

# THE POWER

## OF BIOLOGICAL COLLECTIONS

for Science, Education, and the Economy

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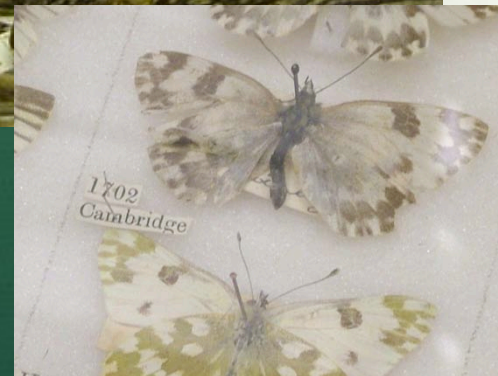




# POWER

## OF COLLECTIONS | Biological Memory

- Biological specimens provide a permanent record of species on our planet. We use them again and again to interpret our world.
- Specimens in global biological collections provide the majority of our knowledge of life on earth.
- Today, biodiversity scientists have discovered and described 1.9 million species on earth. This wealth of knowledge increases what we can say about the past, present, and future of our planet.



What might the DNA of this butterfly collected in 1702 reveal about current populations of this now global species?

# BIOLOGICAL COLLECTIONS | Biodiversity

Species are pieces of the planetary puzzle, and specimens in biological collections help us understand and interpret our world. Biological specimens...

- Possess key information for **protecting and managing** our natural resources.
- Allow us to **predict** distributions of earth's species and natural resources.
- Reveal five billion years of **planetary history** including changes in climate, geological history, and life.
- Provide new materials – from foods and fibers to pharmaceuticals – to **empower** human society.





# BIOLOGICAL SPECIMENS

## Cornerstone of Science

“If a species cannot be identified and that initial datum used to access all that has been discovered about the species, then a substantial part of the genetics, biomedicine, public health, agriculture, biogeography, evolutionary studies, and ecology are flying blind.” --E.O. Wilson

Specimens in museums allow for repeatability – the cornerstone of the scientific process.

Accurate identifications of species unlock knowledge that is linked to:

- Up to 250 years of **published data**
- **Biodiversity data** in collections (distribution, seasonality, habitat, host plants, parasites)
- **Genomics and proteomics data**



The federally endangered American Burying Beetle.

# UNLOCKING

## Planetary Knowledge



We have only scratched the surface of the benefits of biological collections and associated data for informing humankind.

- 2 million species known and another 7 remain to be discovered.
- Over 3 billion specimens are housed in collections world-wide. Specimens in museums provide a treasure trove of data and are the ultimate scientific vouchers for biological research.
- Global Biodiversity Information Facility (GBIF) provides access to over 367,390,218 standardized biodiversity records (1/10<sup>th</sup> of the total specimens).



# POWER

## OF COLLECTIONS | Our Origins



[http://www.sciencenews.org/view/download/id/59524/name/Distant\\_relatives](http://www.sciencenews.org/view/download/id/59524/name/Distant_relatives)

Comparisons of genomes from human, chimpanzees and Neandertals (reconstruction on right) reveal our ancestry. Neanderthal fossils from biological collections were essential in this research.

- Federal investment in the Human Genome Project yielded \$796.3 billion in economic impact from 1998-2010 and scientific innovation.
- “1,000 Genomes Project” will examine genetic variation from approximately 1,200 people.
- GenBank includes 317 million sequences and 202 billion base pairs of available data.
- Molecular sequence data have been sampled from about 10% of all known species with associated specimens vouchered in biological collections.



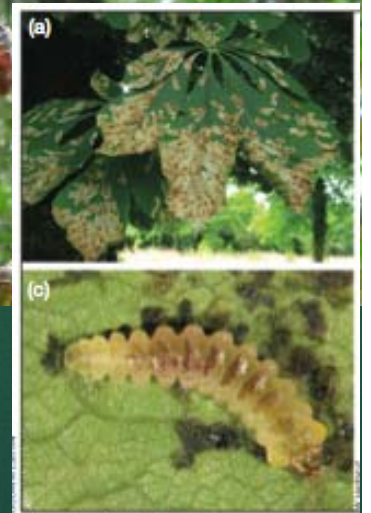
# POWER

## OF COLLECTIONS | Invasive Species

- Invading alien species in the United States cause major environmental damages and losses adding up to \$138 billion per year.
- Analysis of historical plant specimens and associated insect pests allows us to understand origins of invasive species and predict controls.

**“Indeed, herbaria ... have broad relevance in current research, emerging as a premium resource for documenting spatiotemporal changes in biodiversity.”**

--Lees *et al.* 2011.



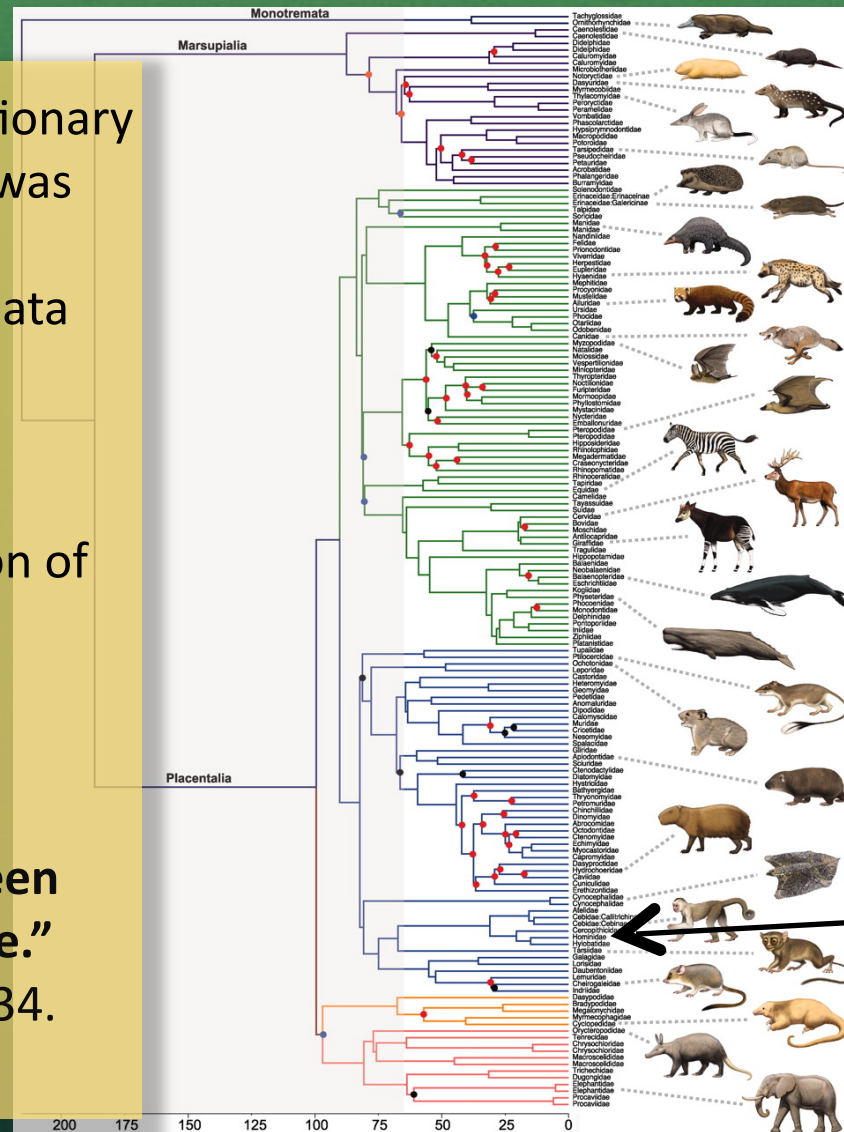
Lees *et al.* 2011. *Frontiers in Ecology and the Environment* 9: 322–328.

# POWER

# OF COLLECTIONS | Knowledge

- The first comprehensive evolutionary tree for all families of mammals was scientifically possible only by combining fossil and molecular data from biological collections.
- Results are useful in conservation planning, prevention of wildlife trafficking, resource management.

**“Specimens squirreled away in museum cabinets have never been more valuable to biology at large.”**  
--Helgen. 2011. *Science* 334.



You are here!



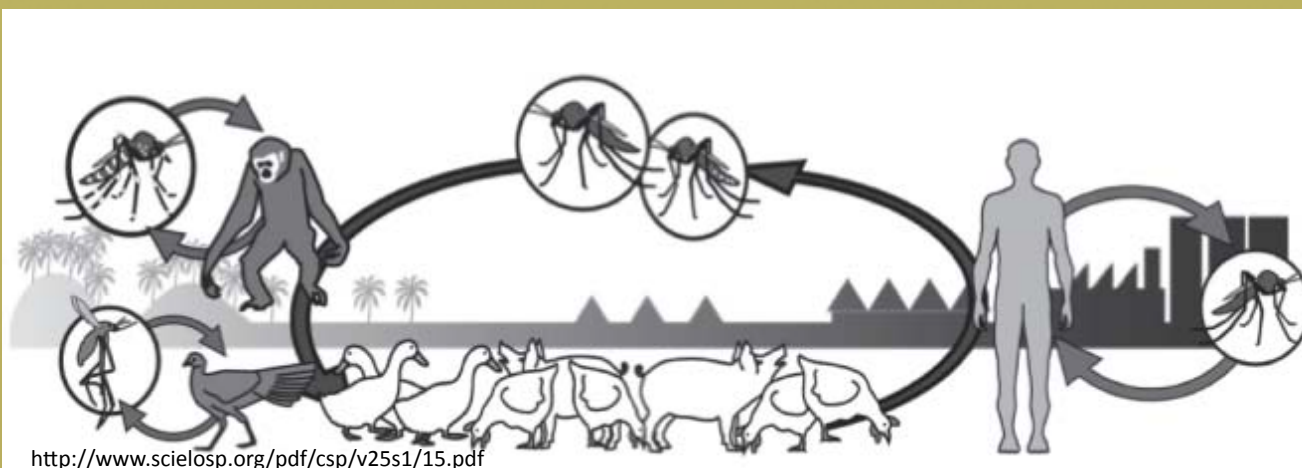
# POWER

## OF COLLECTIONS | Epidemiology

- Our nation spends about \$27 million annually for detection and monitoring of disease and disease-carrying species that affect humans and livestock.
- Accurate identification of disease-carrying species requires biological collections and scientific expertise.
- Biodiversity data that are associated with disease-carrying species allow development of vector control efforts as well as predictions of potential vector distributions.



Monitoring of disease vectors and hosts is required for disease prevention.



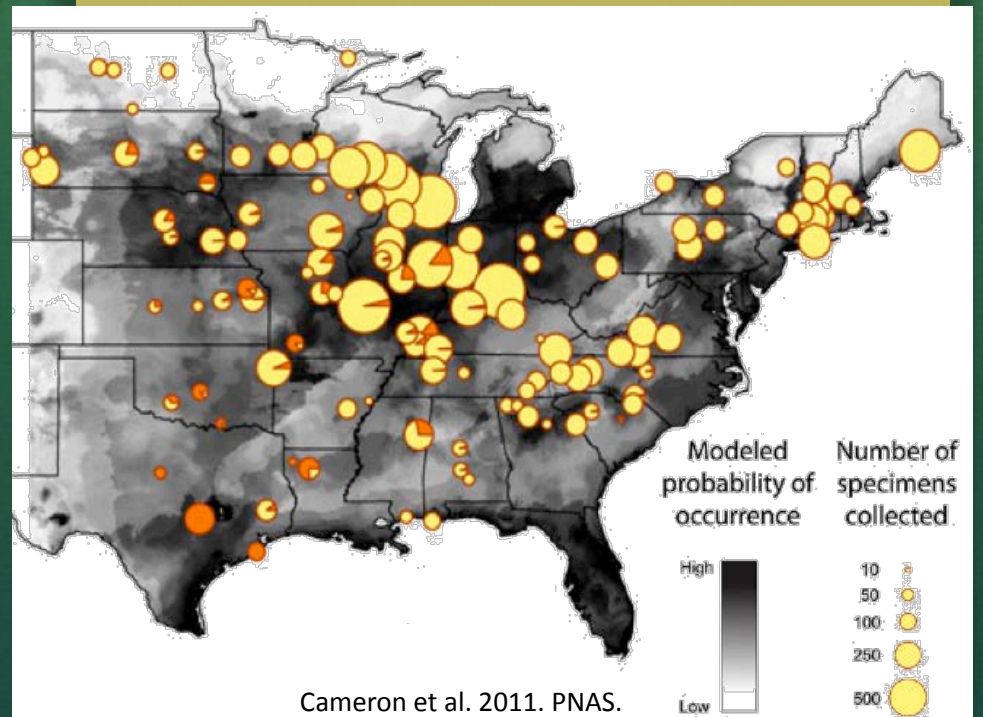
# POWER

## OF COLLECTIONS | Agriculture

- Agriculture relies on biological collections for identification of beneficial species, biological control agents, and pest species.
- Pollination services for agriculture in the United States are estimated to be **\$12-16 billion**, of which native pollinators, such as bumble bees make up about \$3 billion.
- 73,000 museum specimens reveal an alarming decline in native bumble bee pollinators, changing distributions, reduced genetic structure, and higher levels of pathogens in the US.



*Bombus pensylvanicus*, a declining native U.S. bumble bee species.

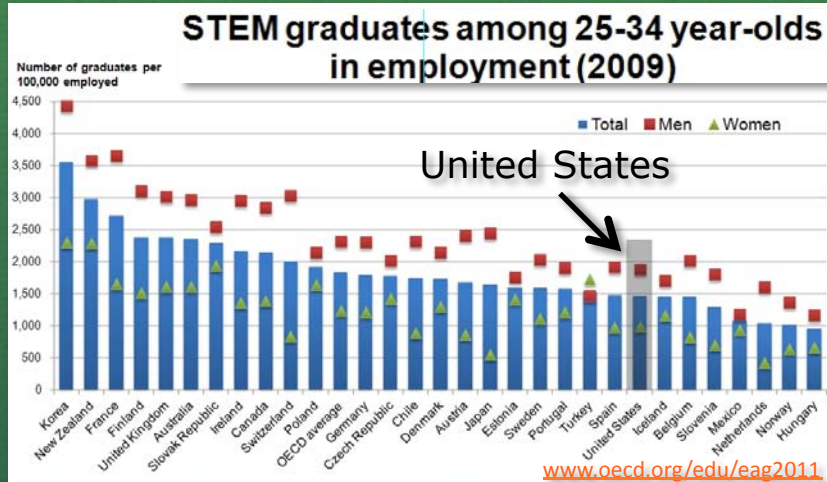


Cameron et al. 2011. PNAS.



# POWER

## OF COLLECTIONS | STEM Education



- The U.S. lags behind other nations in STEM education (Science, Technology, Engineering and Math), resulting in less innovation in our workforce.
- Collections are an exciting educational resource for students and teachers. Like the Human Genome Project, access to data from collections will propel the US on the world stage.
- Biodiversity science, in combination with computation, will train the next generation of interdisciplinary scientists that will lead to new innovations and discoveries for humankind.

# COLLECTIONS ADDRESS

## Overarching Societal Needs

Human health and safety  
Homeland security  
International trade  
Conservation planning  
Prevention of wildlife trafficking  
Sustaining ecosystems  
Land use planning  
Invasive species predictive models  
Discovery and exploration  
Climate change  
Bioprospecting for new medicines, foods, and fibers  
Management of agricultural pests  
Biological control  
Identification of disease vectors  
Forensic science  
Emerging infection diseases





# WHO NEEDS BIODIVERSITY DATA?

Politicians  
Agriculturalists  
Ecological Modelers  
Health and Homeland Security  
Conservationists  
Citizen Scientists  
Education Specialists  
Land Managers  
Climate Change Scientists  
Infectious Disease Specialists  
Biological Control Managers

**ALL OF US!**



# THE POWER OF BIOLOGICAL COLLECTIONS

- Digitizing biological collections is the nexus for innovation and entirely new discoveries.
- The wealth of information in biological collections increases our confidence in inferences and creates challenges for analysis.
- Computation *plus* biology will lead to new fields, new innovations, and new discoveries that will empower humankind.







**In order to meet societal challenges in the environment, human health, and the economy.**