• Phase IV – 2004-2006
  – Center for Ecological Genomics
  – Center for Lipidomics
• Phase V – 2006-2009
  – Ecological Forecasting in the Great Plains
• Kansas’ NSF Funded Centers
  – Center for Remote Sensing of Ice Sheets
• Kansas Phase VI Preview: Climate Change and Renewable Energy
Center for Ecological Genomics
What is ecological genomics?

- genetic mechanisms underlying responses of organisms to their natural environment.
- genome-enabled approaches
  – functions of single or multiple genes.
- biochemical, physiological, morphological, behavioral responses of adaptive significance.

Drawing courtesy of Martin Feder, U of Chicago
Ecological Genomics

ECOLOGY

- Ecosystems
- Communities
- Populations
- Individuals
- Organs
- Tissues
- Cells
- Molecules
- (DNA → RNA → protein)
- Atoms

GENETICS
Ecological Genomics

- What are the regulatory and genetic pathways involved in organismal responses to a changing environment?
  - What can the environment tell us about genome function/evolution?
- What is the ecological context necessary to understand gene expression within organisms?
  - What can genes and gene expression tell us about ecological mechanisms?
- What is the adaptive significance of ecologically relevant genes?

Loretta Johnson and Mike Herman, co-PIs
2003-2006 Center for Ecological Genomics
- Genomic Approaches to Study Organismal Response to Global Change
- Co-PIs Loretta Johnson and Mike Herman, KSU
- Statewide initiative involving WSU, KU, KSU
- EPSCoR: $3.3 million → 17 extramural grants ($12.5 million) and 45 papers

2005-2009 Ecological Genomics Institute at Kansas State University
- 21 faculty from 7 departments and 3 colleges
- Targeted Excellence (TE): objective is to fund projects that will lead KSU to become a top-10 land grant university.
- TE: $ 2.14 million dollars → 15 extramural grants awarded ($8.4 million), 52 papers, one book, and 4 chapters
NSF REU:
Ecological Genomics, Ecology & Evolutionary Biology

Ecology, Evolution, and Genomics in Changing Environments
Training in Integrative Biology - Supported by the U.S. Department of Education GAANN

ecogen.ksu.edu
Center for Lipidomics
Plants are green factories that use solar energy and CO₂ to produce > 25,000 compounds in a single species. A large portion of the compounds are lipids.
Plant lipids are also....

Food
35% calorie intake of US diet
Soy oil 14% calorie

Feed
high energy feed
lowers costs
maximizes production

Industrial feedstocks
plastics, resins
lubricants, inks,
detergents, paints,
textile, paper, ......

Plant lipids are important sources of renewable industrial materials that reduce reliance on imported fuels and nonrenewable materials.

Plant lipids constitute a major source of calories and essential nutrients for humans.
Lipidomics Research Center

Quantitatively Profiling Lipid Molecular Species

1. Solvent extraction of tissues/cells
2. ESI-MS/MS analysis
3. Hundreds of lipid species
4. Quantitative data analysis
5. Biological Interpretation/Implication

Ruth Welti, PI
2003-2006 Center for Lipidomics
- Lipidomics Research Center for Systematic Studies of the Role of Lipids/Membranes in Living Systems.
  - PI, Ruth Welti
  - Comprehensive, quantitative, rapid profiling of lipid molecular species using mass spectrometric technologies.
  - Over 150 laboratories worldwide have analyzed lipids at KLRC
  - Collaborative research for lipid scientists and training for postdoctoral, graduate and undergraduate students.

2009 Center for Plant Lipid Systems (CPLiS)
- Lipidomics Research Center has grown to be a major player in the current STC competition
  - 247 pre-proposals, 43 invited full proposals, 11 site visits, ~5 Centers will be funded
Center for Plant Lipid Systems

NSF Pre-Award Site Visit
Saint Louis, MO    Oct 15-16, 2009

Research  Education  Diversity  Knowledge Transfer
CPLiS Research Goals

**Plant Biology**
Coordinate the development and utilization of enabling technologies to address major challenges
Improve plant production: lipid signaling and chloroplast Lipidomes and improve seed oil production quality: lipid trafficking and accumulation

**Lipidomic Analysis**
Provide comprehensive analysis of lipidomes
Develop “Plug & Play” analytical modules
Discover and characterize new lipids

**Lipid Localization**
Localize and quantify lipids within tissues and cells
MS-imaging and nanoscale sampling
Hyperspectral confocal imaging

**Bioinformatics and Data Integration**
Develop community accessible database
Improve mass spectral data processing
Enhance data visualization and statistical analysis
Integrate lipidomic data with other databases
Ecological Forecasting in the Great Plains
What is ecological forecasting?

• A grand challenge for the 21st century—sense, evaluate, model and forecast the biological and ecological consequences of global changes (National Research Council)
• Global change phenomena are critical for grasslands
  – ecosystem of global importance, providing resources and services to human societies worldwide
  – ecosystem critical to the Kansas and regional economy.
Dr. Samantha Wisely, and students Sara Bowe and Heather Barton, KSU

Skunks and rabies spread - an ecologically based approach

Using environmental data in addition to spatial and phylogeny data to look at spread of rabies.
The situation: Natural History Museums are filled with data on plant and animal specimens spanning several hundreds of years resulting in a need for global storage, i.e., sharing of data, and access.

The solution: Lifemapper: linking all of the species information into one virtual database. Lifemapper creates maps to show where species live as seen for the sunflower (Helianthus annuus) - www.lifemapper.org.
2006-2009 **Ecological Forecasting in the Great Plains**
- co-PIs, Walter K. Dodds, KSU, and Leonard Krishtalka, KU
- Effort included KU, KSU, and Fort Hays State
- EPSCoR: $4.5 million NSF (includes State match) → 31 extramural awards (>14.5 million)
- Infrastructure:
  New tools for the environment such as scintillometers and flux towers (geochemistry and climate)
  Cyberinfrastructure and database management
Involvement in National Networks:

National Ecological Observatory Network (NEON)
  John Blair on Board of Directors
  Konza picked as potential site

Stream Research Experimental and Observational Network (STREON)
Overview
The Center for Remote Sensing of Ice Sheets (CReSIS) is a Science and Technology Center established by the NSF in 2005, with the mission of conducting field investigations and compiling data to understand why polar ice sheets are undergoing rapid changes and develop computer models to explain and predict their response to climate change.

CReSIS is comprised of six partner universities, with the headquarters located at the lead institution, the University of Kansas. The other universities are Elizabeth City State University, Haskell Indian Nations University, The Ohio State University, Penn State University, and the University of Maine. In addition to this core group, CReSIS collaborates with several international institutions and industry partners.
Flight Path

- NSF-funded research has produced the first Synthetic Aperture Radar (SAR) strip-map images of the ice-bed interface. The development of high-sensitivity imaging radars has also contributed to the first ever successful sounding of one of the fastest glaciers in the world, Jakobshavn Glacier.

- Interferometric Synthetic Aperture Radars (InSAR) are revolutionizing the study of polar ice sheets. Satellite data have shown that parts of the Greenland and West Antarctic ice sheets are undergoing rapid changes. However, what is causing these rapid changes is poorly understood. New measurements of the basal boundary conditions will improve glacier-flow models and consequently the understanding of what causes rapid changes in ice sheet mass balance.
Climate Change and Energy: Basic Science, Impacts, Mitigation
**Roadmap for the Future (2009-2014):**

**Climate Change and Renewable Energy: Basic Science, Impacts, and Mitigation**

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<td>Solar energy → Electricity Wu (KU)/Li (KSU)</td>
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You’re not in Kansas anymore?

Kansas is where it’s at!

Kansas Science Smokes!

Thank you NSF EPSCoR!