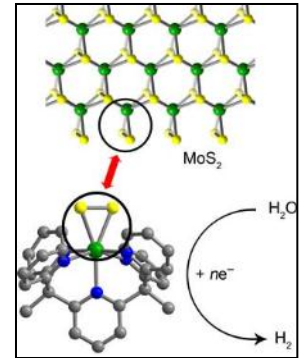
- **Simulation**
(optimize design, facilitate scaling, optimize operations)
 - Push to Exascale computing (100X by ~2020)
 - Sub-grid processes / Multi-scale
 - Uncertainty quantification
- **Instrumentation of everything**
(built, natural, human systems)
 - Sensors everywhere, on everything, on everyone
 - Multisource fusion
(text + imagery + audio + tracks + ...)
 - Storage/Access (privacy)
 - Visualization
 - Cognitive computing
(Can we make sense of it all?)
 - Applications for monitoring, efficiency, compliance (smart cities, ...)
 - Autonomous systems (AI + Robotics)

Combustion simulation



NANO

- **Molecular design**
- **Material design**
 - Self assembly
 - Functionalized surfaces
 - Optical, mechanical, thermal, chemical properties
- **Additive manufacturing**



BIO

DOE Genomic Science Program A Mission-Inspired Fundamental Research Approach

Technologies and Methods for Systems Biology

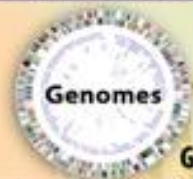
- Microbe genomics, plant genomics, metagenomics
- Analysis of global changes in gene expression and metabolite profiles
- Molecular imaging
- Structure determinations
- Modeling and simulation
- Prediction and design
- Synthetic biology

Fundamental Research Needs

Gain a predictive understanding of how cells work in communities, tissues, plants, and, ultimately, global ecosystems

Explore the functioning and regulation of pathways and dynamic networks in cells

Understand how proteins function individually and in interactions with other cellular components



Genes

Proteins

Molecular Interactions

Pathways

Cellular Function

Communities

Ecosystems



Carbon Cycle

Tools and concepts to determine the carbon cycling and biosequestration processes of ocean and terrestrial ecosystems.

Environmental Remediation

Microbial and plant modeling and experiments to predict and control contaminant fate and transport.

Mission Grand Challenges for Biology

Energy

Tools and concepts for designing and engineering bioenergy plant and microbial systems, including the mechanistic bases.

Technology Endpoints

Payoffs for the Nation



Sustainable and Viable Biofuel Technologies

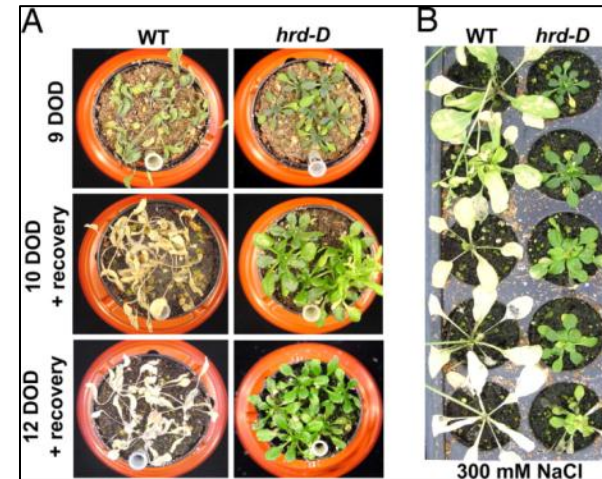
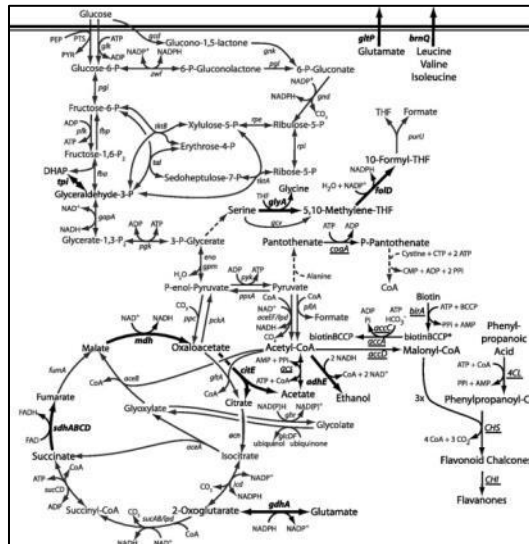
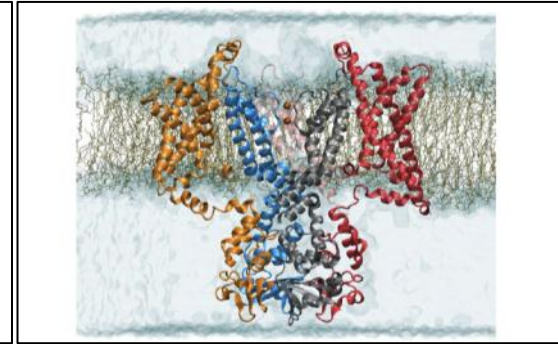
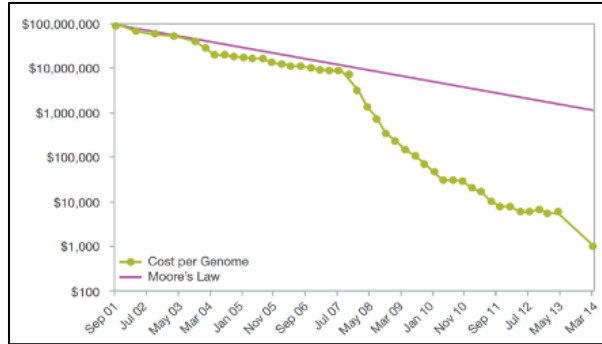
Earth System Modeling and Biosequestration Strategies

Improved Strategies for Environmental Remediation and Long-Term Stewardship

The genome determines dynamic biological structure and function at all scales, from genes to ecosystems.

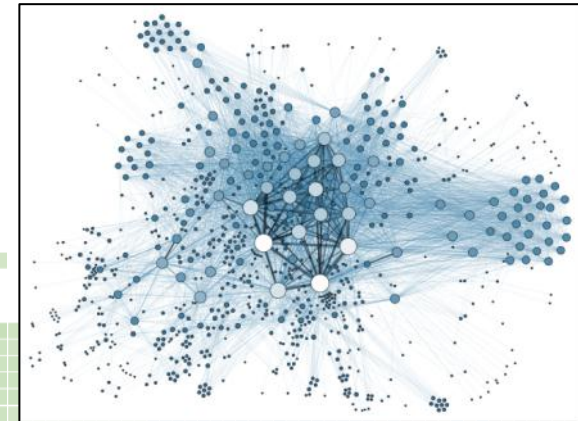
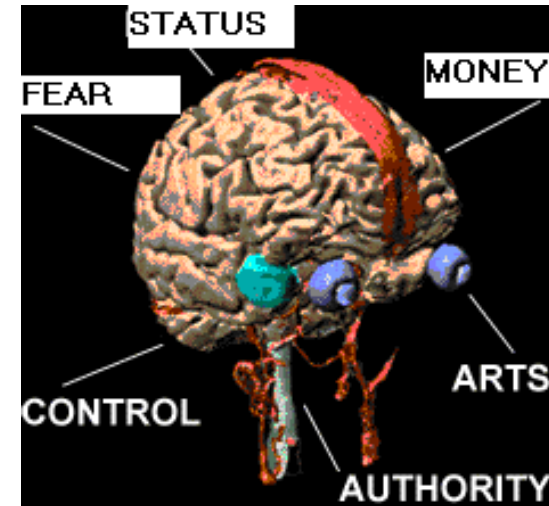
BIO examples

- Sequencing costs plummeting
- Structure of an ion channel
- E. coli metabolic pathway
- Genetic enhancement



NEURO

- **Brain function**
 - New tools (microelectrodes, fMRI, optical, TMS, PET, ...)
 - Consciousness, memory encoding, ...
- **Individual behavior**
 - Learning / Memory / Habit
 - Emotion / esthetics
 - Decision determinants
 - Genetic and epigenetic influences
- **Societal behavior**
 - Networks
 - Crowds



See DOE Quadrennial Technology Review
<http://energy.gov/quadrennial-technology-review>

ENERGY SYSTEMS



Energy systems

- **Transport**
 - Advanced IC / Lightweighting
 - Progressive electrification (batteries, fuel cells?)
 - Natural gas / 2nd and 3rd generation biofuels
 - V2V / V2G / Autonomy
- **Power**
 - Solar balance of systems / Wind optimization / Deep geothermal
 - Small nuclear / nuclear life extension / fusion???
 - Advanced grid (sensing/modeling/control; storage)
 - Water!
- **Stationary efficiency**
 - Whole building systems / retrofit vs new build / market barriers
 - Industrial processes



Questions/Comments

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