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NATIONAL MUSEUM of NATURAL HISTORY

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

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Associate Director of Science
National Museum of Natural History
Smithsonian Institution

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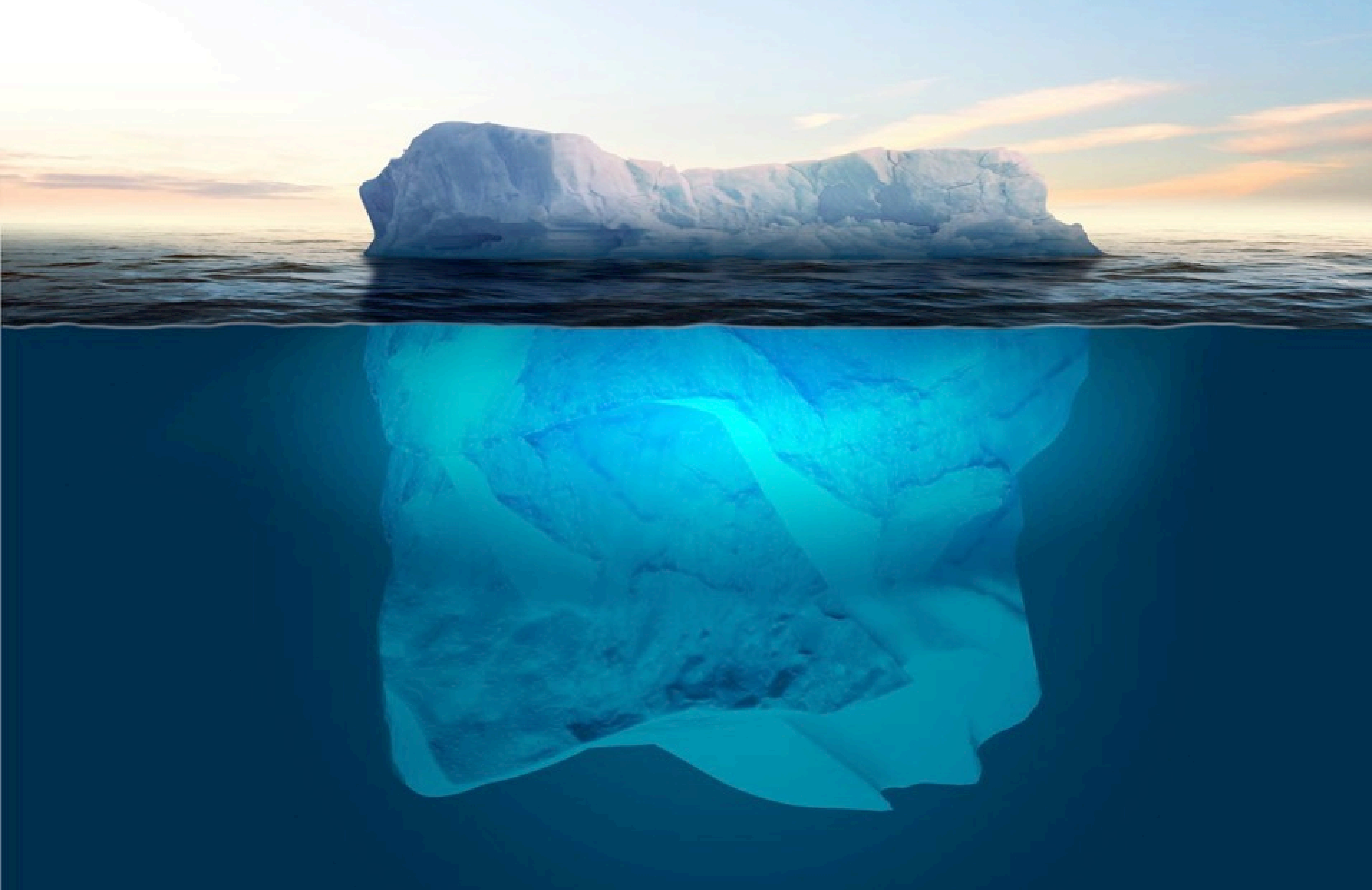
Natural history science is foundational to all science domains and is critical to understanding our rapidly changing world.

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



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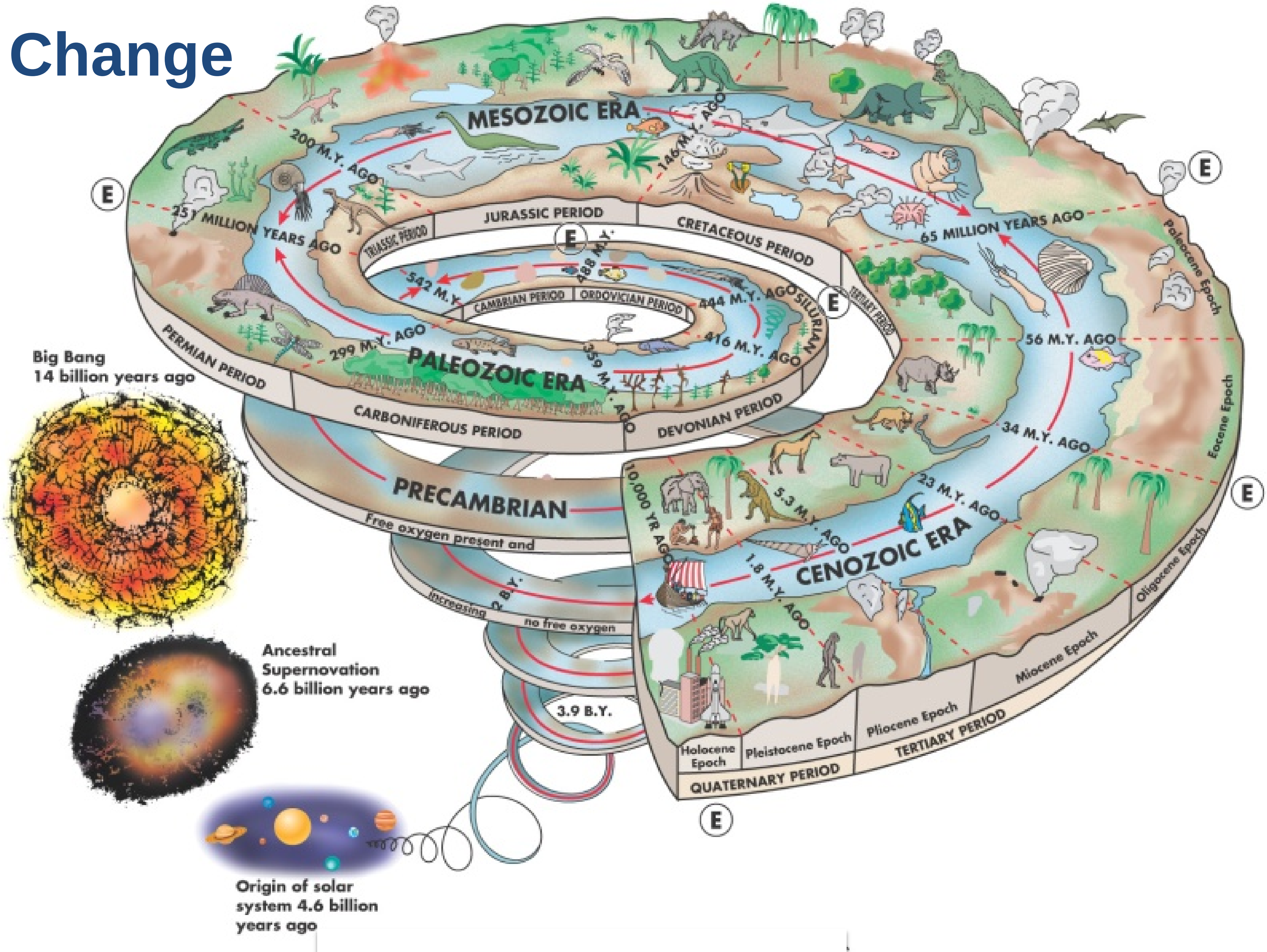
Time

Power

Change

Responsibility

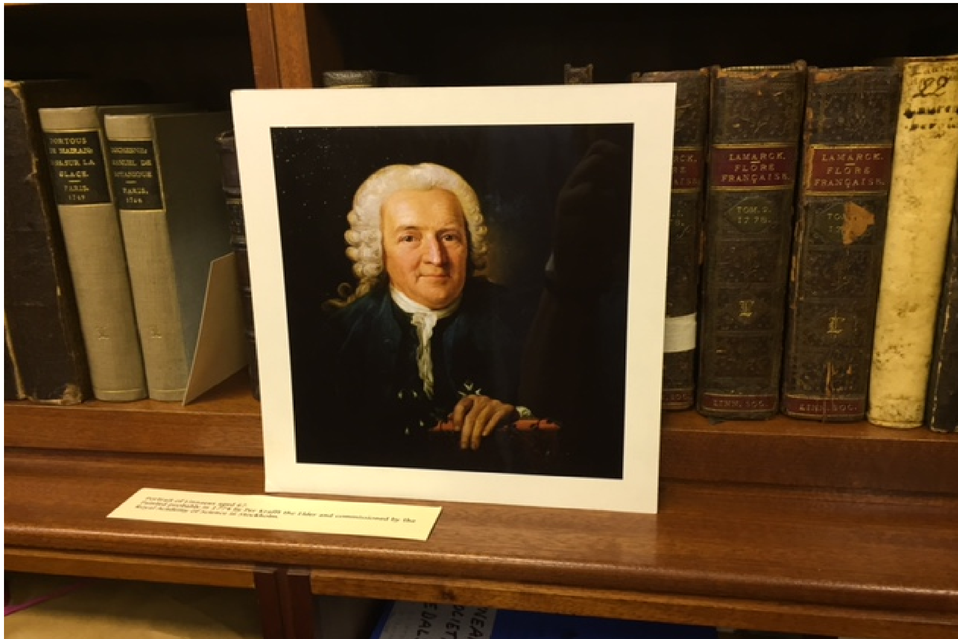
Time
Change


MESOZOIC ERA
PALEOZOIC ERA
CENOZOIC ERA
PRECAMBRIAN
Free oxygen present and increasing
no free oxygen
3.9 B.Y.
2 B.Y.
TRIASSIC PERIOD
JURASSIC PERIOD
CRETACEOUS PERIOD
TERTIARY PERIOD
CAMBRIAN PERIOD
ORDOVICIAN PERIOD
SILURIAN
DEVONIAN PERIOD
CARBONIFEROUS PERIOD
PERMIAN PERIOD
Paleocene Epoch
Eocene Epoch
Oligocene Epoch
Miocene Epoch
Pliocene Epoch
Pleistocene Epoch
Holocene Epoch
TERTIARY PERIOD
QUATERNARY PERIOD
251 MILLION YEARS AGO
200 M.Y. AGO
146 M.Y. AGO
65 MILLION YEARS AGO
56 M.Y. AGO
34 M.Y. AGO
23 M.Y. AGO
5.3 M.Y. AGO
1.8 M.Y. AGO
10,000 YR AGO
542 M.Y.
488 M.Y.
444 M.Y. AGO
416 M.Y. AGO
359 M.Y. AGO
299 M.Y. AGO
E
Big Bang
14 billion years ago
Ancestral
Supernovation
6.6 billion years ago
Origin of solar
system 4.6 billion
years ago

Power

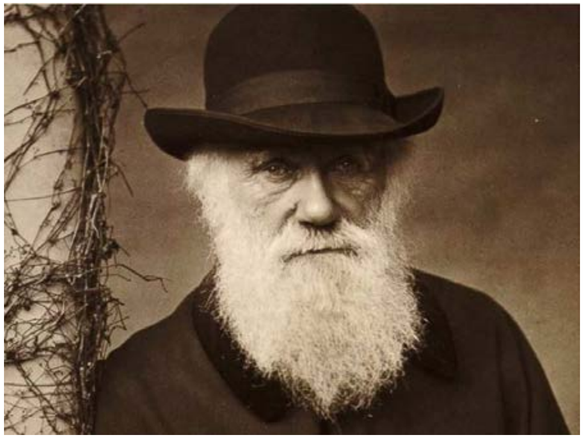
Responsibility

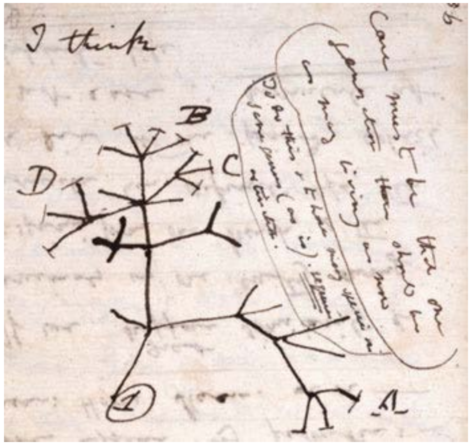
"Curiosity Cabinets"


LAMARCK. FLORE FRANÇAISE
LAMARCK. FLORE FRANÇAISE


21 ulysses


ESSAYS and OBSERVATIONS
MOLLUSCS
BIVALVES
1-17
18-26
27-39
40-59
MOLLUSCS




I think
B
C
D
1

The Great Acceleration

1950 marked the beginning of a massive acceleration in human activity and large-scale changes in the Earth system.

SOURCE: igbp.net | Steffen et al., 2005, Global Change and the Earth System, Springer, pp. 132-133

DESIGN: Globaia.org

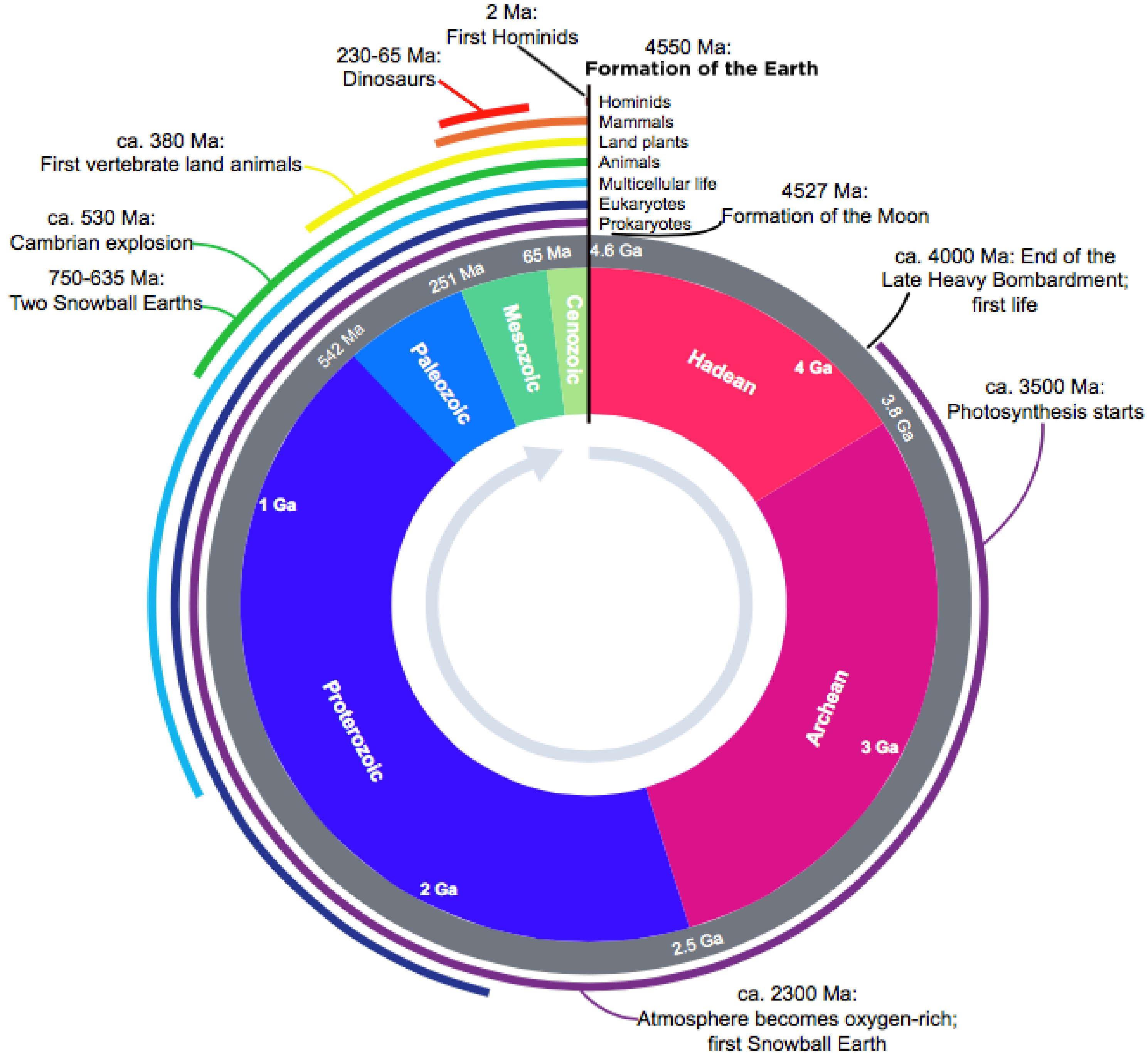
"There is more information about biodiversity …in natural history collections than in all other sources of information combined."

-- Dr. Larry Page

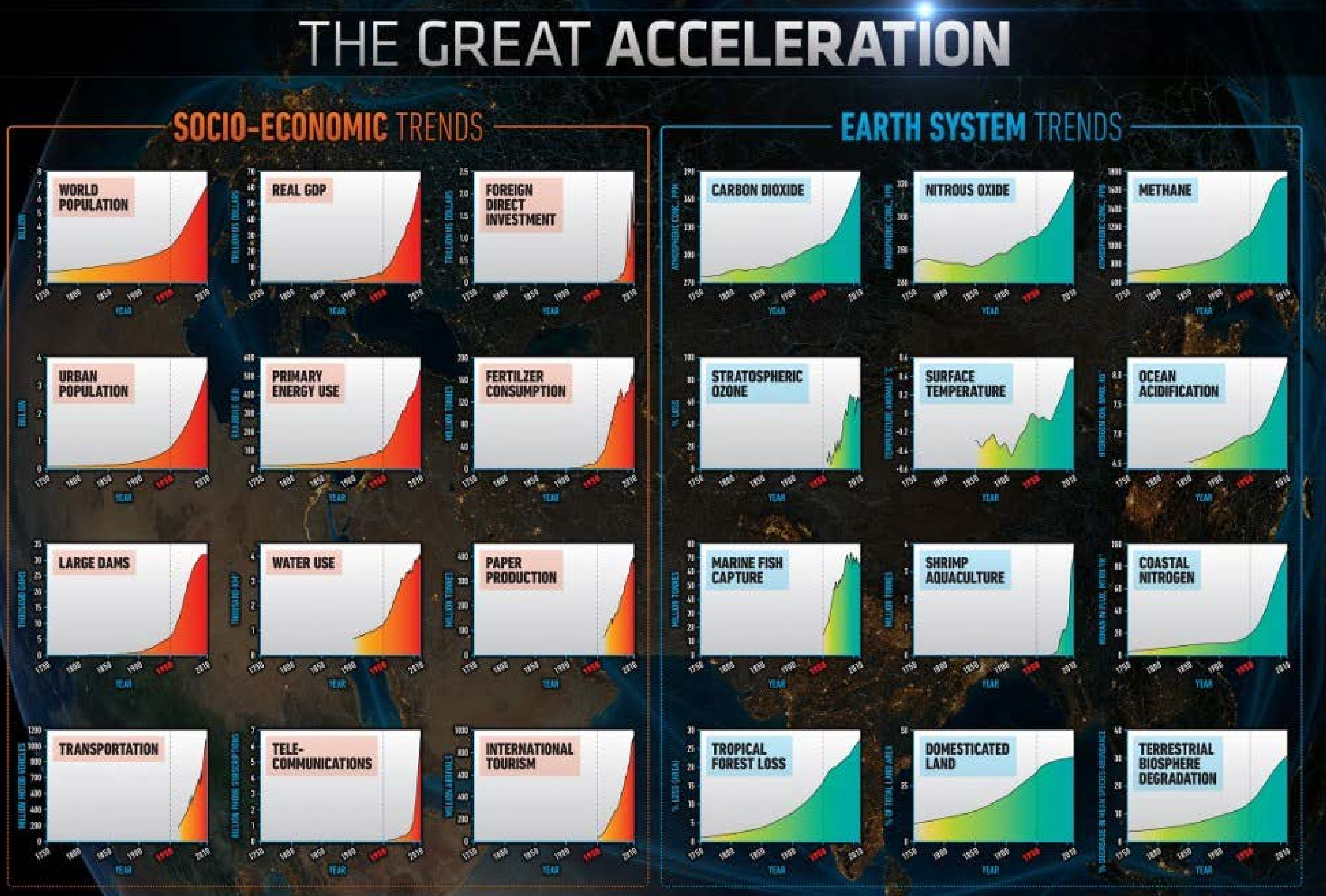
"Basically, our goal is to organize the world's information and to make it universally accessible and useful."

-- Larry Page

The One World Collection
100 Institutions across 6 Continents



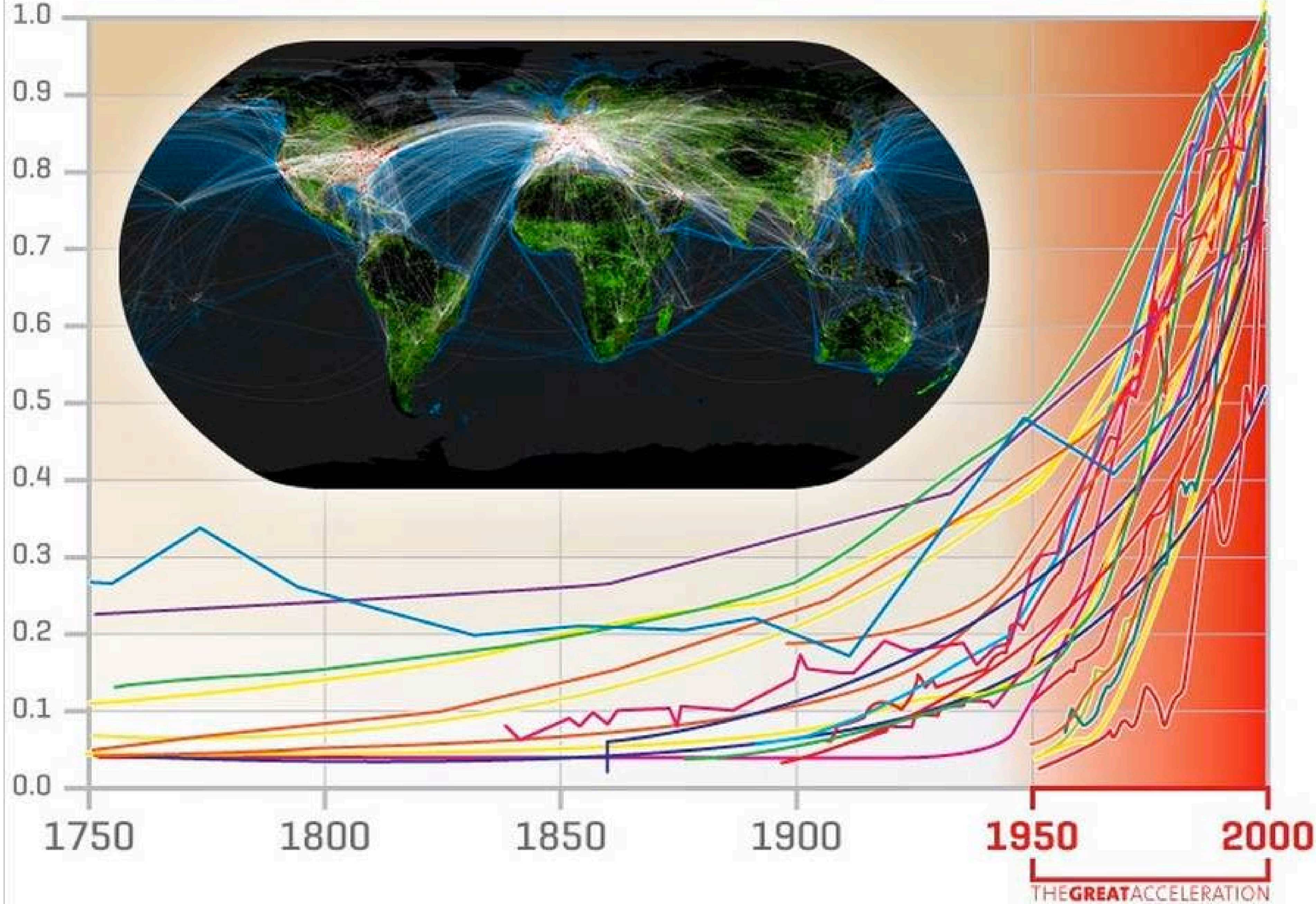
2 Ma:
First Hominids
230-65 Ma:
Dinosaurs
4550 Ma:
Formation of the Earth
Hominids
Mammals
Land plants
Animals
Multicellular life
Eukaryotes
Prokaryotes
4527 Ma:
Formation of the Moon
ca. 380 Ma:
First vertebrate land animals
ca. 530 Ma:
Cambrian explosion
750-635 Ma:
Two Snowball Earths
ca. 4000 Ma: End of the
Late Heavy Bombardment;
first life
65 Ma
4.6 Ga
251 Ma
542 Ma
Cenozoic
Mesozoic
Paleozoic
Hadean
4 Ga
3.8 Ga
ca. 3500 Ma:
Photosynthesis starts
1 Ga
Proterozoic
Archean
3 Ga
2 Ga
2.5 Ga
ca. 2300 Ma:
Atmosphere becomes oxygen-rich;
first Snowball Earth



REFERENCE: Steffen, W., W. Broadgate, L. Deutsch, O. Gaffney and C. Ludwig. The Trajectory of the Anthropocene: the Great Acceleration, *The Anthropocene Review*, 16 January 2015.

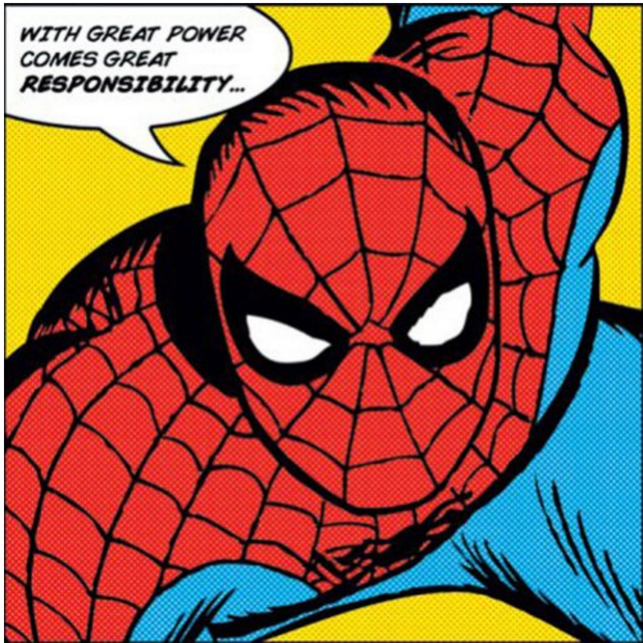
MAP & DESIGN: Félix Pharand-Deschênes / Globaia

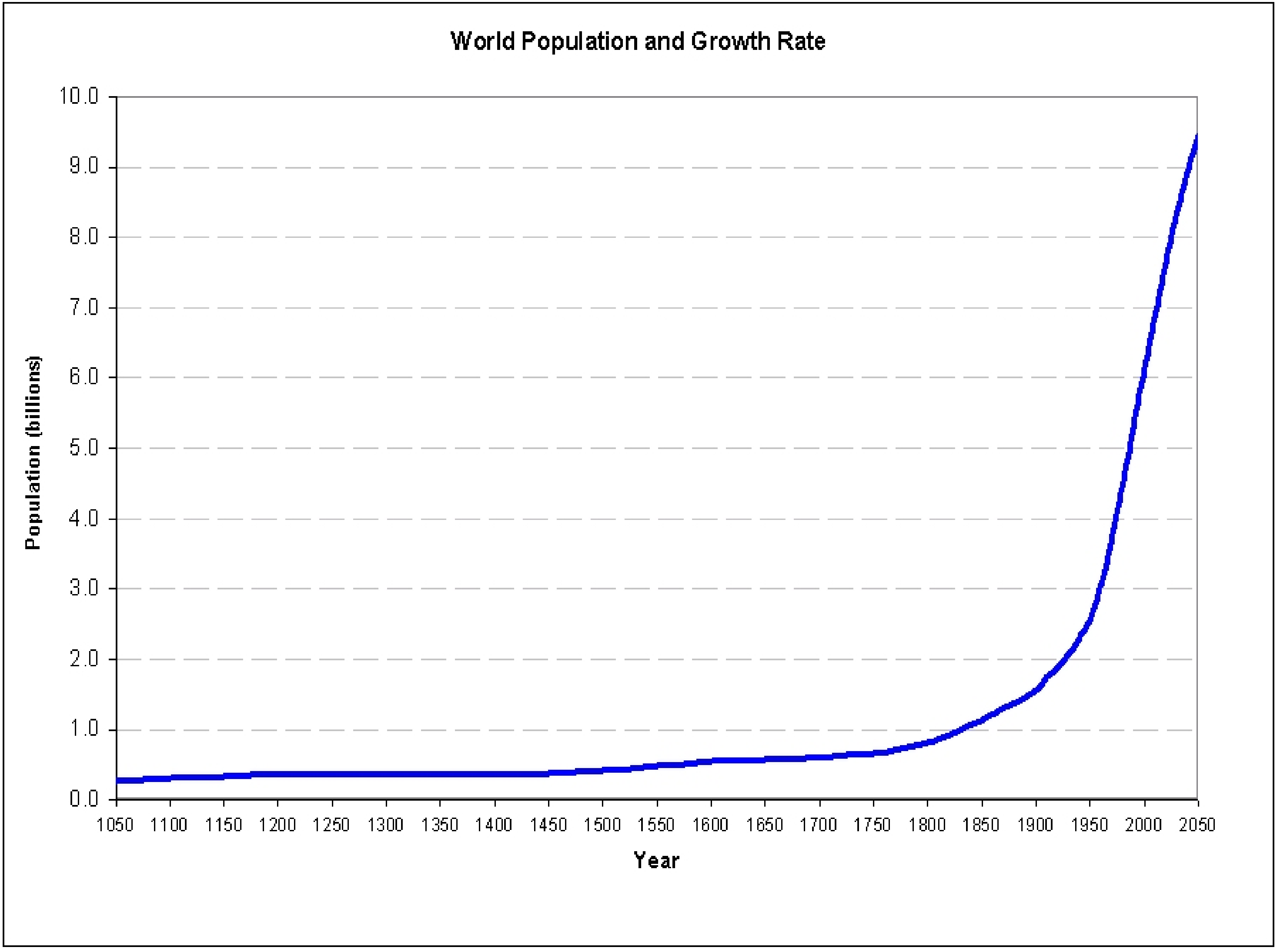
The Anthropocene | 24 Indicators, 1 Chart

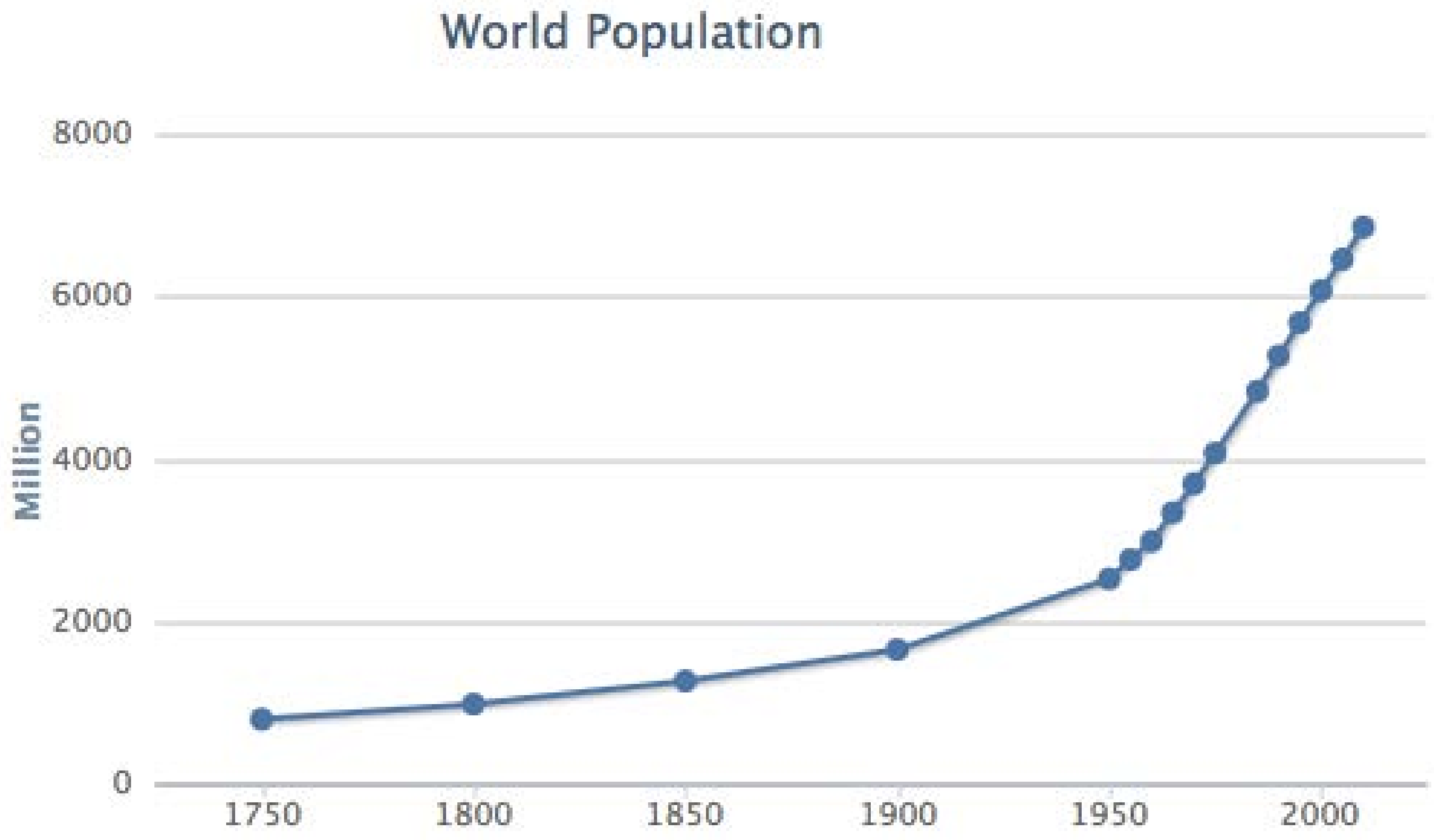


"With great power, comes great responsibility."

-- Spiderman

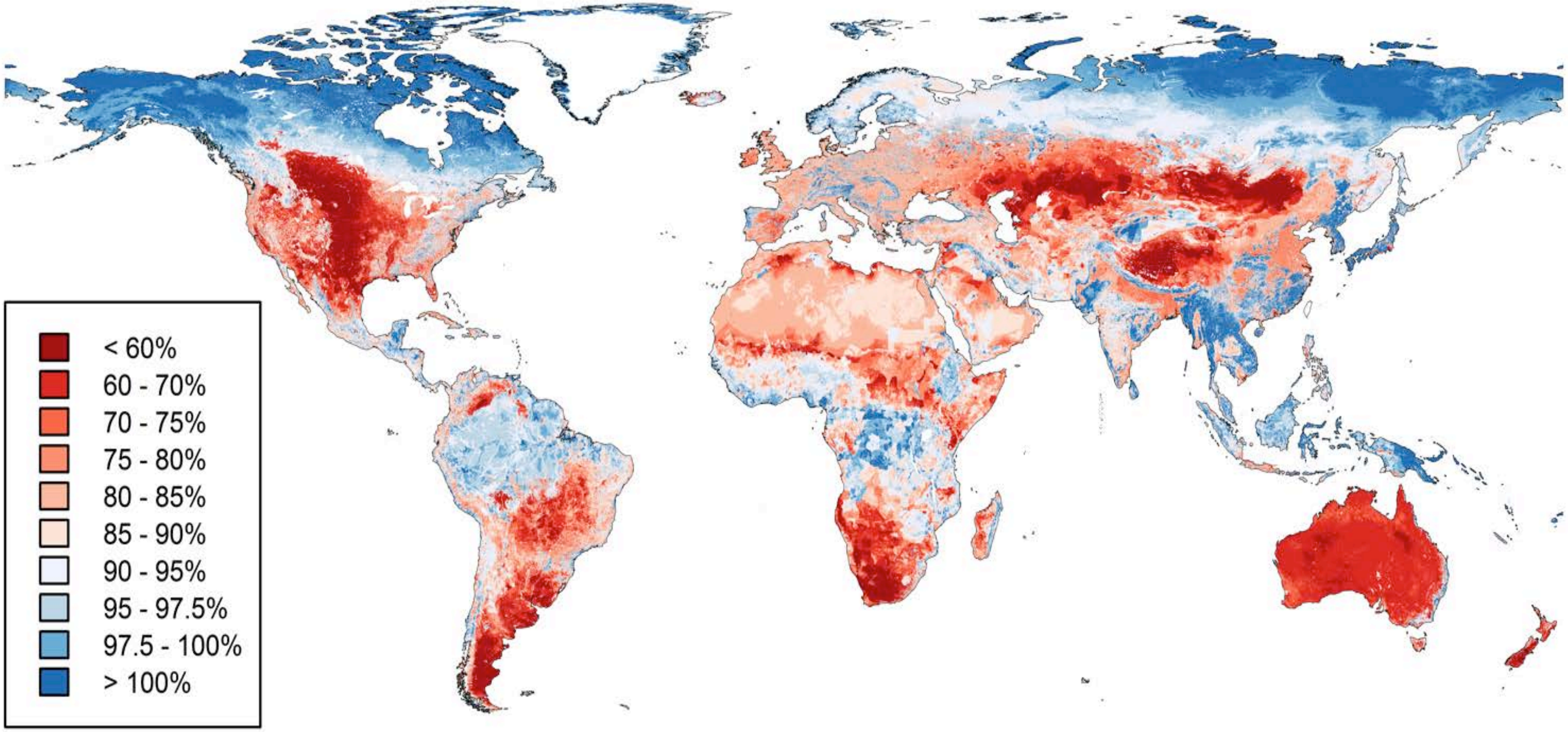



World Population and Growth Rate
Population (billions)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
2050
Year



Paris
Philadelphia
Washington, DC
San Francisco
Boston
London
New York
Chicago

BIODIVERSITY INTACTNESS INDEX



Newbold, T., L. N. Hudson, et al. (2016). "Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment." Science 353(6296): 288-291.

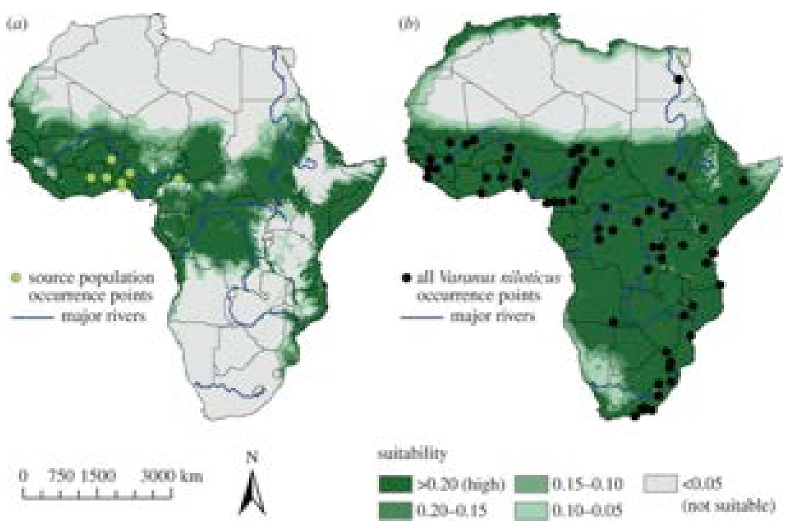
Modeling environmental, biotic, and climatic change over the history of life

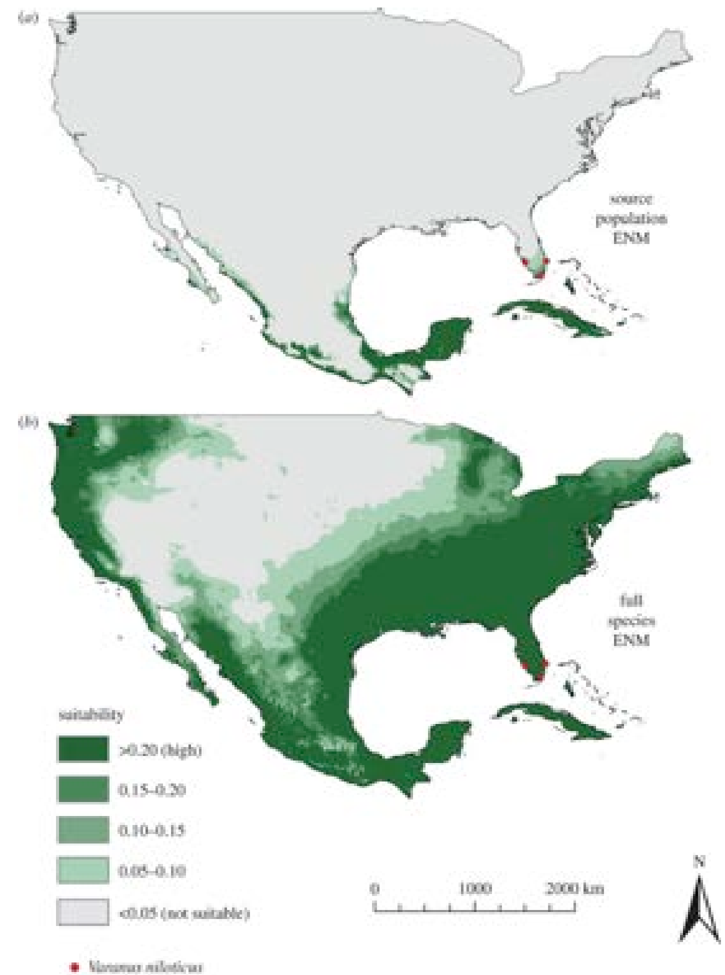
Control of neglected and emerging tropical diseases and invasive species

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)

NATURAL HISTORY BASIC RESEARCH TACKLES SCIENTIFIC GRAND CHALLENGES

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.

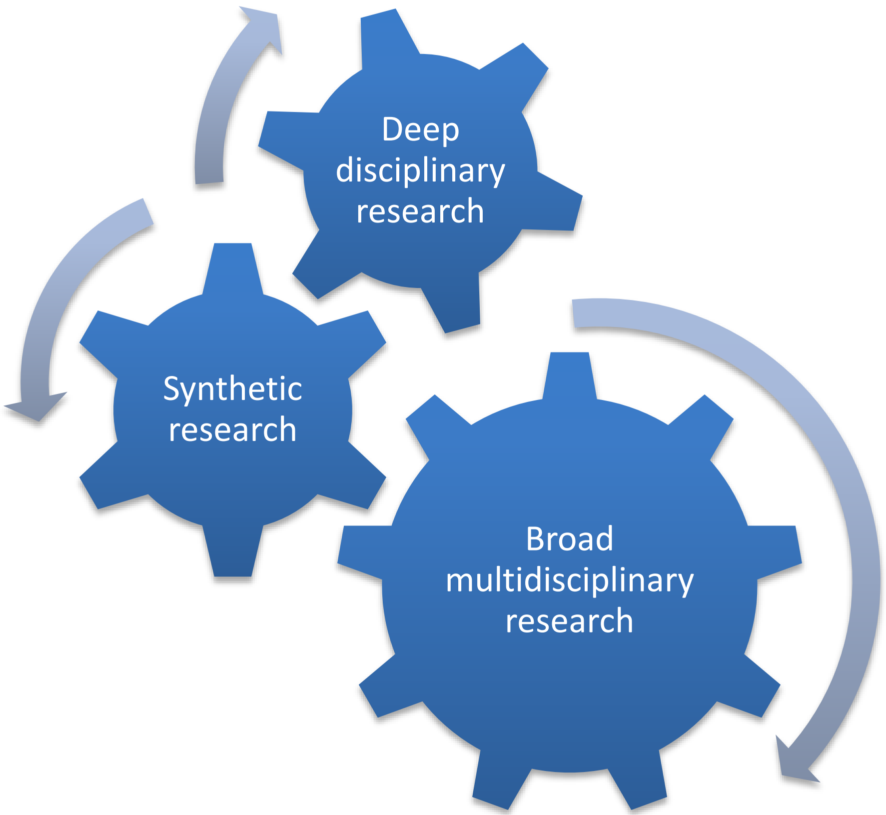
Genomic basis for functional diversity: combining data from paleontology, living organisms and developmental biology reveals the genomic basis for the evolution of phenotypic characters.

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

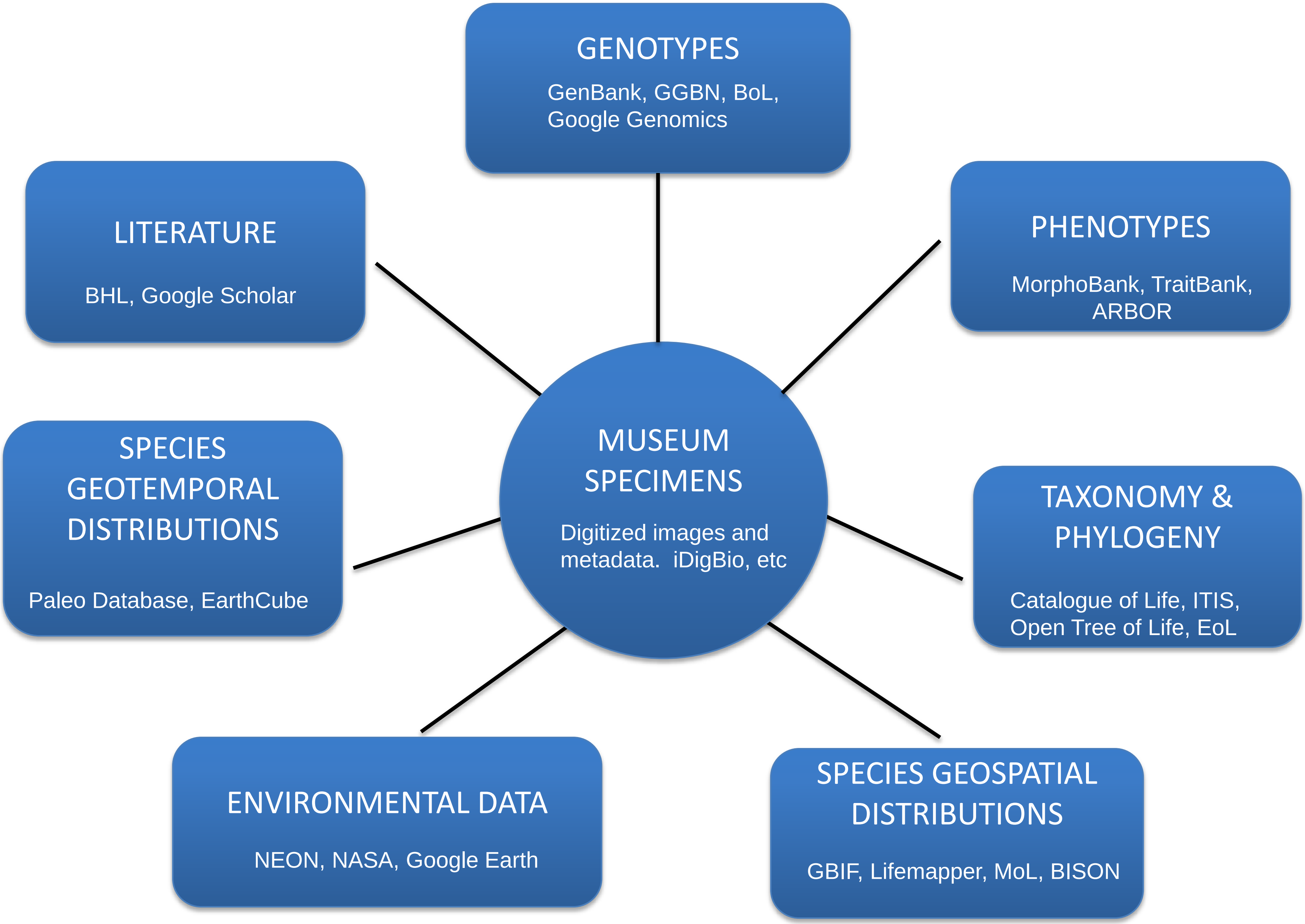
Reconstructing the Tree of Life: for all living and extinct species, using molecular and phenotypic data, extant and extinct specimens.

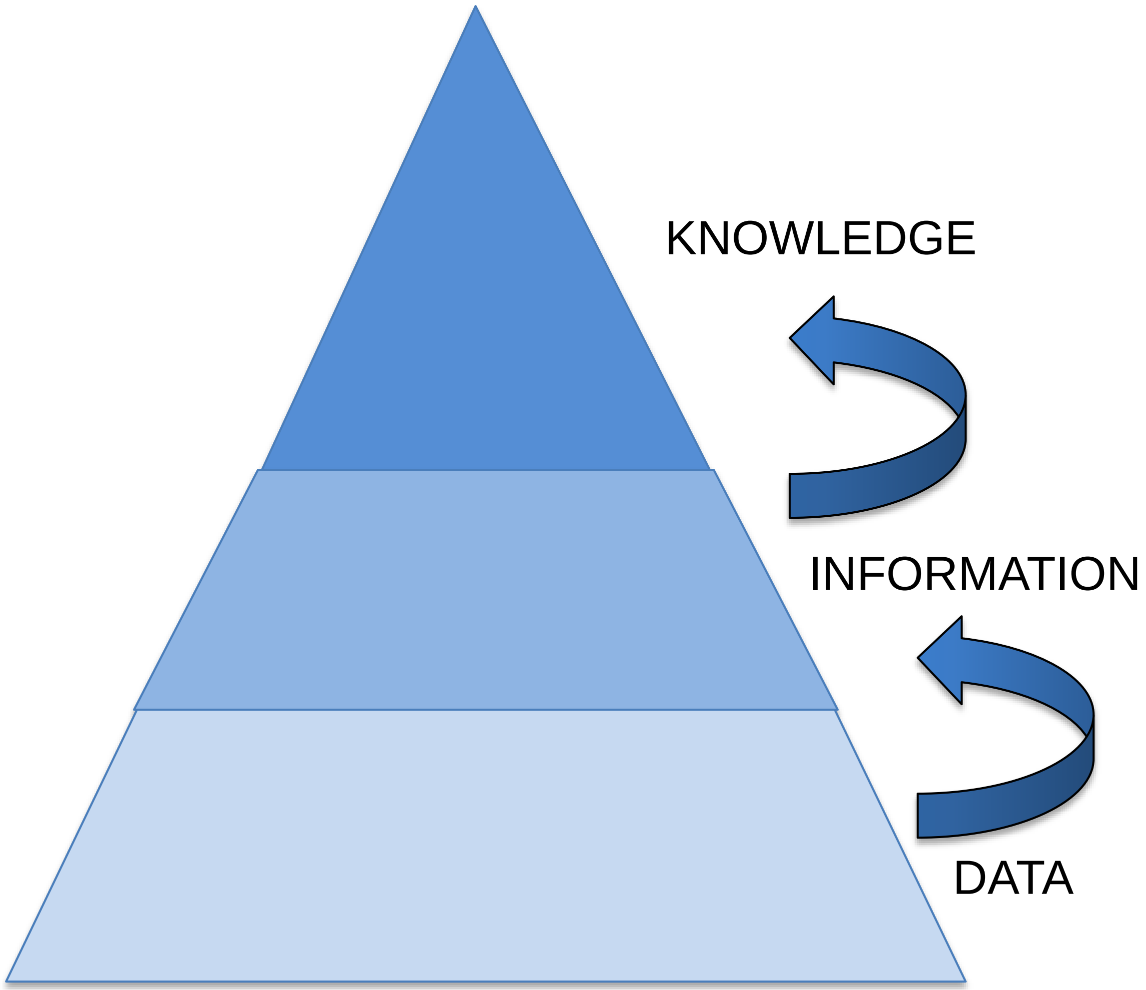
Understanding the Co-evolution of Earth-life systems: study of relationship between history of life on Earth and the history of the planet.

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
LITERATURE
BHL, Google Scholar
PHENOTYPES
MorphoBank, TraitBank, ARBOR
SPECIES GEOTEMPORAL DISTRIBUTIONS
Paleo Database, EarthCube
MUSEUM SPECIMENS
Digitized images and metadata. iDigBio, etc
TAXONOMY & PHYLOGENY
Catalogue of Life, ITIS, Open Tree of Life, EoL
ENVIRONMENTAL DATA
NEON, NASA, Google Earth
SPECIES GEOSPATIAL DISTRIBUTIONS
GBIF, Lifemapper, MoL, BISON


KNOWLEDGE
INFORMATION
DATA

nature ecology & evolution

PERSPECTIVE

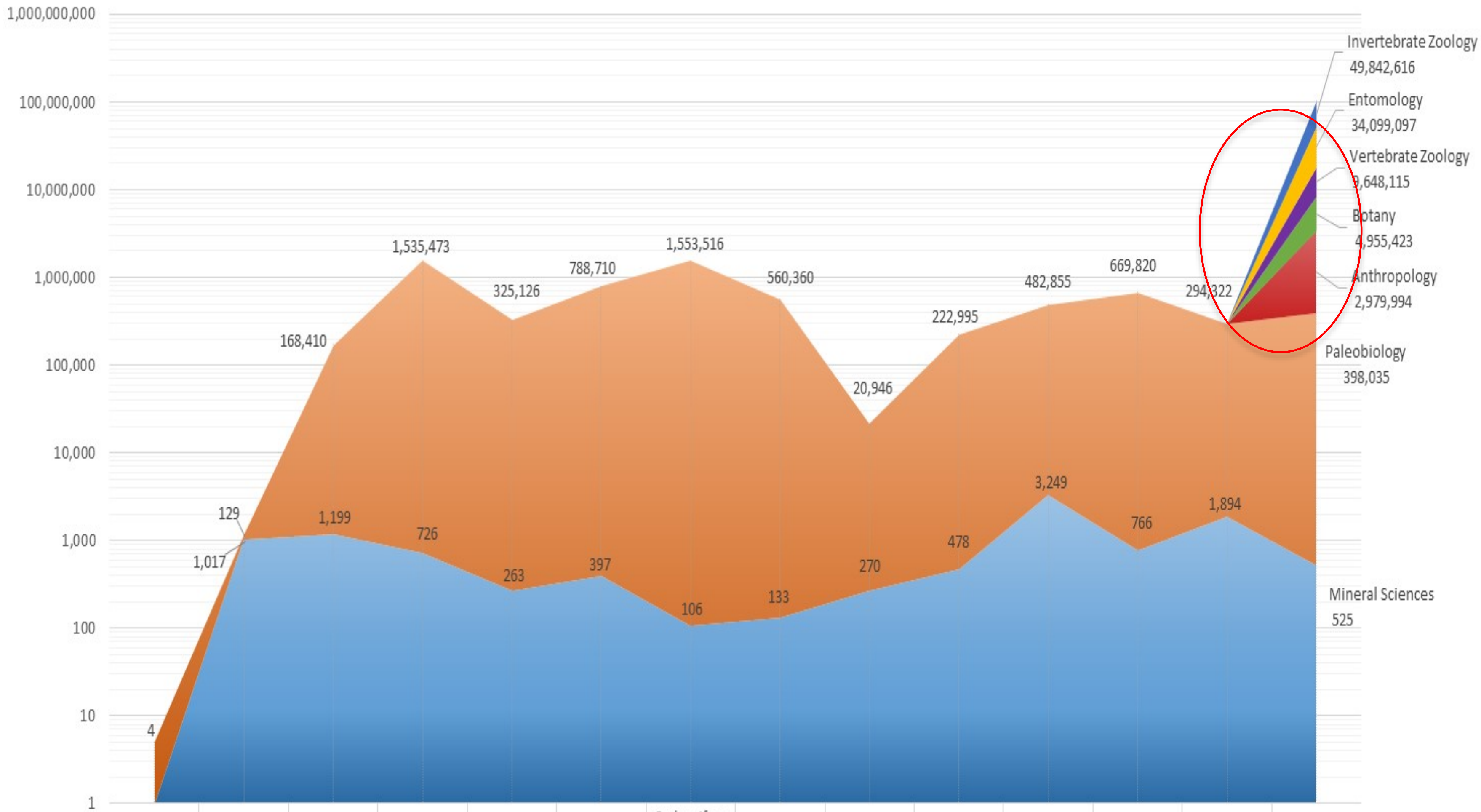
PUBLISHED: 23 MAY 2017 | VOLUME: 1 | ARTICLE NUMBER: 0165

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

Charles R. Marshall

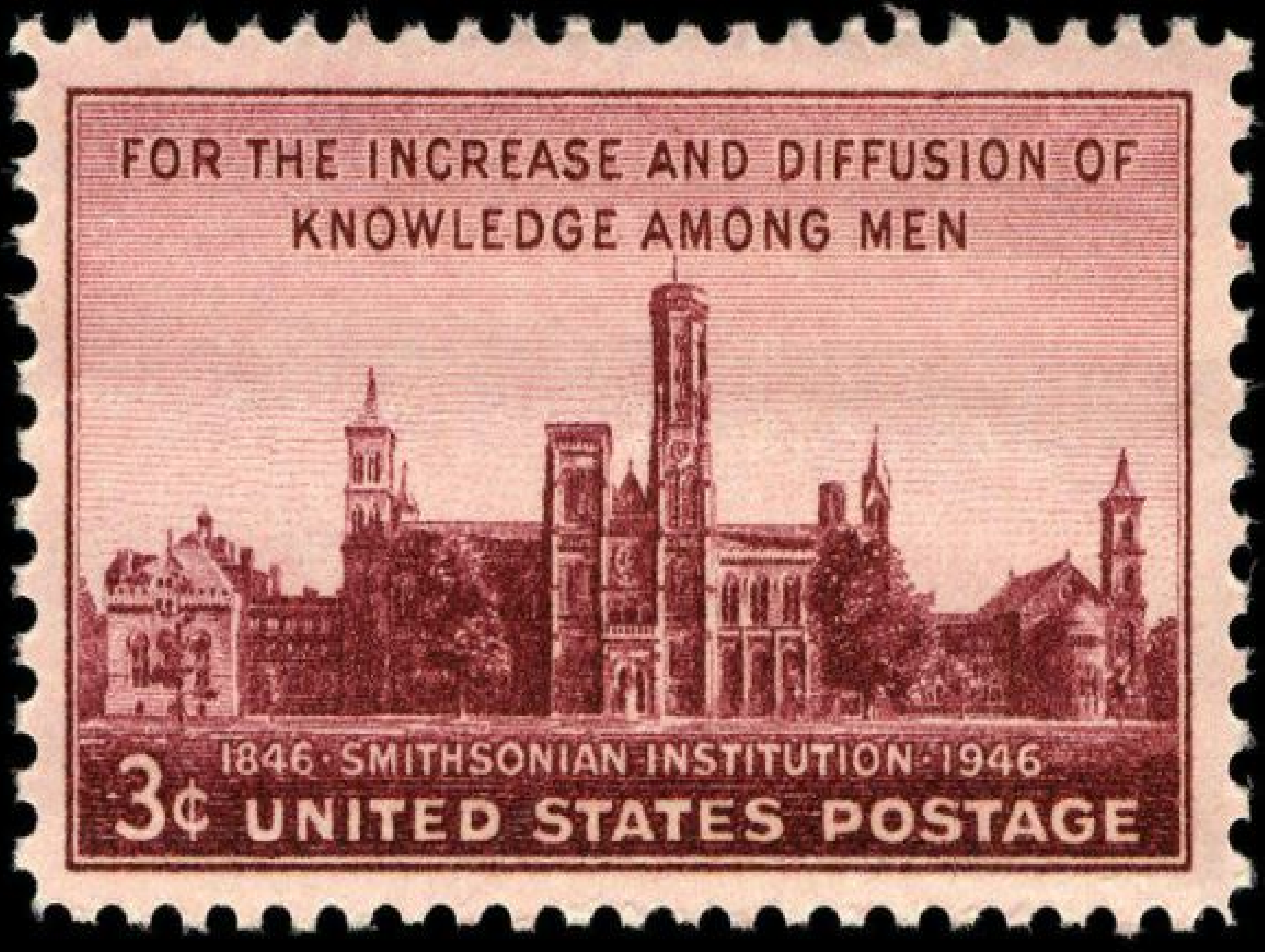
The foundations of several disciplines can be expressed as simple quantitative laws, for example, Newton's laws or the laws of thermodynamics. Here I present five laws derived from fossil data that describe the relationships among species extinction and longevity, species richness, origination rates, 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.

Collection Items Through Geologic Time



	Archaean	Proterozoic	Cambrian	Ordovician	Silurian	Devonian	Carboniferous	Permian	Triassic	Jurassic	Cretaceous	Paleogene	Neogene	Quaternary
Invertebrate Zoology	-	-	-	-	-	-	-	-	-	-	-	-	-	49,842,616
Entomology	-	-	-	-	-	-	-	-	-	-	-	-	-	34,099,097
Vertebrate Zoology	-	-	-	-	-	-	-	-	-	-	-	-	-	9,648,115
Botany	-	-	-	-	-	-	-	-	-	-	-	-	-	4,955,423
Anthropology	-	-	-	-	-	-	-	-	-	-	-	-	-	2,979,994
Paleobiology	4	129	168,410	1,535,473	325,126	788,710	1,553,516	560,360	20,946	222,995	482,855	669,820	294,322	398,035
Mineral Sciences	1	1,017	1,199	726	263	397	106	133	270	478	3,249	766	1,894	525

Nov 28, 2016 v. 1.0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KNOWLEDGE AMONG MEN
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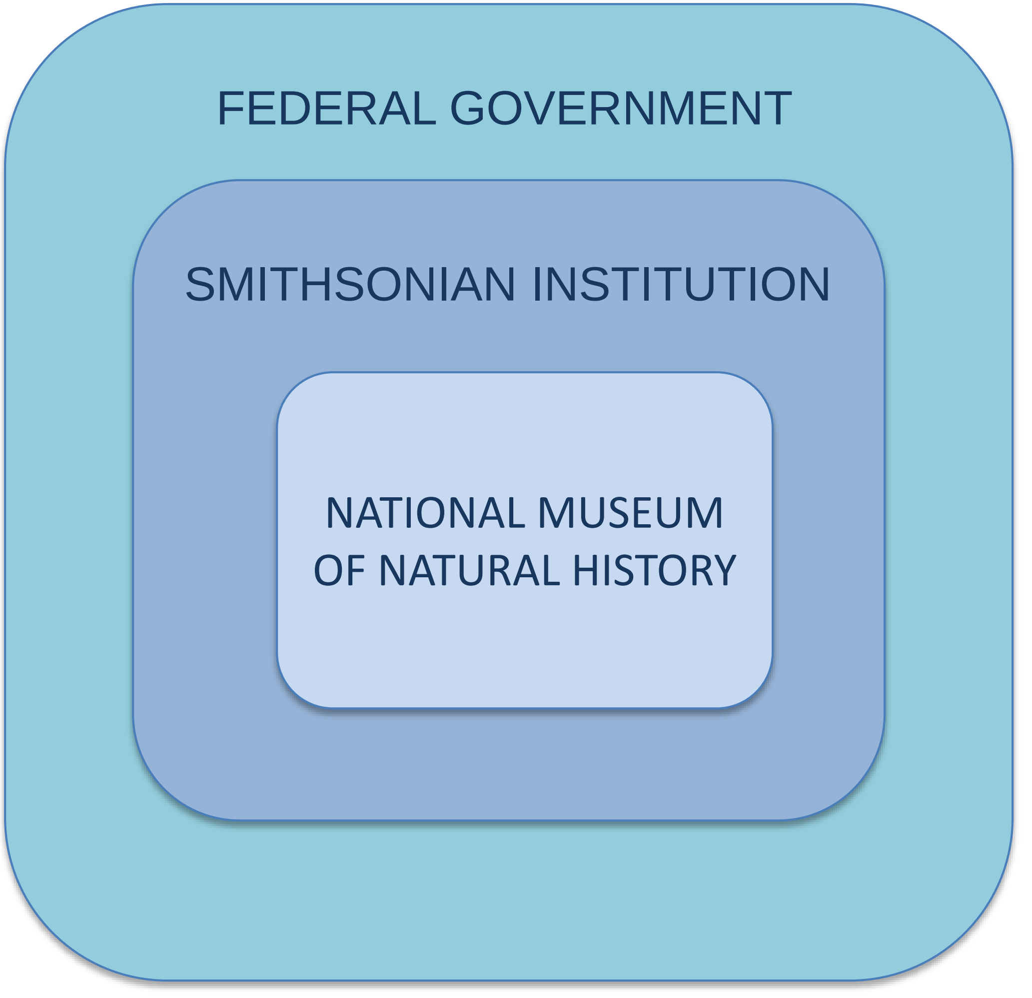
3¢ UNITED STATES POSTAGE

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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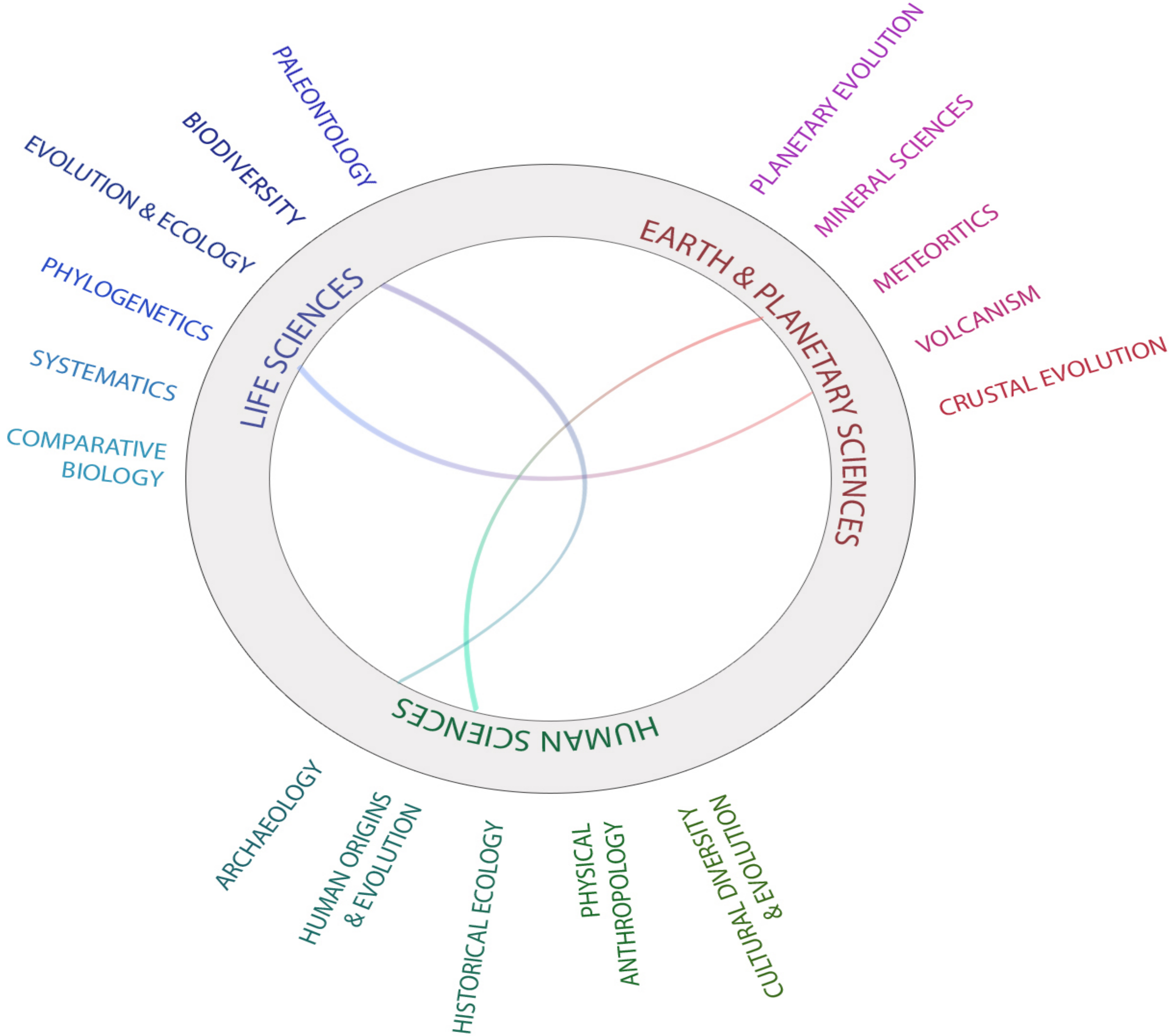
Major Science Themes Address Our Diverse and Changing Planet:

- 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


LIFE SCIENCES
EARTH & PLANETARY SCIENCES
HUMAN SCIENCES
PALEONTOLOGY
BIODIVERSITY
EVOLUTION & ECOLOGY
PHYLOGENETICS
SYSTEMATICS
COMPARATIVE BIOLOGY
PLANETARY EVOLUTION
MINERAL SCIENCES
METEORITICS
VOLCANISM
CRUSTAL EVOLUTION
ARCHAEOLOGY
HUMAN ORIGINS & EVOLUTION
HISTORICAL ECOLOGY
PHYSICAL ANTHROPOLOGY
CULTURAL DIVERSITY & EVOLUTION

GLOBAL GENOME INITIATIVE

Encyclopedia of Life

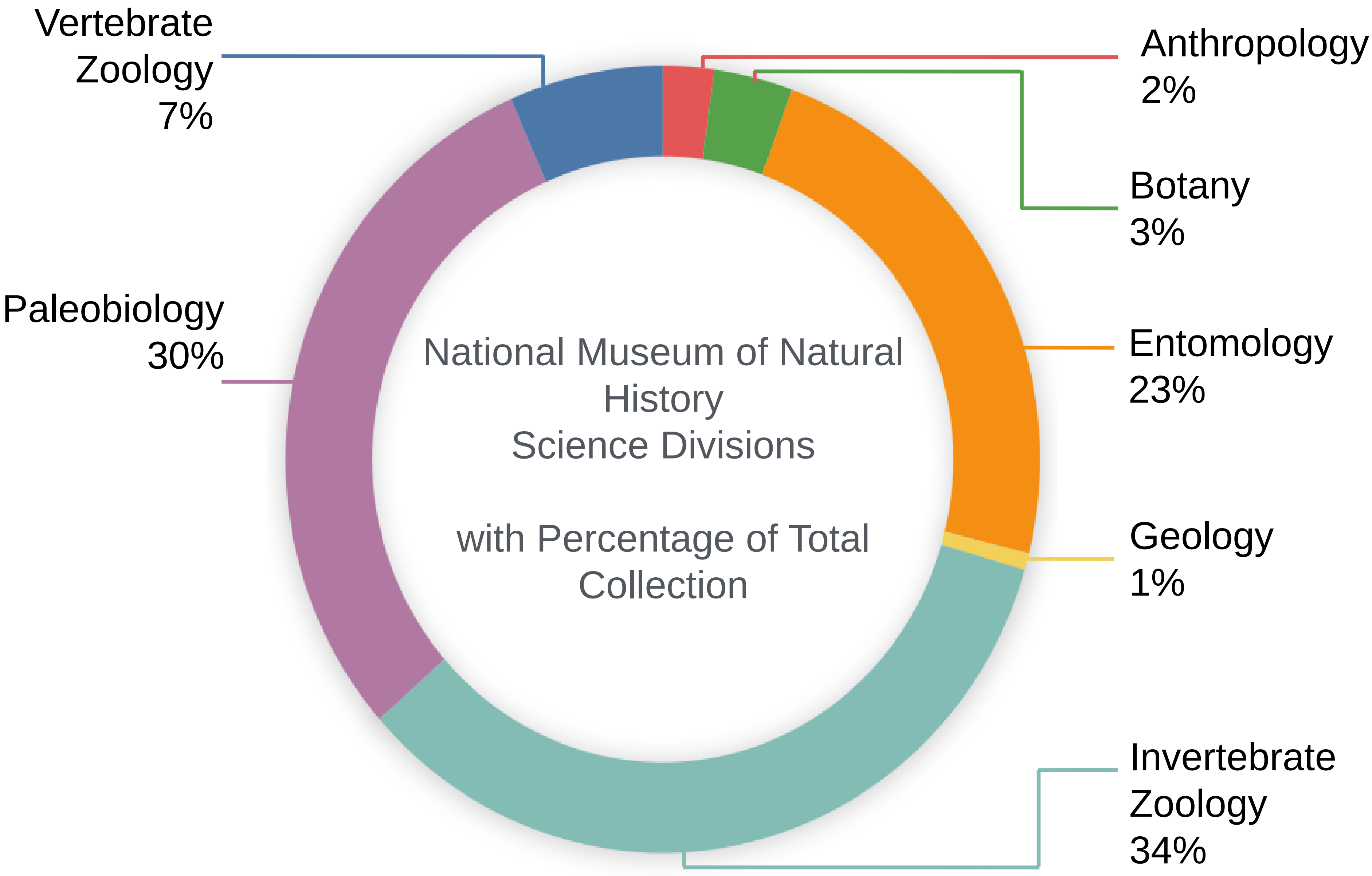
ITIS

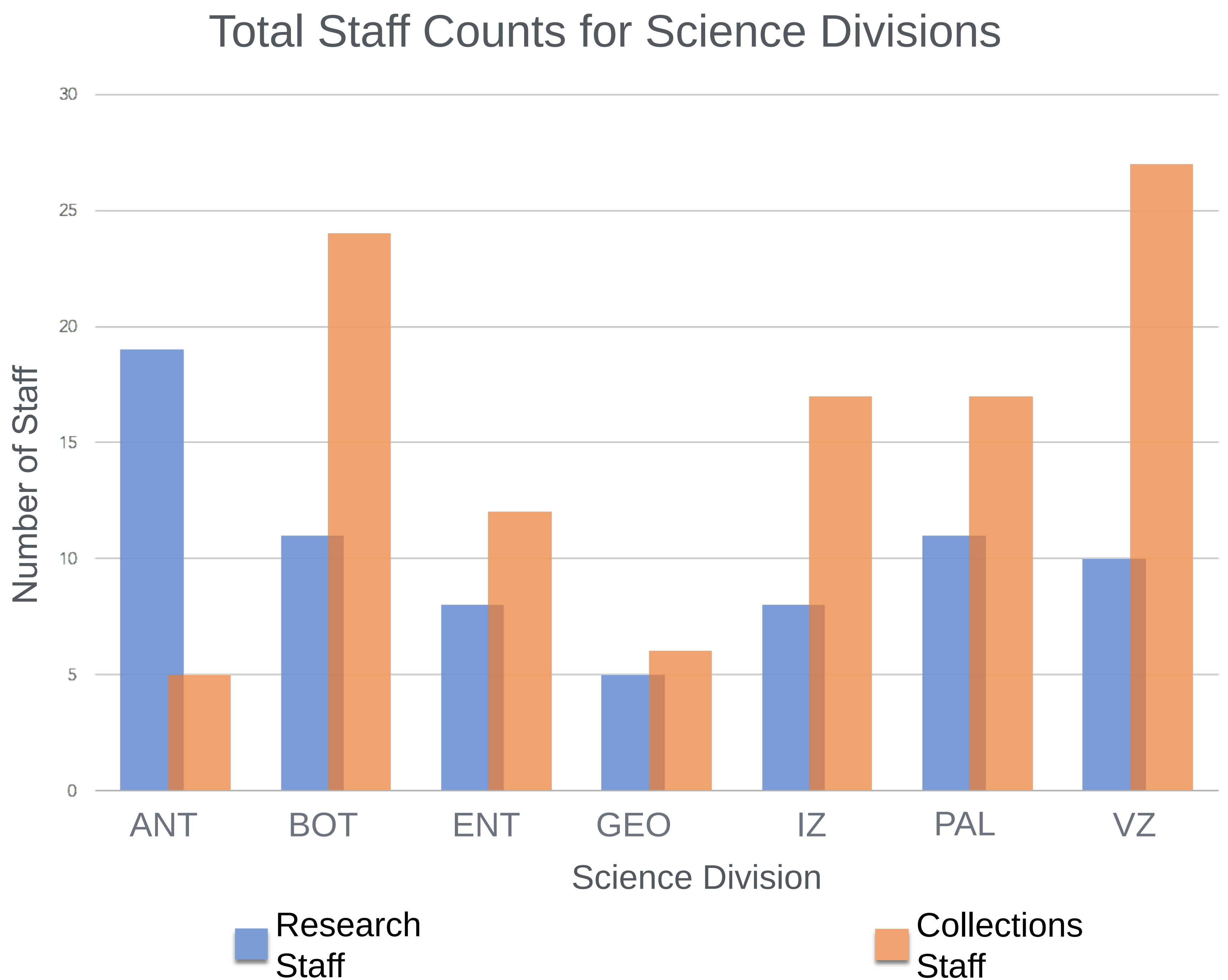
BHL

Biodiversity Heritage Library

Smithsonian Digitization Program Office

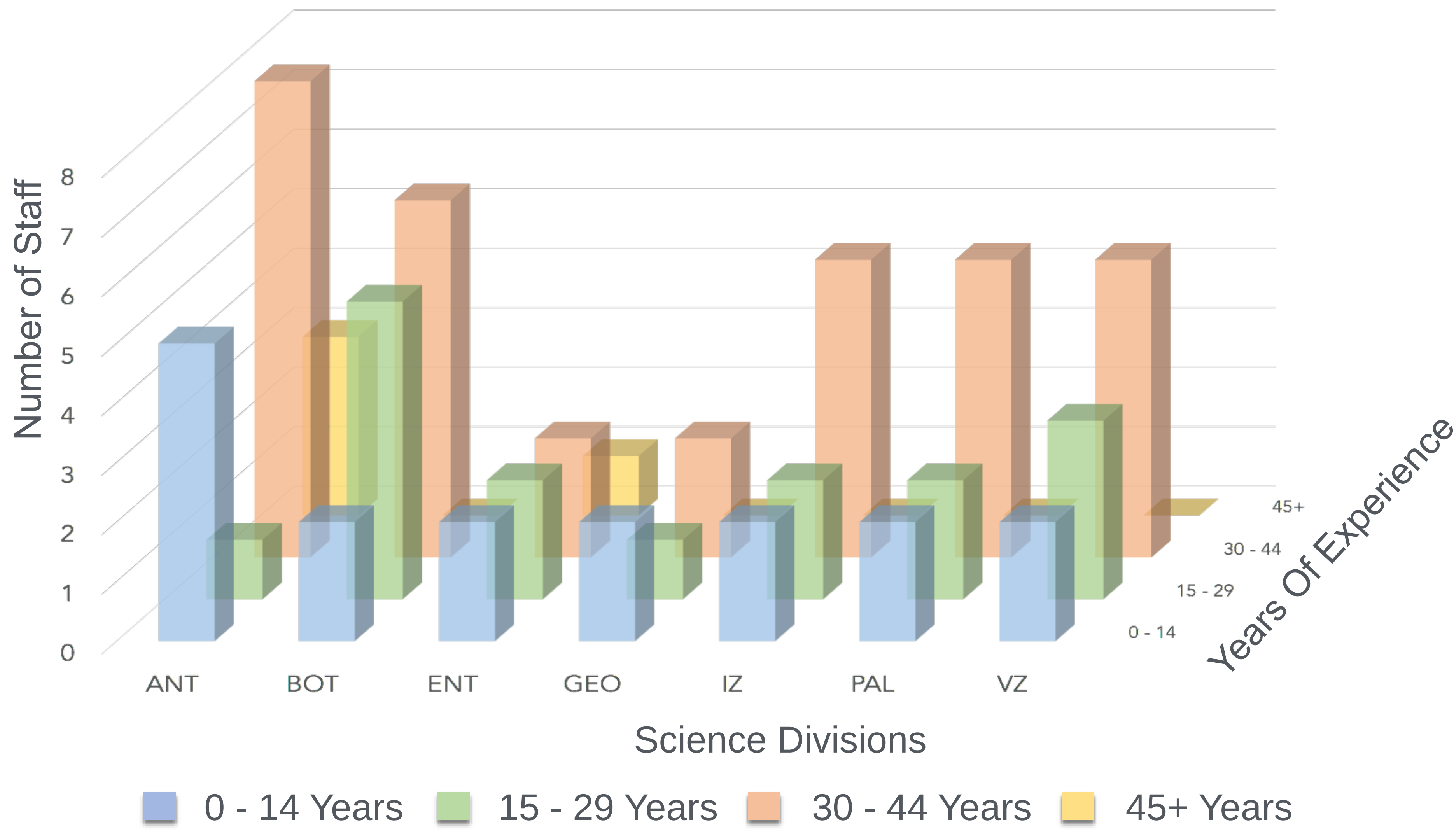
An Emerging Strategy for NMNH Science


Vertebrate Zoology 7%
Anthropology 2%
Botany 3%
Paleobiology 30%
Entomology 23%
National Museum of Natural History
Science Divisions
with Percentage of Total Collection
Geology 1%
Invertebrate Zoology 34%

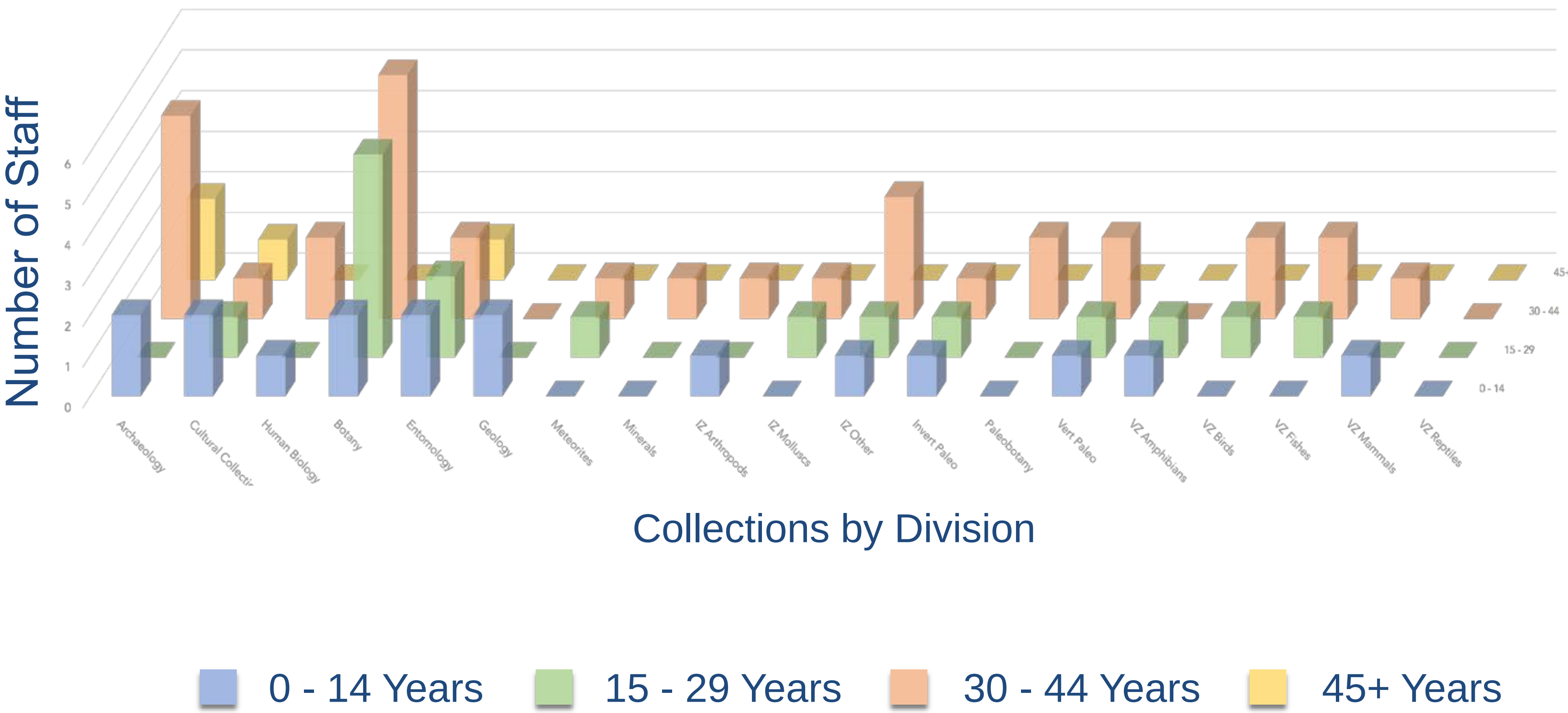


Total Staff Counts for Science Divisions
Number of Staff
0
5
10
15
20
25
30
ANT
BOT
ENT
GEO
IZ
PAL
VZ
Science Division
Research Staff
Collections Staff

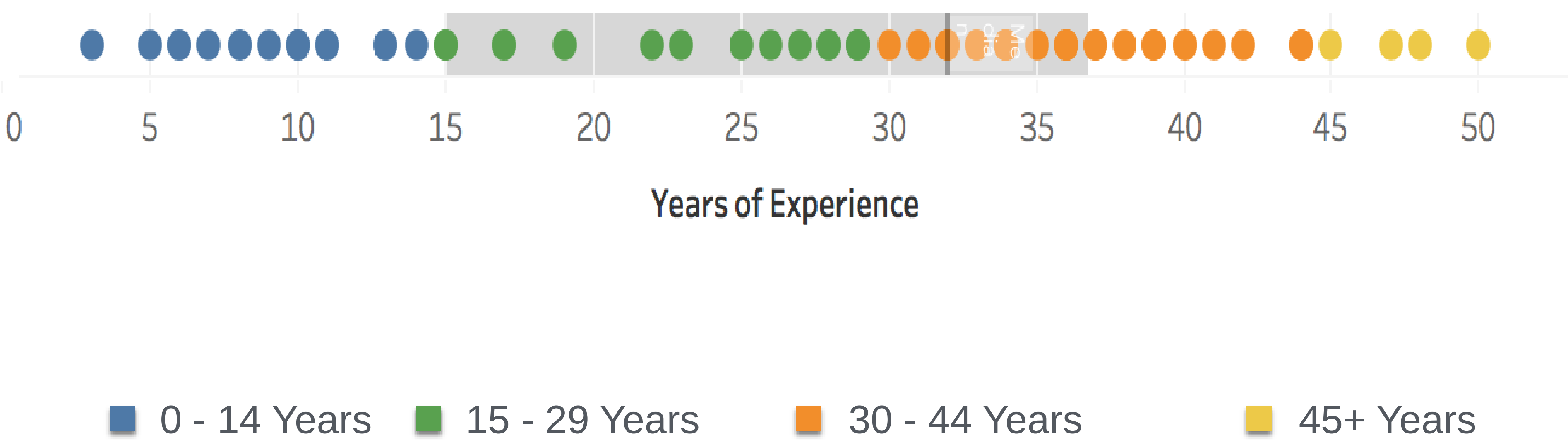
Distribution of Research Experience Across Science Divisions



Distribution of Research Experience Across Collections



Median Years of Experience for NMNH= 31.5 years



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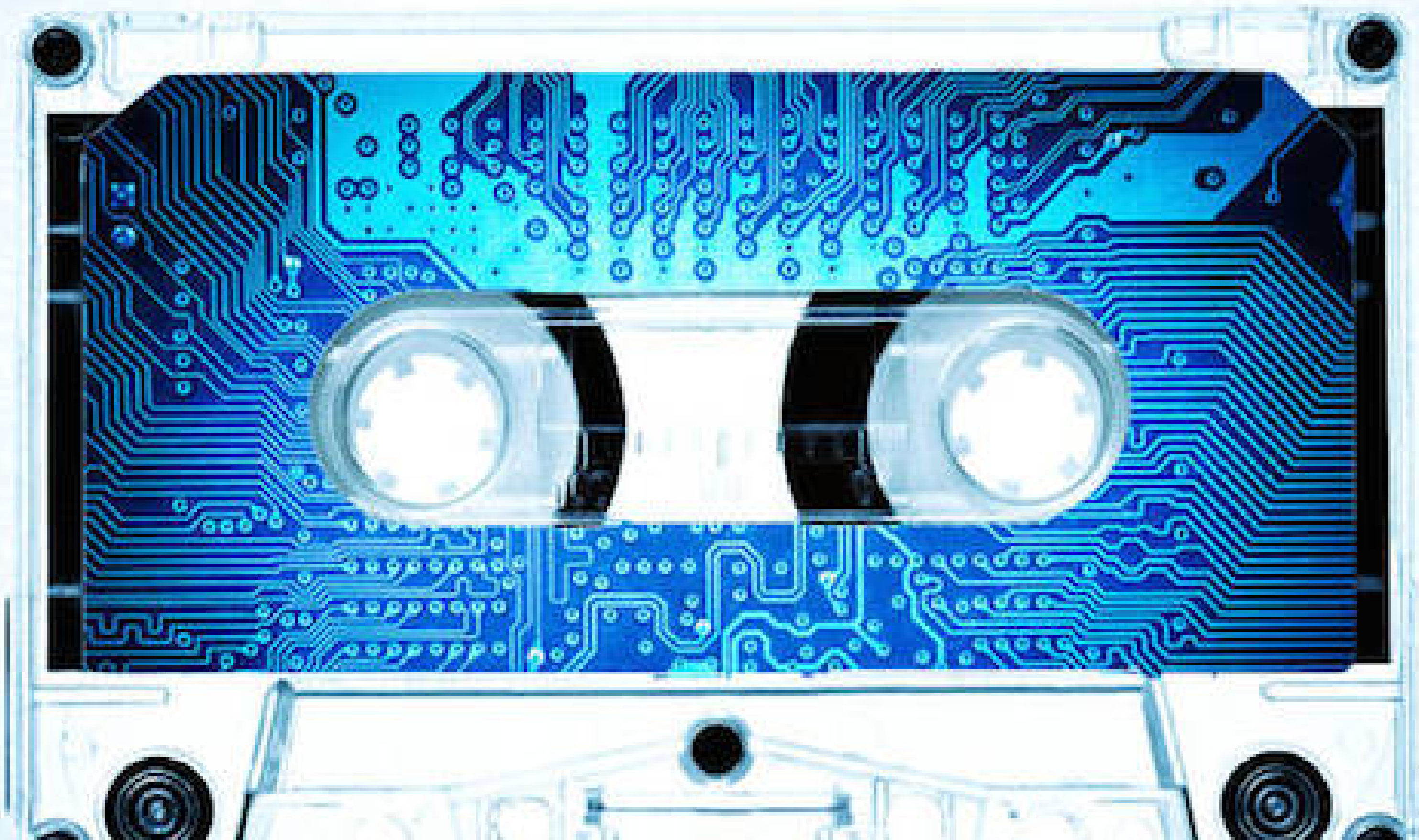
analog in a | DIGITAL WORLD

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THELONIOUS MONK CRISS-CROSS
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