DOE GENOMICS:GTL
SYSTEMS BIOLOGY FOR ENERGY AND ENVIRONMENT
OFFICE OF SCIENCE U.S. DEPARTMENT OF ENERGY

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GENOMICS RESEARCH

Building a Biological Foundation for Secure Energy Alternatives, Environmental Remediation, and Climate Protection

Office of Science
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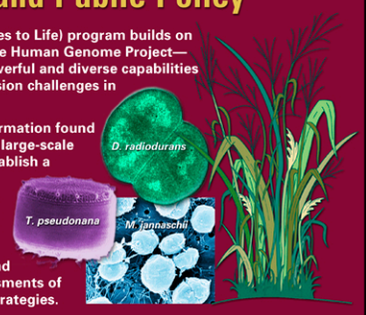
From the Genome To Industrial Applications and Public Policy

The Genomics:GTL (formerly Genomes to Life) program builds on the technological achievements of the Human Genome Project—initiated by DOE—to tap into the powerful and diverse capabilities of the natural world for meeting mission challenges in energy and environment.

The GTL approach combines the information found in microbial and plant genomes with large-scale technologies and computation to establish a broad scientific foundation for

- Future applications: Resources and technologies for biofuel production and bioremediation.
- Policy-support products: Climate and economic models to support assessments of energy and carbon-sequestration strategies.



Explorations into the genomes of microbes and plants

Microbes and plants and their communities have evolved unique biochemistries offering a rich resource that can be applied to diverse national needs.

Some recent projects funded by DOE's Office of Biological and Environmental Research highlight the potential wealth of natural capabilities available to us.

Detailed DNA sequencing and analysis for biofuels, carbon storage

Understanding the genes and regulatory mechanisms controlling growth and other traits in the recently sequenced poplar tree may lead to its use for bioethanol production and for sequestering carbon. Sequencing was done at the DOE Joint Genome Institute (JGI), one of the worlds largest and most productive public genome sequencing centers. JGI's capacity exceeds 40 billion DNA bases per year. Sequencing is focused on complex projects including plants, microbes, and microbial-community metagenomes relevant to DOE missions.

Ocean DNA: Millions of new genes and capabilities

Ecogenomic sampling of DNA from ocean microbes analyzes genome fragments directly from environmental samples instead of from whole cells. This work has led to the discovery of millions of previously unknown genes and proteins, thousands of species, and innumerable variations of important biochemical functions that may have practical use.

Termite microbes: A potential source of enzymes to digest biomass for bioenergy production

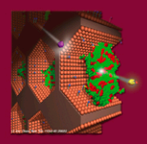
Researchers at the DOE Joint Genome Institute are investigating bacteria that live in the hindguts of termites and churn out wood-digesting enzymes. These enzymes may be usable in industrial settings to break down the tough cellulose material in plants into the sugars needed for ethanol production. The enzymes used in this activity also produce hydrogen as a by-product, a process that itself may be amenable to scaleup.

Potential GTL Applications

Clean, sustainable energy from biomass

Optimized microbial enzymes and biomass may be able to generate enough cellulosic ethanol to replace a significant portion of gasoline by 2030.

Synthetic nanostructures harnessing microbial enzyme functions



Enzymes incorporated into synthetic membranes can carry out some of the functions of living cells and may be useful for generating energy, inactivating contaminants, and sequestering atmospheric carbon.

Technologies for ocean monitoring

Nanoscale ecogenomic sensors are being planned to monitor microbial populations and their interactions with environmental processes. The real-time approach envisioned by DOE merges information from genome research with nanotechnologies and smart sensors.

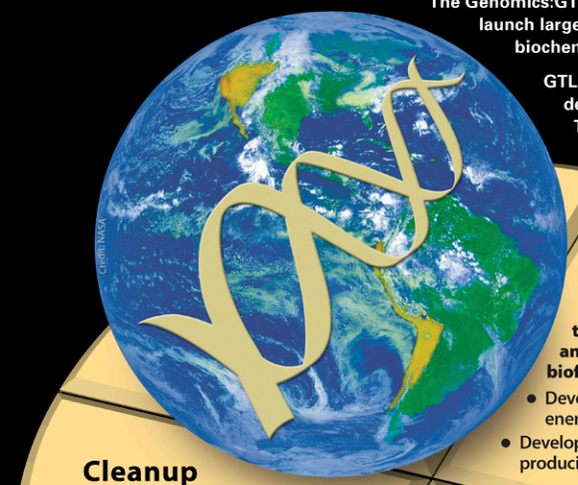
The knowledge gained will enhance understanding of the genetic diversity and functions of microbial communities and help answer key questions about their influence on ocean and terrestrial biogeochemical cycles.

Genomics:GTL Program—Systems Biology for DOE Missions

genomics.energy.gov

The Genomics:GTL program uses DNA sequences of microbes and plants to launch large-scale investigations into their wide-ranging and sophisticated biochemical capabilities.

GTL leverages DOE strengths in genomics, computing, technology development, and multidisciplinary teaming to achieve this goal. The program is cosponsored by the DOE Offices of Biological and Environmental Research and Advanced Scientific Computing Research.



Biofuels

Gain knowledge and tools for using microbes and plants to build a national biofuel capability to

- Develop sustainable energy crops.
- Develop biotechnologies for producing advanced biofuels.

Cleanup

Understand microbial and plant impacts on subsurface contaminant fate to

- Develop better assessment tools.
- Design improved bioremediation methodologies.

Climate Stabilization

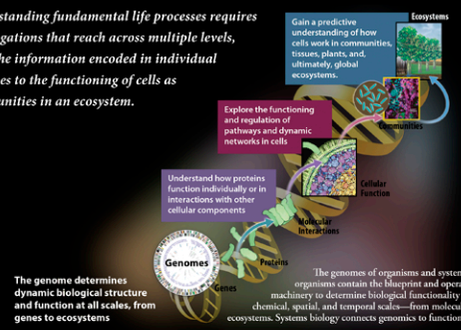
Determine ocean and terrestrial ecosystem contributions to the global carbon cycle to

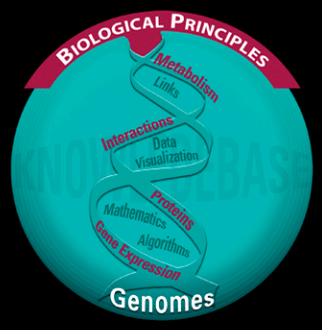
- Improve projections of climate change and its impacts.
- Create carbon-biosequestration strategies.

Payoffs for the Nation

Conducting multiscale explorations to generate a broad knowledgebase

Understanding fundamental life processes requires investigations that reach across multiple levels, from the information encoded in individual genomes to the functioning of cells as communities in an ecosystem.





The GTL Knowledgebase will link all research efforts through DNA sequence and will accelerate insights into fundamental biological principles and research strategies.

Catalyzing research and industry

GTL will make all resources, capabilities, and knowledgebase data available to scientists and industry, enabling cutting-edge investigations on the systems biology level that will catalyze rapid translation of science into new technologies.

Contacts

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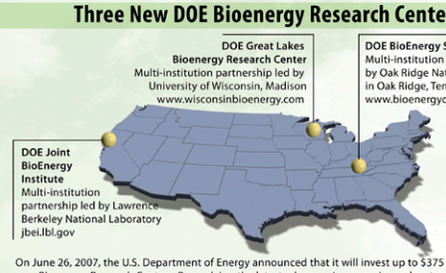
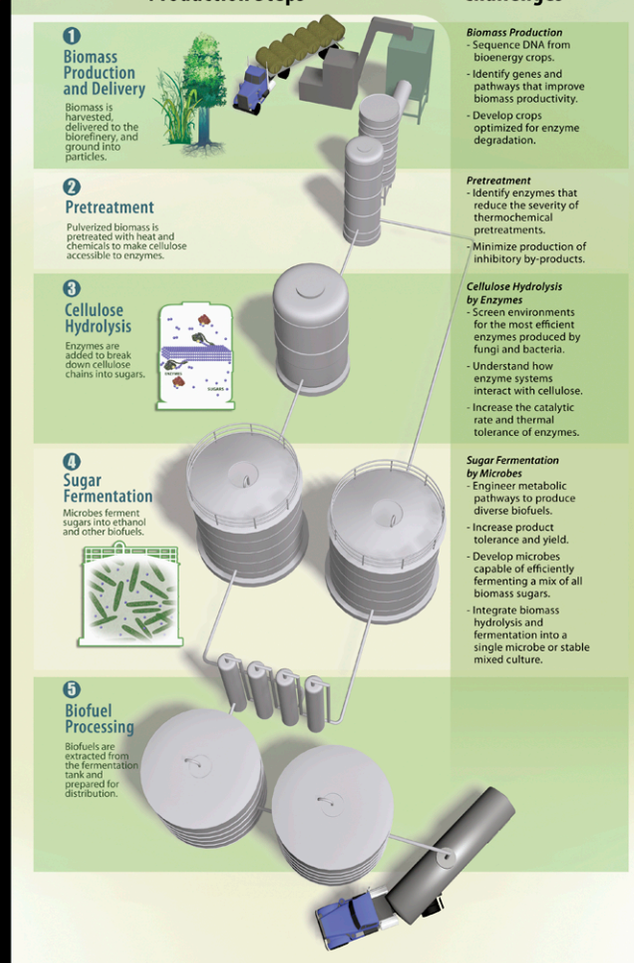
A Closer Look at Cellulosic Ethanol

Three New DOE Bioenergy Research Centers



On June 26, 2007, the U.S. Department of Energy announced that it will invest up to $375 million in three new Bioenergy Research Centers. By applying the latest advances in genomics and systems biology to microbial and plant systems, the centers will accelerate basic research underlying the biological production of ethanol and other renewable alternatives to petroleum. Each center represents a partnership. Partners include universities, national laboratories, private companies, and one nonprofit organization. Some biological challenges targeted by these centers are listed below.

genomicsgtl.energy.gov/centers/



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