Expanding the Boundaries of Natural History Knowledge and its Potential to Transform Science and Benefit Society

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Natural history science is foundational to all science domains and is critical to understanding our rapidly changing world.

Natural history scientists study the processes and patterns of Earth’s 4.5 billion year old story – a story that is continuing to unfold.

Natural history science encompasses both basic discovery and understanding of complex systems.
Mobilization of natural history collections data is vital to the future of natural history science and the future of the planet.
Understanding the natural world and our place in it.
Responsibility
“Curiosity Cabinets”
The Great Acceleration

1950 marked the beginning of a massive acceleration in human activity and large-scale changes in the Earth system.
“There is more information about biodiversity ... in natural history collections than in all other sources of information combined.”

-- Dr. Larry Page
“Basically, our goal is to organize the world’s information and to make it universally accessible and useful.”

-- Larry Page
The One World Collection
100 Institutions across 6 Continents
THE GREAT ACCELERATION

SOCIO-ECONOMIC TRENDS

- WORLD POPULATION
- REAL GDP
- FOREIGN DIRECT INVESTMENT

- URBAN POPULATION
- PRIMARY ENERGY USE
- FERTILIZER CONSUMPTION

- LARGE DAMS
- WATER USE
- PAPER PRODUCTION

- TRANSPORTATION
- TELECOMMUNICATIONS
- INTERNATIONAL TOURISM

EARTH SYSTEM TRENDS

- CARBON DIOXIDE
- NITROUS OXIDE
- METHANE

- STRATOSPHERIC OZONE
- SURFACE TEMPERATURE
- OCEAN ACIDIFICATION

- MARINE FISH CAPTURE
- SHRIMP AQUACULTURE
- COASTAL NITROGEN

- TROPICAL FOREST LOSS
- DOMESTICATED LAND
- TERRESTRIAL BIOSPHERE DEGRADATION


MAP & DESIGN: Félix Phairand-Descîné / Globalia
“With great power, comes great responsibility.”

-- Spiderman
World Population and Growth Rate

![Graph showing world population growth over time.

The y-axis represents population (billions), ranging from 0 to 10. The x-axis represents years, ranging from 1050 to 2050.

The graph shows a steady increase in population from the early 1100s to the late 1800s, with a significant acceleration starting around 1950, leading to a projection of a near-exponential growth by 2050.]
Modeling environmental, biotic, and climatic change over the history of life
Control of neglected and emerging tropical diseases and invasive species
Ensuring sustainable agriculture and supply of raw materials
Applying genomic information and an understanding of the natural history and evolution of infectious species as diagnostic tools in biomedicine
BIODIVERSITY FORECASTING

(Dowell et al, 2016, Royal Society)
Tempo and mode of evolution: study of large series of natural history specimens allows us to explain how trait variation influences the rate at which different species evolve.

Genomic basis for functional diversity: combining data from paleontology, living organisms and developmental biology reveals the genomic basis for the evolution of phenotypic characters.

Ancient DNA: It is now possible to extract genomic sequences from historical natural history specimens, enabling genomic analysis of extinct and historical populations.

Reconstructing the Tree of Life: for all living and extinct species, using molecular and phenotypic data, extant and extinct specimens.

Coupling deep disciplinary and multidisciplinary researchers to innovate and meet the complexity of natural sciences.
GOAL: To organize the massive amount of information about the natural environment contained in the world’s natural history museums and make it universally accessible and useful for tackling scientific and societal challenges.
GENOTYPES
GenBank, GGBN, BoL, Google Genomics

PHENOTYPES
MorphoBank, TraitBank, ARBOR

TAXONOMY & PHYLOGENY
Catalogue of Life, ITIS, Open Tree of Life, EoL

LITERATURE
BHL, Google Scholar

SPECIES GEOTEMPORAL DISTRIBUTIONS
Paleo Database, EarthCube

ENVIRONMENTAL DATA
NEON, NASA, Google Earth

MUSEUM SPECIMENS
Digitized images and metadata. iDigBio, etc

SPECIES GEOSPATIAL DISTRIBUTIONS
GBIF, Lifemapper, MoL, BISON
INFORMATION

DATA

KNOWLEDGE
Five palaeobiological laws needed to understand the evolution of the living biota

Charles R. Marshall

The foundations of several disciplines can be expressed as simple quantitative laws, for example, Newton’s laws or the laws of thermodynamics. Here I present five laws derived from fossil data that describe the relationships among species extinction and longevity, species richness, origination rates, extinction rates and diversification. These statements of our palaeobiological knowledge constitute a dimension largely hidden from view when studying the living biota, which are nonetheless crucial to the study of evolution and ecology even for groups with poor or non-existent fossil records. These laws encapsulate: the critical fact of extinction; that species are typically geologically short-lived, and thus that the number of extinct species typically dwarfs the number of living species; that extinction and origination rates typically have similar magnitudes; and, that significant extinction makes it difficult to infer much about a clade’s early history or its current diversity dynamics from the living biota alone. Although important strides are being made to integrate these core palaeontological findings into our analysis of the living biota, this knowledge needs to be incorporated more widely if we are to understand their evolutionary dynamics.
FOR THE INCREASE AND DIFFUSION OF KNOWLEDGE AMONG MEN

1846 SMITHSONIAN INSTITUTION 1946

3¢ UNITED STATES POSTAGE
Our Mission: For the increase and diffusion of knowledge…
SCIENCE: 75 curators, over 500 scientists and affiliated scholars
COLLECTIONS: 145.3 collected objects
AUDIENCE: 7 million visitors/year
Major Science Themes Address Our Diverse and Changing Planet:

- Discovering, Documenting, and Understanding Biodiversity
- Formation and Evolution of Earth and Other Planets
- Human Diversity and Cultural Change
- Evolutionary and Ecological Processes Throughout the History of Life
An Emerging Strategy for NMNH Science
National Museum of Natural History Science Divisions

with Percentage of Total Collection

Vertebrate Zoology: 7%
Paleobiology: 30%
Anthropology: 2%
Botany: 3%
Entomology: 23%
Geology: 1%
Invertebrate Zoology: 34%
Total Staff Counts for Science Divisions

<table>
<thead>
<tr>
<th>Science Division</th>
<th>Research Staff</th>
<th>Collections Staff</th>
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<td>4</td>
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<tr>
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<tr>
<td>VZ</td>
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</tbody>
</table>

Number of Staff
Distribution of Research Experience Across Science Divisions

- **0 - 14 Years**
- **15 - 29 Years**
- **30 - 44 Years**
- **45+ Years**

Science Divisions:

- ANT
- BOT
- ENT
- GEO
- IZ
- PAL
- VZ

Number of Staff:

- 0 - 14 Years
- 15 - 29 Years
- 30 - 44 Years
- 45+ Years

Years Of Experience:

- 0 - 14
- 15 - 29
- 30 - 44
- 45+
Distribution of Research Experience Across Collections

Collections by Division

Number of Staff

- 0 - 14 Years
- 15 - 29 Years
- 30 - 44 Years
- 45+ Years
Median Years of Experience for NMNH= 31.5 years
A | dW
analog in a digital world
LINKED
GLOBAL
NATURAL
HISTORY
KNOWLEDGE