DOE JGI FACTS

BIOENERGY

DOE JOINT GENOME INSTITUTE
US DEPARTMENT OF ENERGY
OFFICE OF SCIENCE

Harnessing DNA to Fuel our Nation's Energy Security

The U.S. Department of Energy Joint Genome Institute (DOE JGI) occupies a unique niche as a national user facility dedicated to harnessing the power of information embedded in microbes and plants through DNA sequencing. In the field of bioenergy, DOE JGI is attempting to make alternative fuels cheaper and easier to produce.

JGI MISSION

The Joint Genome Institute, supported by the DOE Office of Science, unites the expertise of five national laboratories—Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, and Pacific Northwest, along with the Stanford Human Genome Center—to advance genomics in support of the DOE mission related to clean energy generation and environmental characterization and clean-up. JGI's Production Genomics Facility provides integrated high-throughput sequencing and computational analysis to enable systems-based scientific approaches to these challenges.

WHAT IS SEQUENCING?

Just as computer software is rendered in long strings of 0s and 1s, the "software" of life is represented by a string of four chemicals, abbreviated as A, T, C, and G. To understand the software of either a computer or a living organism, we must know the order, or sequence, of these informative bits.

FASTER, BETTER, CHEAPER

DOE JGI's monthly sequencing output typically exceeds 3.1 billion letters (bases) of genetic code. That represents the equivalent of the entire human genome—or about 1,000 bases of sequence every second. When the Human Genome Project began twenty years ago, it cost about $10 to sequence a single base, compared to $0.0001 today. Since 1999, JGI has contributed over 140 billion bases, from over 500 different organisms, to the worldwide genomics community.

http://www.jgi.doe.gov/

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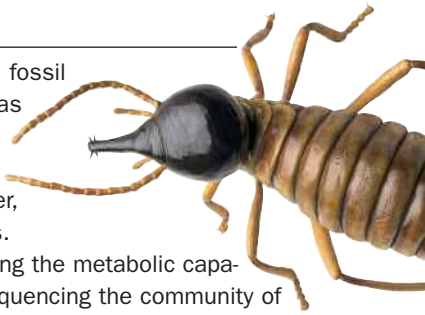
TERMITES: FUELING THE FUTURE

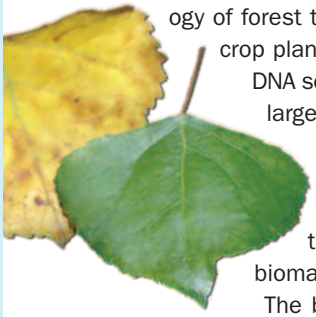


One of DOE's most enduring goals is to replace fossil fuels with renewable sources of cleaner energy, such as hydrogen produced from plant biomass fermentation. The lowly termite is capable of cranking out two liters of hydrogen from fermenting just one sheet of paper, making it one of the planet's most efficient bioreactors.

Termites accomplish this Herculean task by exploiting the metabolic capabilities of microorganisms inhabiting their hindguts. Sequencing the community of microbes in the termite hindgut, providing a better understanding of the biochemical pathways, may lead to more efficient strategies for converting biomass to fuels and chemicals. Harnessing the pathways directly involved in hydrogen production in the termite gut may make it possible for biological production of this alternative fuel source.

POPLAR TREES: ADVANCING ALTERNATIVE ENERGY SOURCES

Forest trees contain more than 90% of the Earth's terrestrial biomass, providing such environmental benefits as carbon sequestration, renewable energy supplies, improved air quality, and biodiversity. However, little is known about the biology of forest trees in comparison to the detailed information available for crop plants.



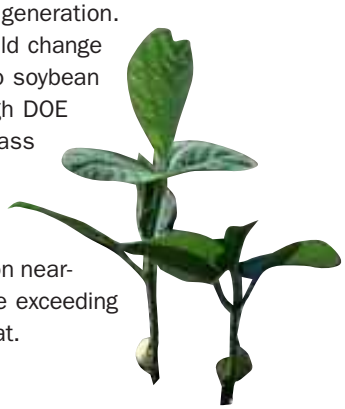
DNA sequence information will enable forest tree biologists to perform large-scale analyses of genes, leading to improved plant materials for the forest products industry and eventually to the selection of genetic traits for addressing questions related to the DOE's energy-related mission. DOE JGI has already identified candidate genes that will help domesticate poplar for biomass and reduce costs from $50 down to about $20 per ton.

The black cottonwood, *Populus trichocarpa,* is used in activities such as carbon sequestration research, free-air CO_2 enrichment studies, and the development of fast-growing trees as a renewable bioenergy resource. The sequencing effort will also inform applications of phytoremediation, where trees can be used to remediate hazardous waste sites.

SOYBEANS: TRANSLATIONAL GENOMICS FOR CLEAN ENERGY

The soybean, *Glycine max,* is the principle source of biodiesel, a renewable, alternative fuel. Biodiesel has the highest energy content of any alternative fuel and is much more environmentally friendly than comparable petroleum-based fuels. Biodiesel degrades rapidly in the environment and burns more cleanly than conventional fuels, releasing only half the pollutants and reducing the production of carcinogenic compounds by more than 80%.

Detailed knowledge of the soybean genetic code will allow for crop improvements and the effective application of this plant to clean energy generation. Knowing which genes control specific traits, researchers could change the type and quantity of oil produced by the crop, and lead to soybean plants that are more resistant to drought or disease. Through DOE JGI's efforts, it may be possible to develop a customized biomass production platform for combining oil seed production for biodiesel with enhanced vegetative growth for ethanol conversion—doubling the energy output of the crop.



In 2004, over 3.1 billion bushels of soybeans were grown on nearly 75 million acres in the US, with an estimated annual value exceeding $17 billion—second only to corn, and about twice that of wheat.