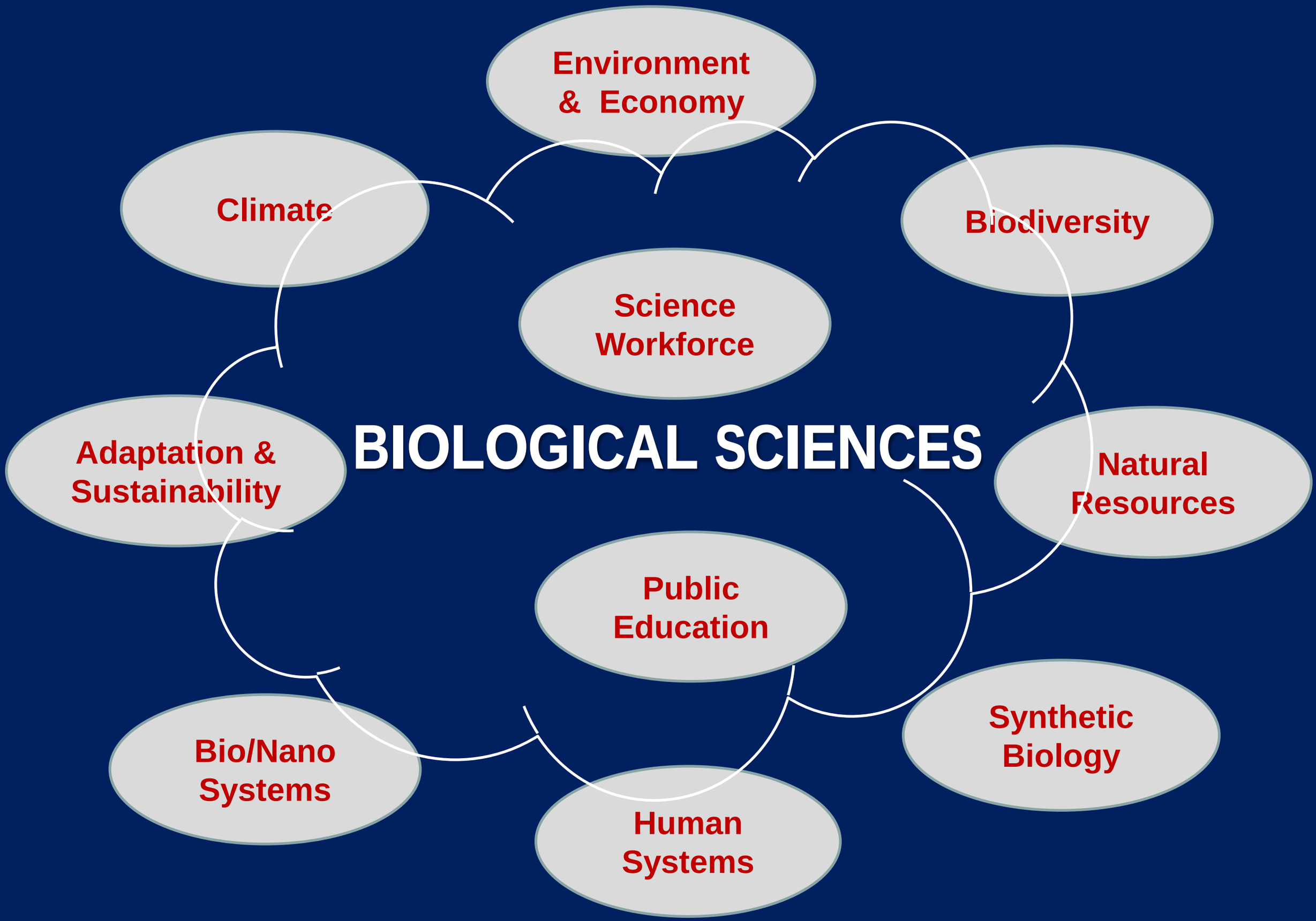
BIO Advisory Committee Meeting
September 5-6, 2012

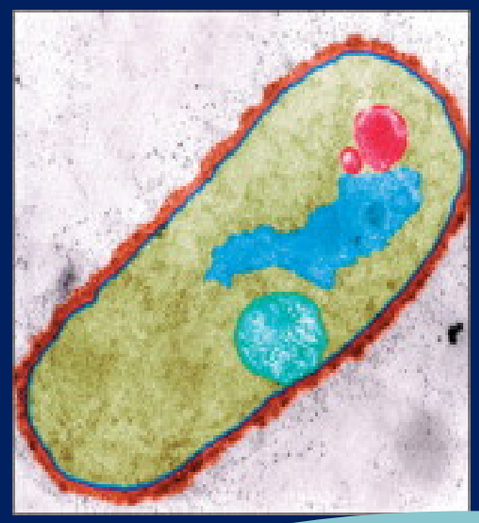
Strategic Innovation for the Biological Sciences

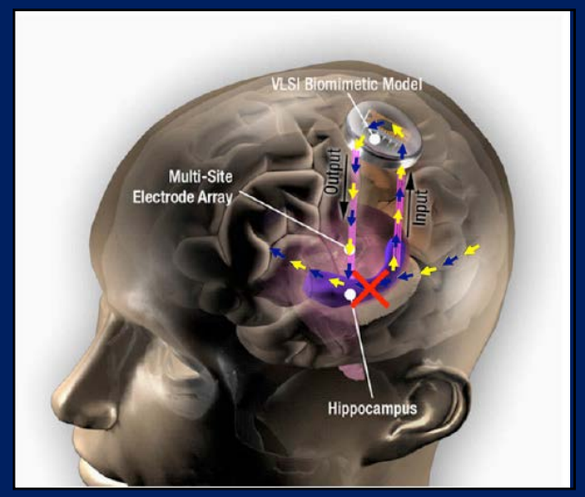
John Wingfield
Assistant Director
Directorate for Biological Sciences

Challenges Facing Humanity in the Next 50 Years



Grand Challenges for 21st Century Biology





Genomes to Phenomes

Synthesizing Life

Neural Systems

2009 NRC Report*

Biological Diversity

Earth, Climate, & Biosphere

** Research at the Intersection of the Physical and Life Sciences*

Earth's climate and life support systems are changing in unusual and unexpected ways.

Estes Park, CO
2012

Oakton, IN 2012

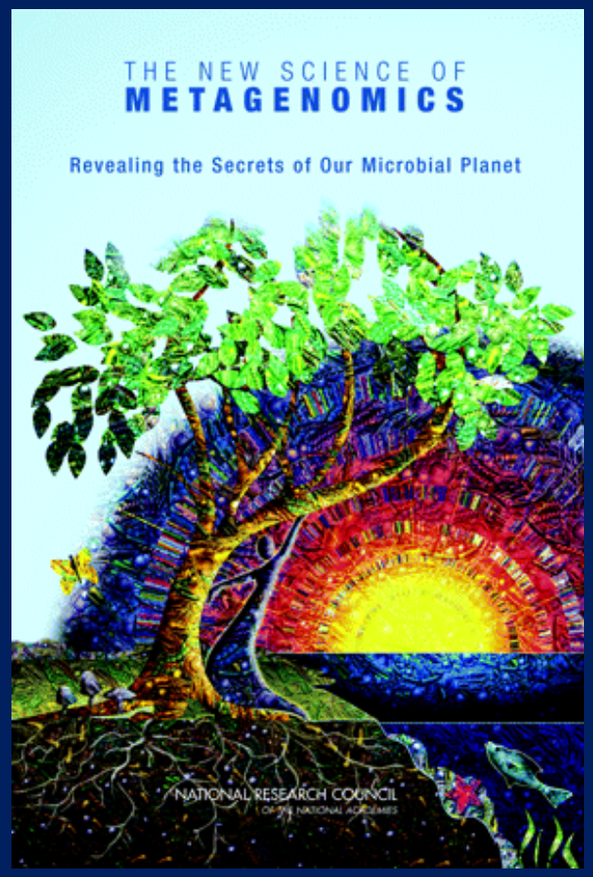
Phoenix, AZ 2012

Duluth, MN 2012

Skelton, IN 2012

How will living systems respond and adapt to rapidly changing environments?

Community DNA



Ecophysiology

Ecosystem Metabolism

EVOLVING GENOMES → EVOLVING POPULATIONS → CHANGING ECOSYSTEMS

Connecting Genomes to Ecosystems

Strategic Innovation for the Biological Sciences

Create an integrated system to achieve a deep temporal and spatial understanding of life on earth by:

1. **Exploration and discovery**
2. **Data-enabled science**
3. **Hypothesis based research**

Immediate Challenge Areas Include:

1. **Secure and improve critical collections**
2. **Deposit research vouchers**
3. **Mobilize the “dark data”**
4. **Improve data synthesis**

TREE OF LIFE

DIMENSIONS OF BIODIVERSITY

LIFE ON EARTH
PAST, PRESENT, FUTURE

BIOLOGICAL COLLECTIONS

OBSERVATORIES & RESEARCH FACILITIES

Framework to the Biological Sciences

From Cells to Ecosystems

LIFE ON EARTH
PAST, PRESENT, FUTURE

Across Scales: Genomes to Organisms

LTER Sites
Marine Labs
Field Stations
NEON

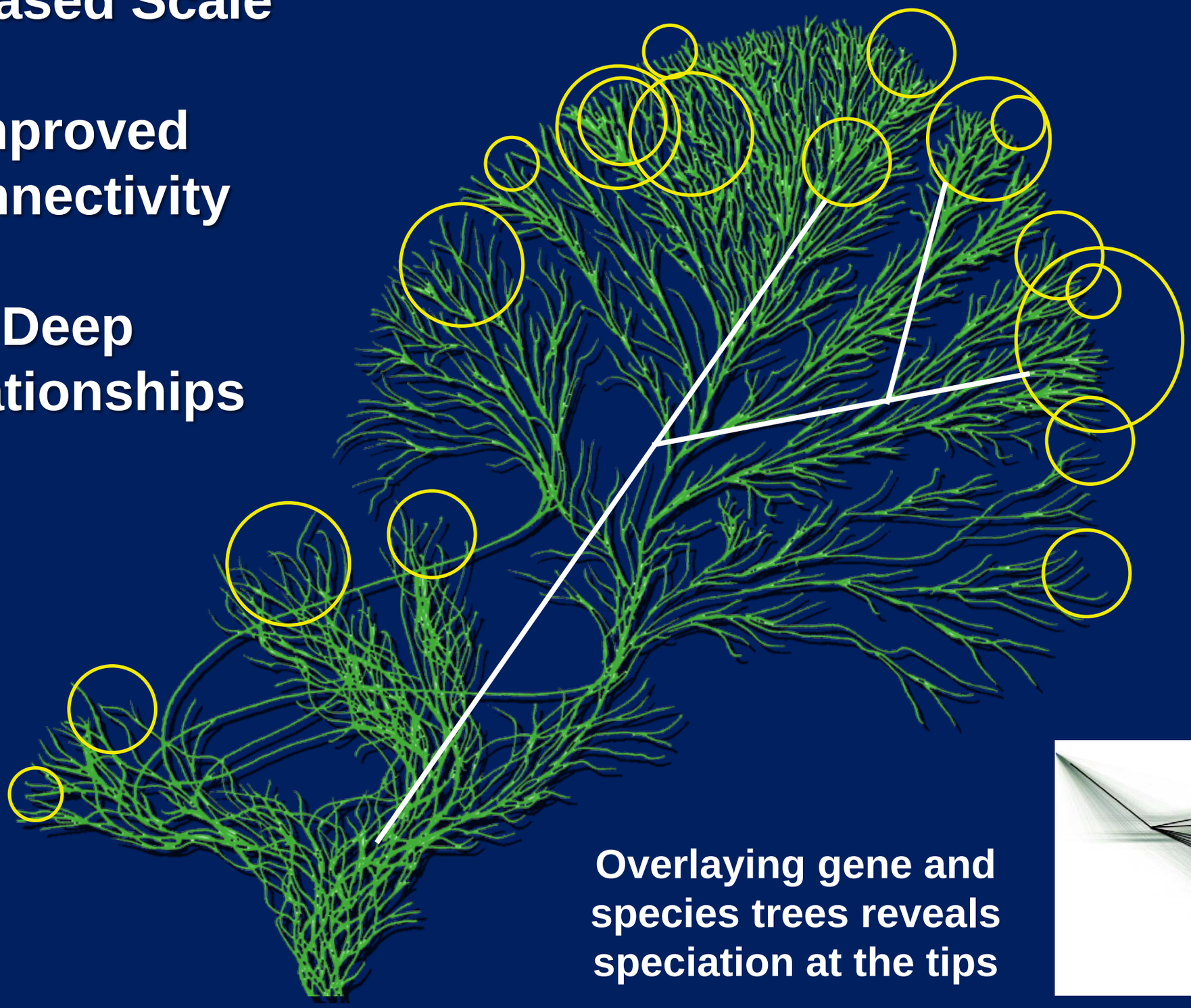
Advancing the Tree of Life (AToL)

Adding Process to Pattern

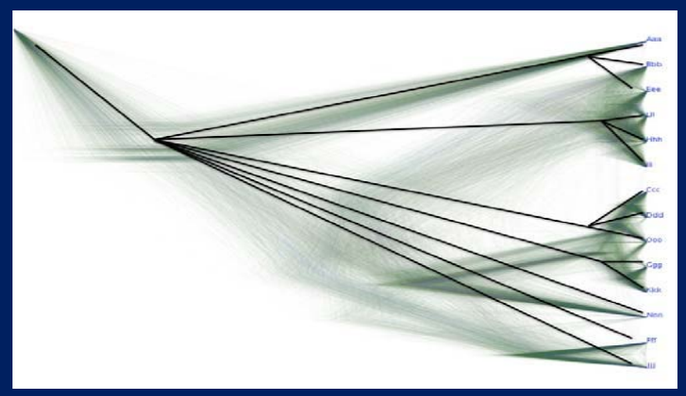
Increased Scale

Improved Connectivity

Deep Relationships



Overlaying gene and species trees reveals speciation at the tips



Strategic Innovation in Biological Sciences

Assembling, Visualizing and Analyzing the Tree of Life (AVATOL)

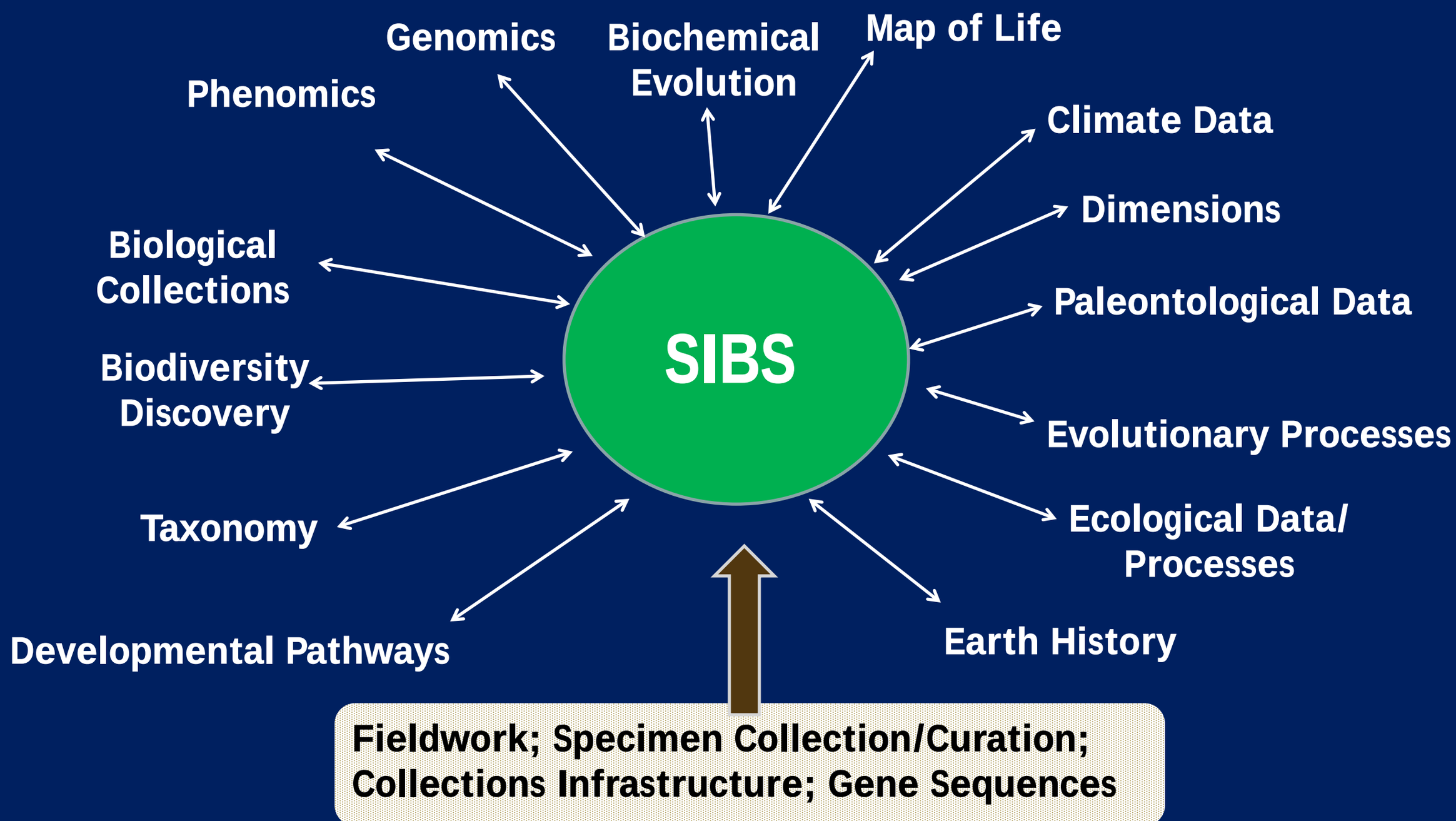
A Framework for the Biological Sciences

- **The Tree of Life is dynamic**
  - **The scope of biodiversity is both unknown and changing**
  - **The tips of the Tree of Life continue to evolve new species**
  - **Novel data are providing new phylogenetic information that must be reconciled with existing information**

- **Systematics is contributing to an open, community-based Tree of Life that will be continually updated as new data are collected and new species are discovered.**

Strategic Innovation in Biological Sciences

Improved integration will produce a centralized, widely accessible Tree of Life that can be annotated with diverse kinds of data and queried by scientists and non-scientists



TREE OF LIFE

From Cells to Ecosystems

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Dimensions of Biodiversity

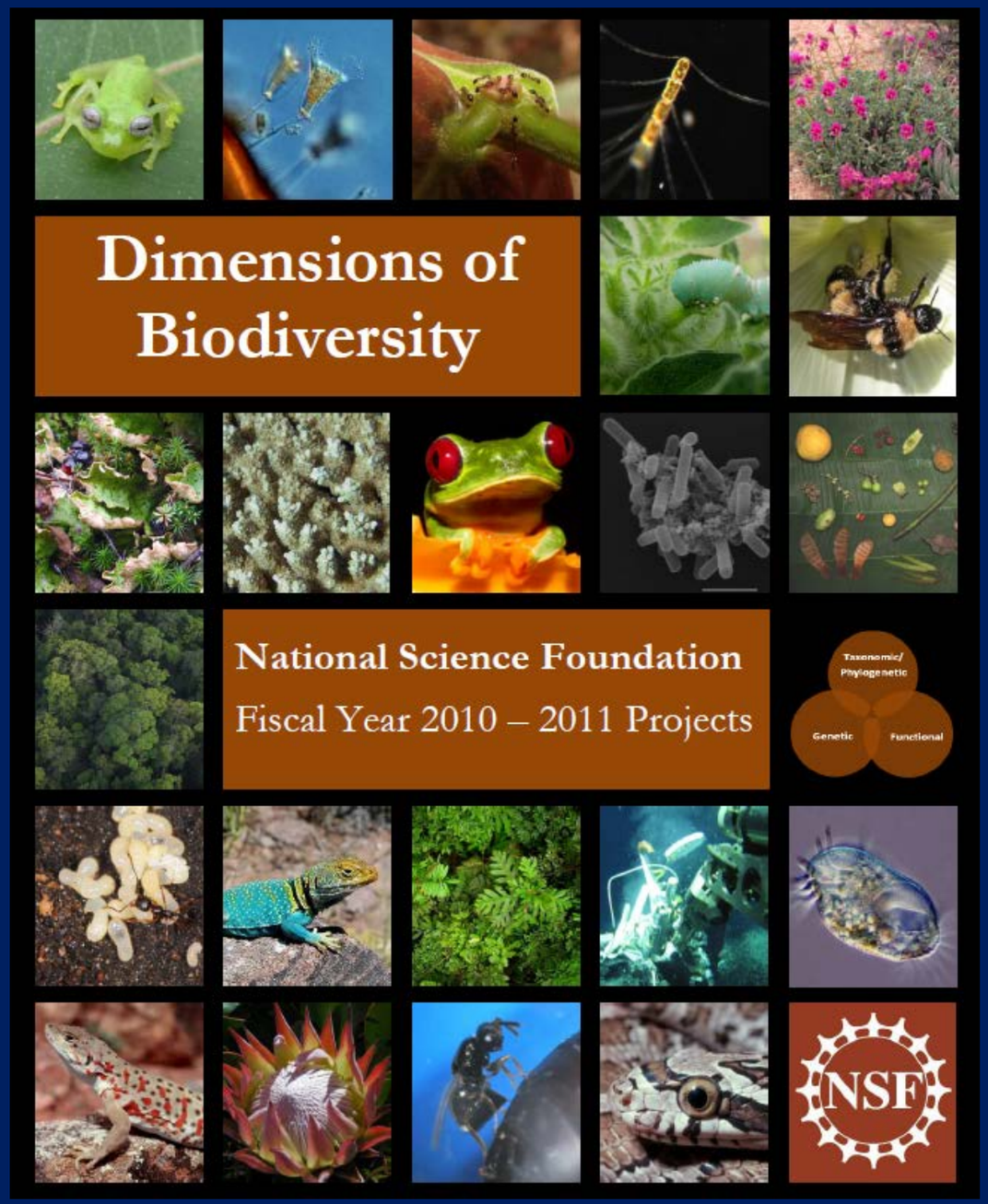
We are the first generation of scientists with the tools to address the dimensions of biodiversity on Earth…

And we may be the last generation with the opportunity to discover and understand Earth's extant species before many are lost…

Thomas et al. (2004, Nature): predict that "on the basis of mid-range climate-warming scenarios for 2050, 15-37% of species" in their sample of regions and taxa will be "committed to extinction."

Dimensions of Biodiversity
[BIO, GEO, OISE, OPP, NASA, Brazil, China]

A multi year effort to characterize the dimensions of biodiversity on Earth



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Across Scales: Genomes to Organisms

OBSERVATORIES & RESEARCH FACILITIES

Collections Contain an Irreplaceable Legacy of Biological Knowledge

1993

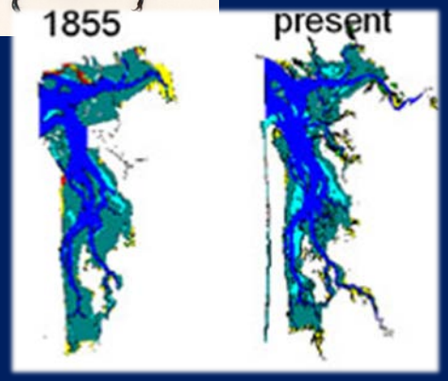
2013

2033

Upon collection

Size, color, habitat

DNA analysis (for taxonomy, phylogeny)



Document habitat change through data on locality, phenology, size, etc.

New technologies for new analyses

Linking Research to Collections

Protein ⟹ alignment ⟹ phylogenetics ⟹ sequence ⟹ GenBank ⟹ vouchered specimen ⟹ museum

Linking Research to Collections

Home | Funding | Awards | Discoveries | News | Publications | Statistics | About | FastLane

National Science Foundation
Directorate for Biological Sciences (BIO)

NSF Web Site

BIO Home | BIO Funding | BIO Awards | BIO Discoveries | BIO News | About BIO

Integrative Organismal Systems (IOS)

- IOS Home
- About IOS
- Funding Opportunities
- Awards
- News
- Events
- Discoveries
- Publications
- Career Opportunities
- Examples of Broader Impacts
- Supplements & Other Opportunities

Email Print

News From the Field

Colorful butterflies Increase Their Odds of Survival by Sharing Traits

May 16, 2012

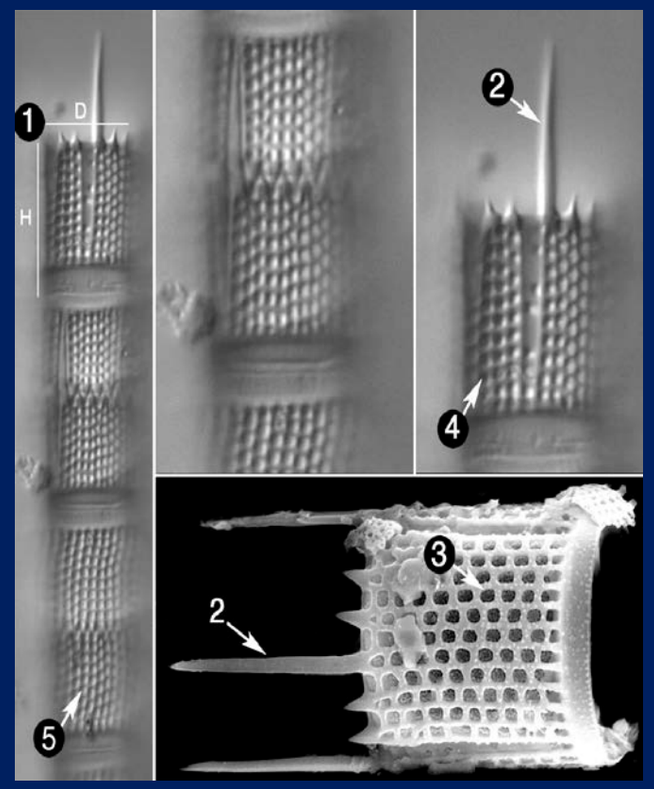
Researchers have discovered that different species of *Heliconius* butterflies common to the Amazonian rain forest are crossbreeding to more quickly acquire superior wing colors. Such genetic sharing among species may help populations adapt to new or changing environments. Full Story

Source
University of California, Irvine

The National Science Foundation (NSF) is an independent federal agency that supports fundamental research and education across all fields of science and engineering. In fiscal year (FY) 2012, its budget is $7.0 billion. NSF funds reach all 50 states through grants to nearly 2,000 colleges, universities and other institutions. Each year, NSF receives over 50,000 competitive requests for funding, and makes about 11,000 new funding awards. NSF also awards nearly $420 million in professional and service contracts yearly.

Protein ⟹ alignment⟹sequence ⟹ GenBank ⟹vouchered specimen⟹ museum

Linking Research to Collections



Ecosystem study ⟹ climate models ⟹ georeferenced specimens ⟹ museum

Digitization of Biological Collections
The DATA Challenge

1. 250 years of information and specimens in non-federal U.S. collections
2. Where are the specimens?
3. What is known and where are the gaps?

Digitization of Biological Collection
The CyberInfrastructure Challenge

1. Linking data across resources
2. Automated workflow specific to collection needs
3. Storage of 2D & 3D images
4. Improved Optical Character and Voice Recognition
5. Accessibility



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LTER Sites
Marine Labs
Field Stations
NEON

Understanding How Living Systems Respond to Environmental Change

National Ecological Observatory Network

The National Socio-Environmental Synthesis Center

Long-term Ecological Research Program (BIO, GEO, OPP)

Cyber-Enabled Observatories, Synthesis Centers, Long Term Ecological Research Programs, Marine Labs and Field Stations

LTER 30 Year Report

NSF response:

- "…intended to be prospective,…articulating a strategic vision that strengthens the core science agenda for the LTER network over the coming decade."
- "…priorities should highlight [LTER] sites' scientific strengths and strengthen [LTER] sites' abilities to address compelling research questions."

Cedar Creek LTER

Cedar Creek long-term experiments have fundamentally changed our understanding of the ecological consequences of biodiversity.

Long-term data are the basis for extensive data syntheses, new research directions, and direct societal impacts from a better understanding of biofuel efficiency.

Cedar Creek LTER: Bio-diverse Cellulosic Feed Stocks Yield More Energy from Biofuels

Switchgrass

Corn Stalks & Wheat Straw

Hybrid Poplar

Mixed Prairie Grass

1. Prairie plants require little energy and grow on degraded agricultural land.
2. Diverse prairie grass mixtures produce 238% more energy than a single species planted on the same land.
3. Prairie biomass yields 51% more energy than corn based ethanol.

Field Station Research

University of Montana
Flathead Lake
Biological Station

Riverscape Analysis Project

More than 30 physical characteristics, such as river gradient, floodplain area, and channel complexity, are used to rank rivers for their potential to produce wild salmon.

Incorporating human influences such as dams, roads, and land use into the ranking makes it possible to represent not only habitat characteristics but also habitat stresses.

Field Station Research

Missouri State University

Bull Shoals Field Station

Bull Shoals Lake

Bull Shoals Field Station (BSFS) has joined the national drought network, which is examining large sections of the continental United States that are currently undergoing varying degrees of drought.

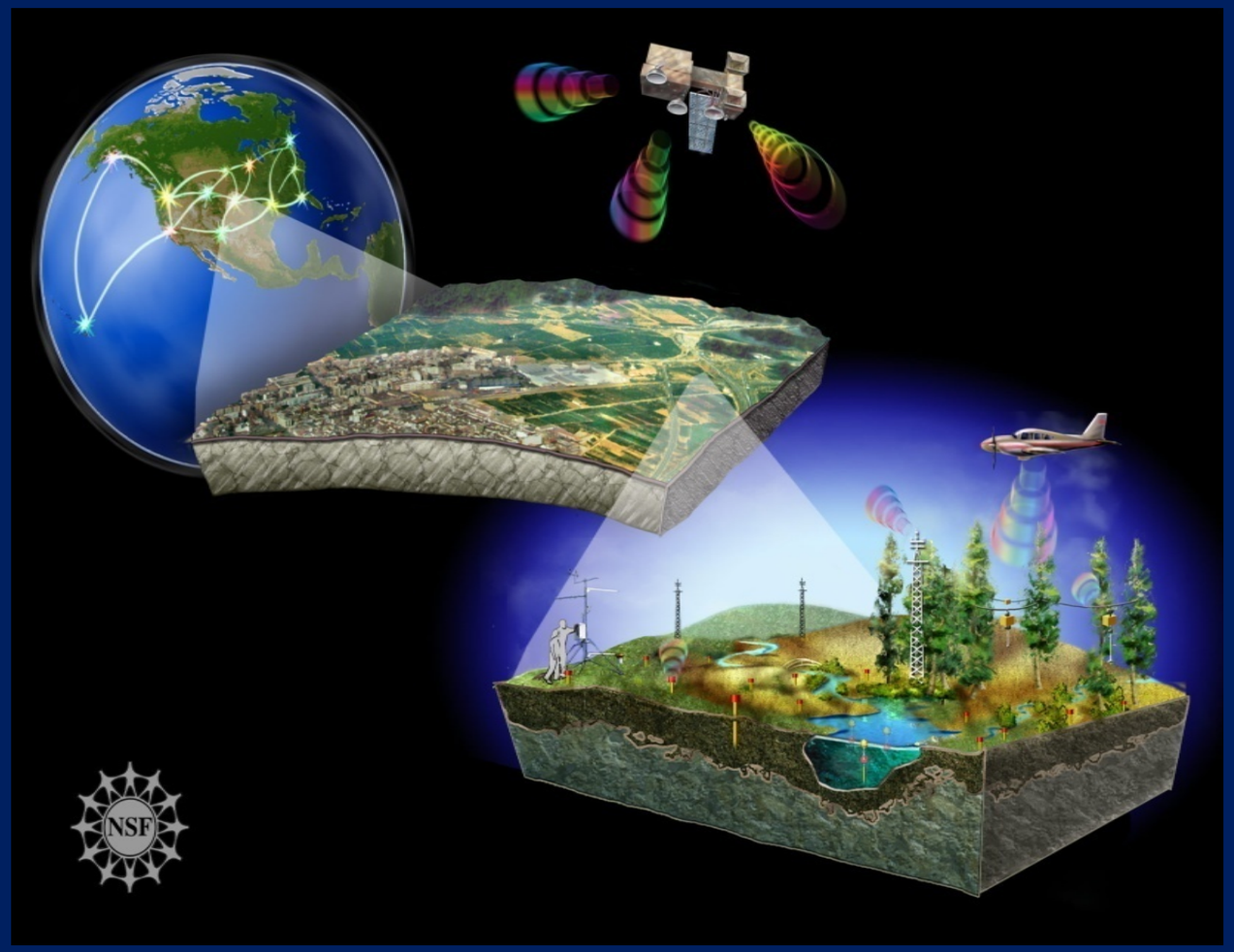
This collaborative research team examines tree mortality from drought across multiple systems that no research group could tackle alone. Investigators take small, manageable sets of identical field measurements in their tree-dominated ecosystems.

Missouri State College of Natural and Applied Sciences News Watch
August 15, 2012

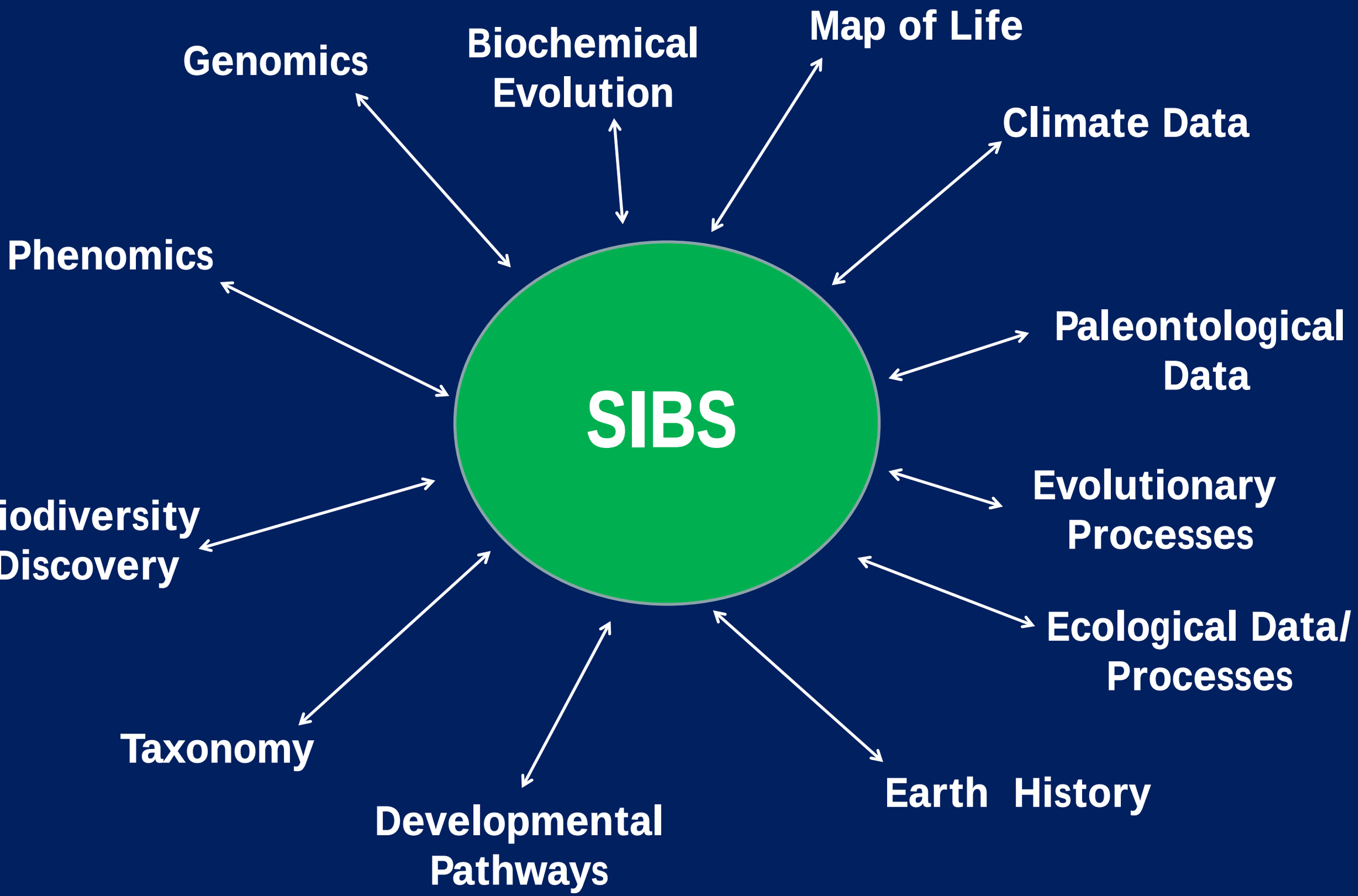
National Ecological Observatory Network (NEON)

Regional to continental scale research platform for all biology

- **Molecules to Biosphere**
- **Long-term measurements**
- **Standardized infrastructure & quality control**
- **Near real time data access**
- **Decision support tools**
- **Networking**



A NEW CONTEXT FOR ADDRESSING BIO GRAND CHALLENGES



Biological Data Issues

1. Global or use-based solutions? (Genbank, Protein Data Bank, Digital Data Repository)
2. What data will be stored? For how long? Who decides?
3. How and where will data be stored and curated?
4. What are the cyberinfrastructure requirements?
5. How will standards (annotation, addition & access) be designed and implemented?
6. Who pays and who's in charge?

The Data Challenge

How can data collected from multiple experimental and observational platforms be combined to solve complex problems?

Infrastructure challenges include:

- **scalability**
- **sustainability**
- **availability**
- **security**
- **integrity**

BIO Centers

Focus for critical new cyberinfrastructure capabilities

Priorities identified at combined centers cyber-infrastructure workshop (April 2012):

1. **Increased data storage capacity**
2. **Coordinated access/interoperability**
3. **Increased collaboration and CI reuse**
4. **CI investments that are guided by research**

DataWay: A National Data Infrastructure

Community-based cyberinfrastructure to support integration of data and information for knowledge management

DataWay Charrette (*anticipated Fall 2012/Winter 2013*)

- Develop strategies to identify and support broadly useful ideas for a data infrastructure
- Facilitate and promote efficient data utilization and management across research communities
- Participation: NSF Dear Colleague Letter (~ Sept. 2012)
- Link to DataWay website for instructions and FAQs
- Questions/comments/requests to **DataWay@nsf.gov**

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Thanks to the Biological Sciences Directorate, DBI, DEB, IOS and MCB for discussions and input

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