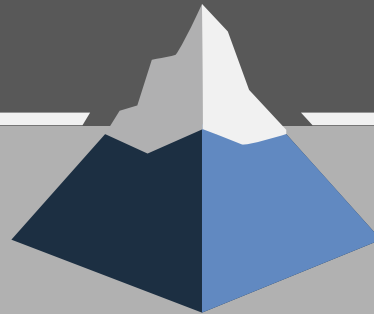


EARTH BIOGENOME PROJECT

SEQUENCING LIFE FOR THE FUTURE OF LIFE



i5K Update

GENE E. ROBINSON

CARL R. WOESE INSTITUTE FOR GENOMIC BIOLOGY
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

3 APRIL 2019

A GRAND CHALLENGE

Sequence the DNA of all life on Earth in 10 years

A GRAND VISION

Create a new foundation for science to drive solutions for preserving biodiversity and sustaining human societies.



Earth BioGenome Project: Sequencing life for the future of life

Harris A. Lewin, Gene E. Robinson, W. John Kress, William J. Baker, Jonathan Coddington, Keith A. Crandall, Richard Durbin, Scott V. Edwards, Félix Forest, M. Thomas P. Gilbert, Melissa M. Goldstein, Igor V. Grigoriev, Kevin J. Hackett, David Haussler, Erich D. Jarvis, Warren E. Johnson, Aristides Patrinos, Stephen Richards, Juan Carlos Castilla-Rubio, Marie-Anne van Sluys, Pamela S. Soltis, Xun Xu, Huanming Yang, and Guojie Zhang

PNAS April 24, 2018. 115 (17) 4325-4333; published ahead of print April 24, 2018.

<https://doi.org/10.1073/pnas.1720115115>

“The sixth great extinction spasm of geological time is upon us.”

E.O. Wilson, *The Diversity of Life*



20,000
endangered species

Audacious Goal: Sequencing all life

“To sequence everything in the world—that is the reason we are here.”

Huanming Yang, quoted by Elizabeth Pennisi
Science, February 24, 2017



0.3%
species sequenced

WHY SEQUENCE LIFE?

Conserve, protect, and restore biodiversity

Revolutionize biology

Create new benefits for society and human welfare

Genomes are books of life:
They reveal the past,
encode the present,
and hint at the future.



UNLOCK THE FULL **POWER OF GENOME SCIENCE**

Biological synthetic fuels

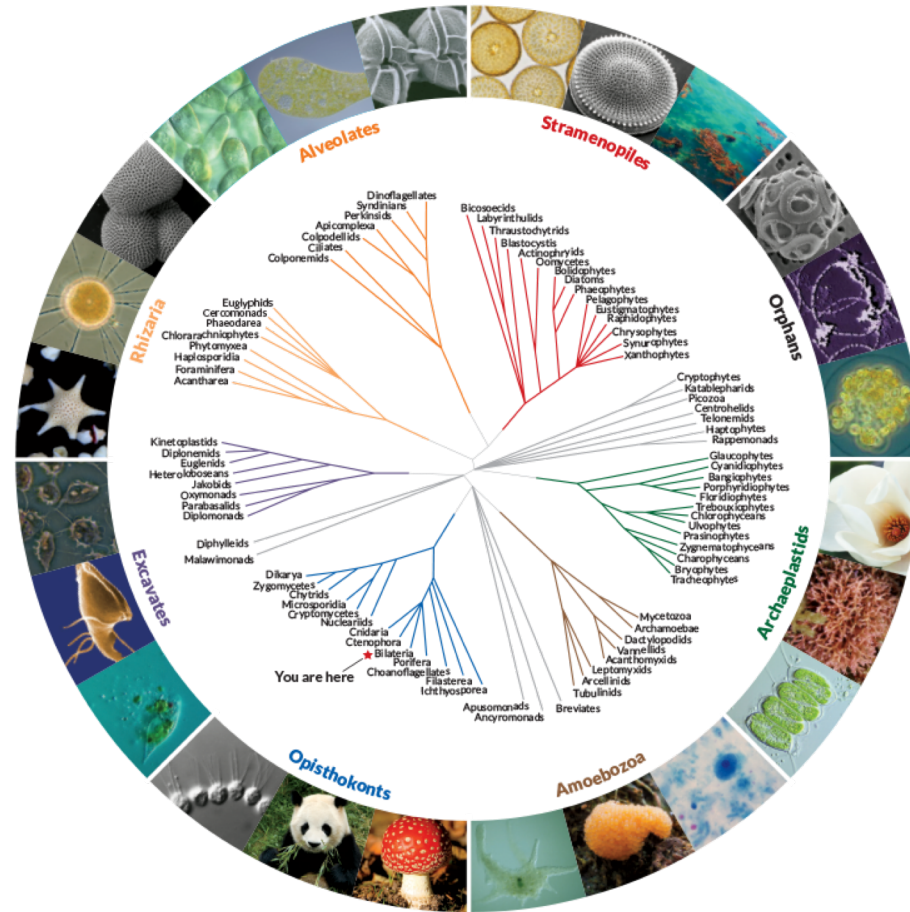
New approaches to feeding the world

New tools for conservation

Drugs to reverse aging

New treatments for both infectious and inherited diseases

Revise and Reinvigorate Our Understanding of Biology and Evolution



Source: F. Burki/Cold Spring Harbor
Perspectives in Biology 2014

Maximize Returns to Society and Human Welfare



Medicines from Nature: Examples

▶ Terrestrial Plants (>390,000 species)

Quinine: Chinchona bark (*Chinchona officialinis*)

Artemisinin: Sweet wormwood (*Artemisia annua*)

Morphine: Opium poppy (*Papaver somniferum*)

Vinca alkaloids: Madagascar Periwinkle
(*Catharanthus roseus*) vincristine & vinblastine

Aspirin: many plants, especially willows and spireas; produce salicylic acid (later synthesized)

Sweet Clover: *Melilotus spp.*; coumarin (converted to dicoumarol by molds) – a powerful anticoagulant. Led to use as a rodenticide (Warfarin)



Tu Youyou

2015 Nobel Prize in Physiology or Medicine
Discovery of Artemisinin (treatment for malaria)

Medicines from Nature: Examples

- ▶ Marine Organisms (>20,000 species of marine invertebrates)

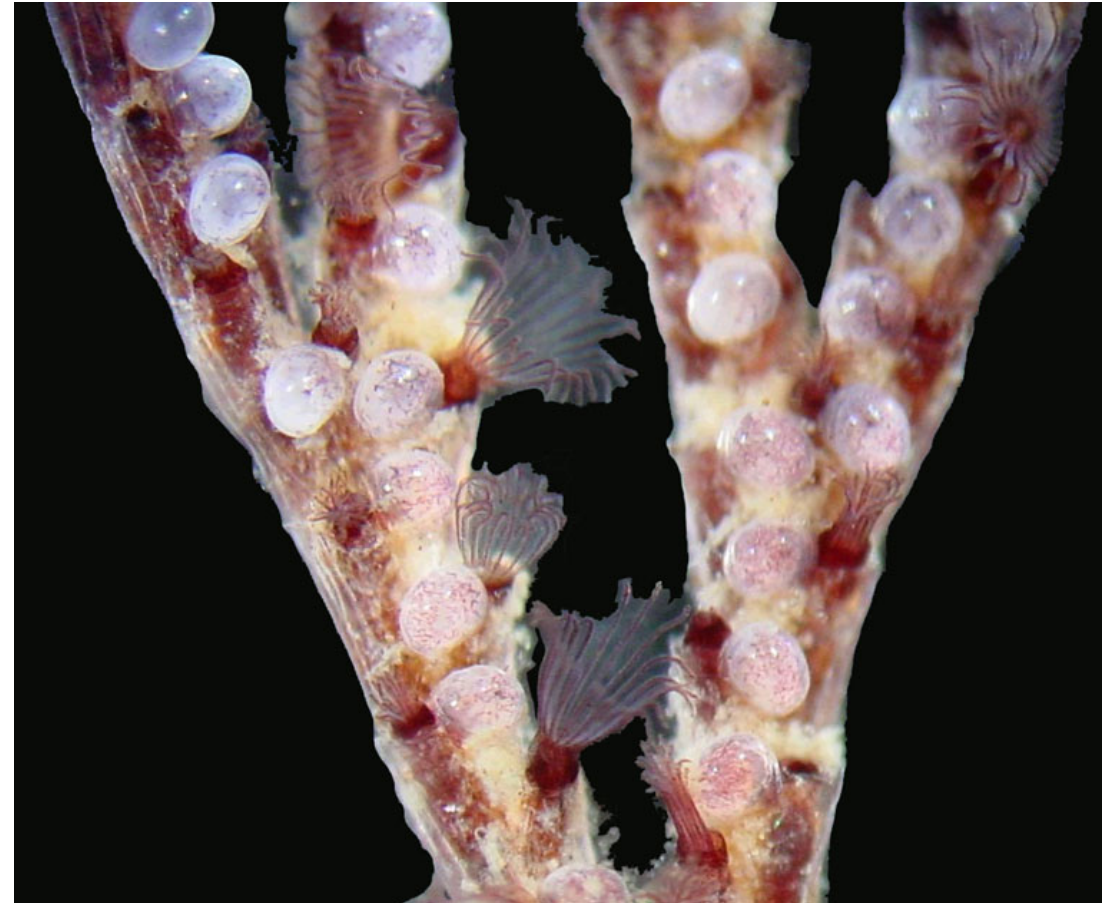
Bryostatin-I (*Bugula neritina*)
Potent anti-cancer agent

Activator of immune system

Cytarabine (*Cryptotethya crypta*)

Treatments for leukemias and lymphomas

AZT - first anti-HIV/AIDS drug



Bugula neritina

Medicines from Nature: Examples

▶ Fungi (*Penicillium citrinum*)

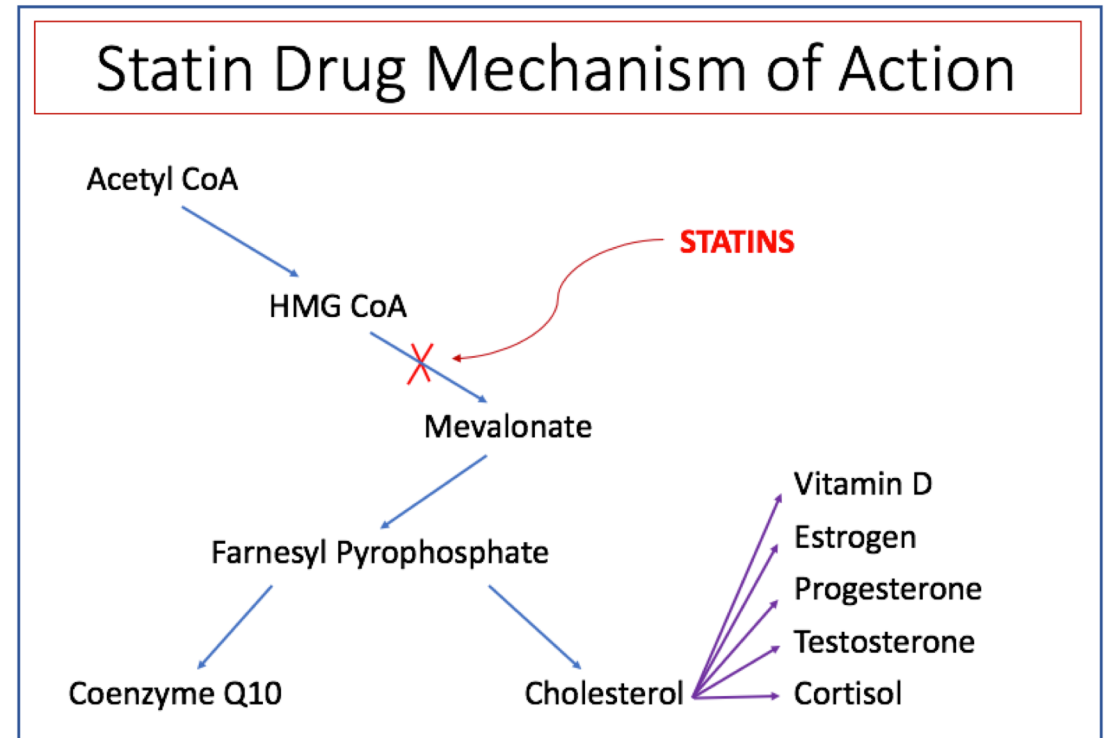
>5 million species of fungi

Statins (e.g., mevastatin)



Used to treat hypercholesterolemia

Significantly reduces deaths from heart attacks and strokes due to atherosclerosis



New Sources of Genetic Variation for Agriculture

- ▶ 12 plant species provide ~75% of total food supply
 - ▶ Wheat, rice, corn and potatoes more than all others combined
- ▶ 15 species of mammals and birds provide >90% of livestock and poultry production



Conservation, Protection and Regeneration of Biodiversity

- ▶ Identify genes for resiliency to climate change
- ▶ Mitigate impacts of pollution and habitat encroachment on biodiversity
- ▶ Develop evidence-based conservation plans
- ▶ Create genomic resources to restore damaged ecosystems and for de-extinction



marsupials – endangered and extinct



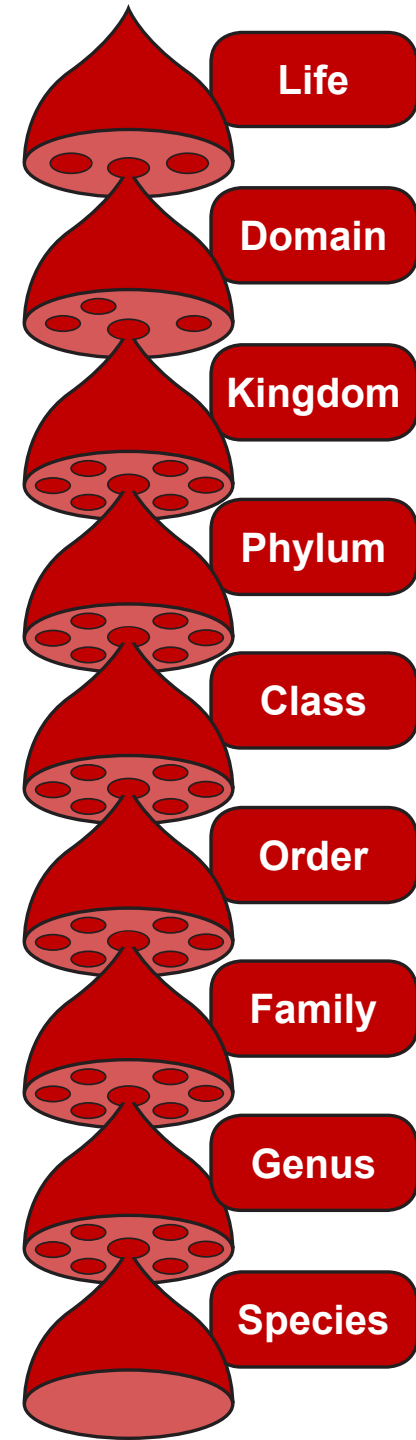
Cheetah



California Condor

EARTH BIOGENOME PROJECT STRATEGY

March through the tree of life

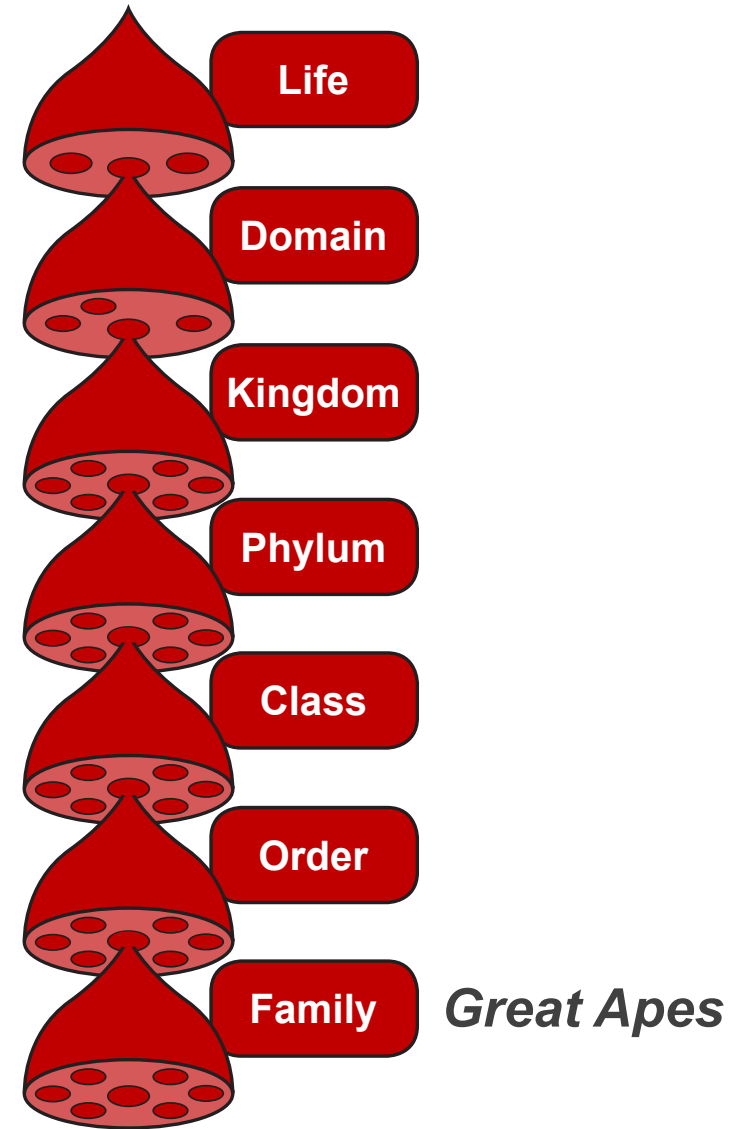


EARTH BIOGENOME PROJECT STRATEGY

Phase 1:

All known families (~9K; reference level)

Years 1-3, **\$500M**



EARTH BIOGENOME PROJECT STRATEGY

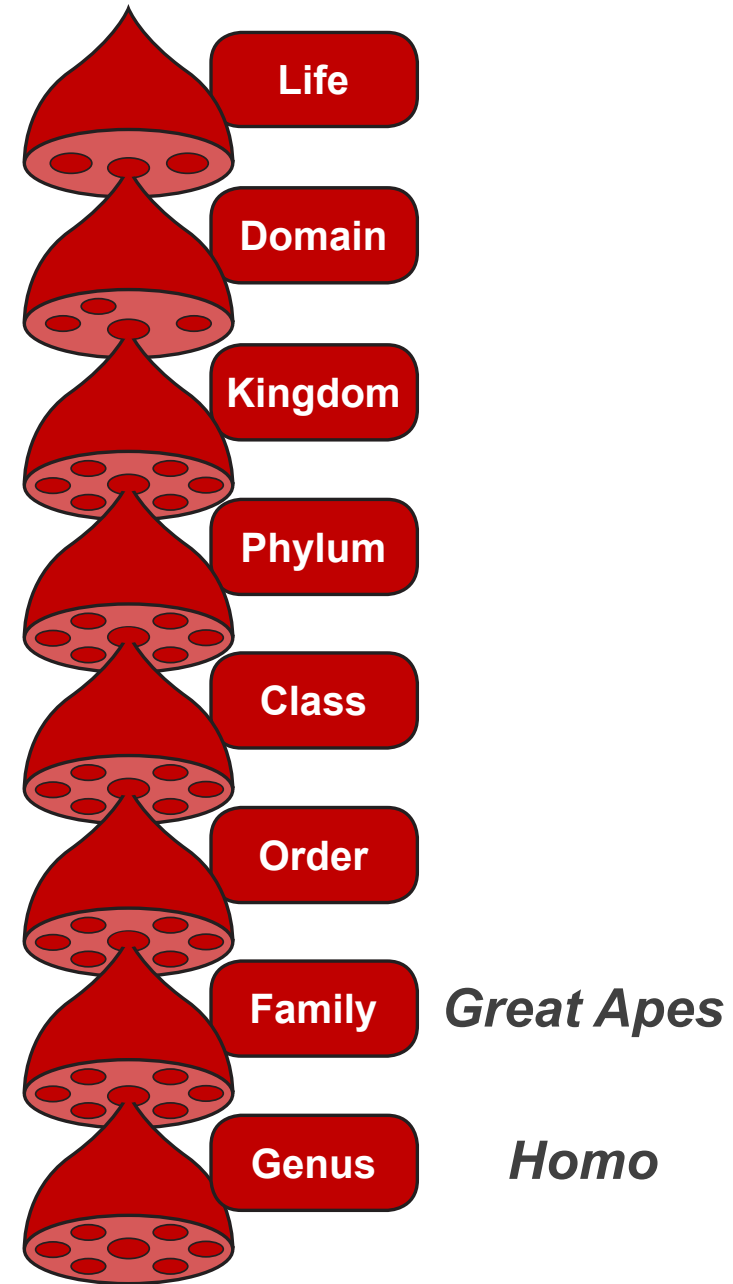
Phase 1:

All known families (~9K; reference level)

Years 1-3, \$500M

Phase 2:

All known genera (140K—200K)



EARTH BIOGENOME PROJECT STRATEGY

Phase 1:

All known families (~9K; reference level)

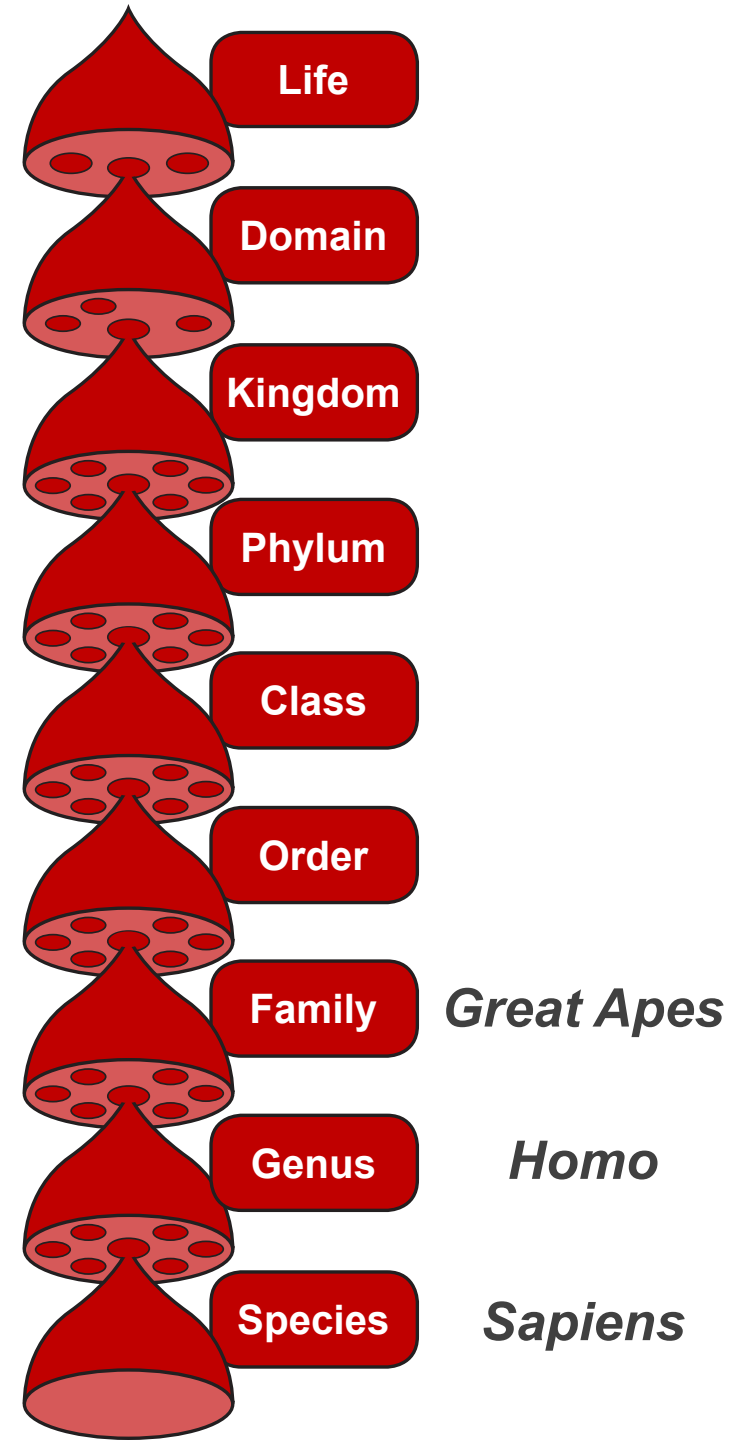
Years 1-3, \$500M

Phase 2:

All known genera (140K—200K)

Phase 3:

All known species (~1.5M)



DISCOVER NEW SPECIES: **ONLY ~10% OF LIFE IS KNOWN**

Sequence all organisms in particular biodiversity hotspots

- Create a new, genomic based, ecology
- Produce multidimensional, dynamic view of life



FEASIBILITY: CAN BE DONE WITH CURRENT TECHNOLOGY

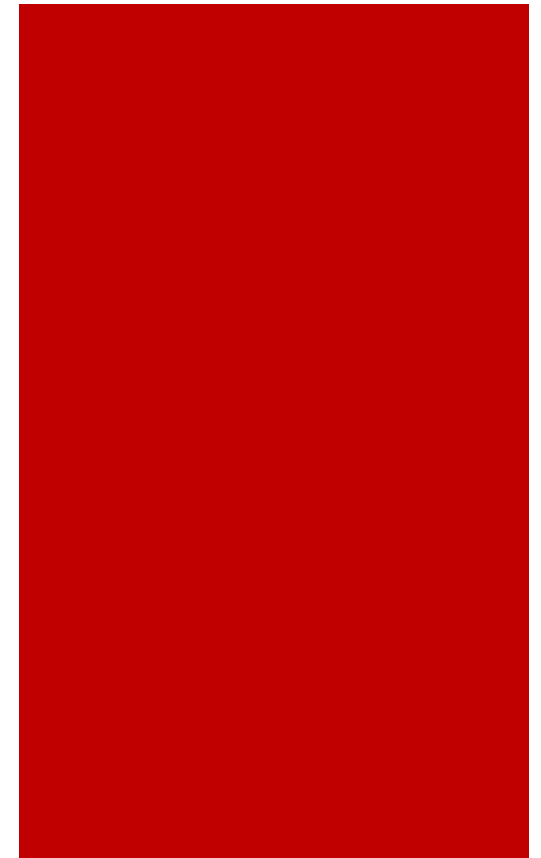
30 machines
1.5M genomes, 10 years



Estimated Cost:
~\$4 billion



Human Genome Project:
\$2.7B
(\$4.8B in 2017 dollars)



EARTH BIOGENOME PROJECT WILL SPUR INNOVATION IN **TECHNOLOGY**

- Sample collection
- Sample identification
- Sample sequencing

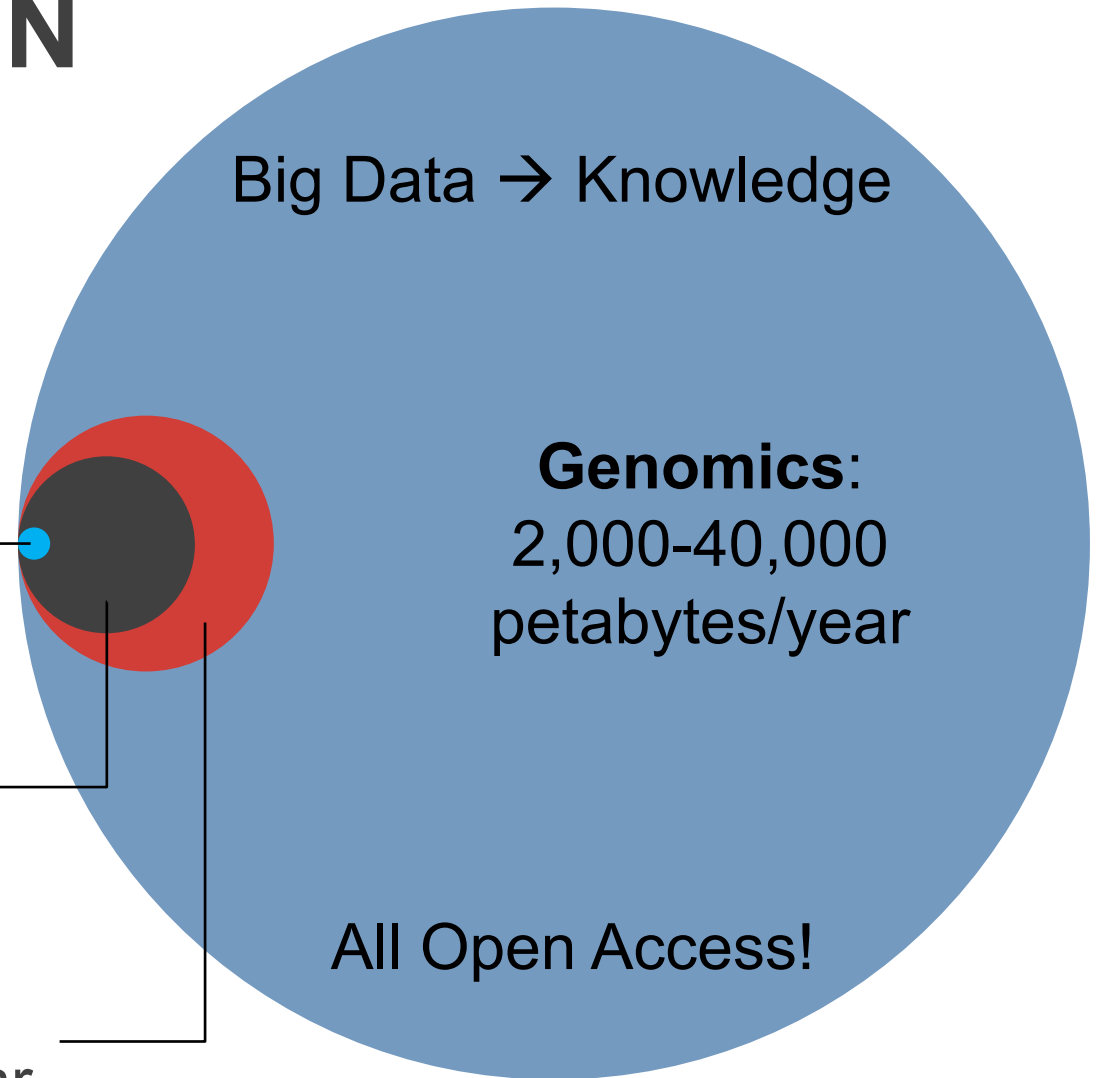


EARTH BIOGENOME PROJECT WILL SPUR INNOVATION IN **COMPUTING**

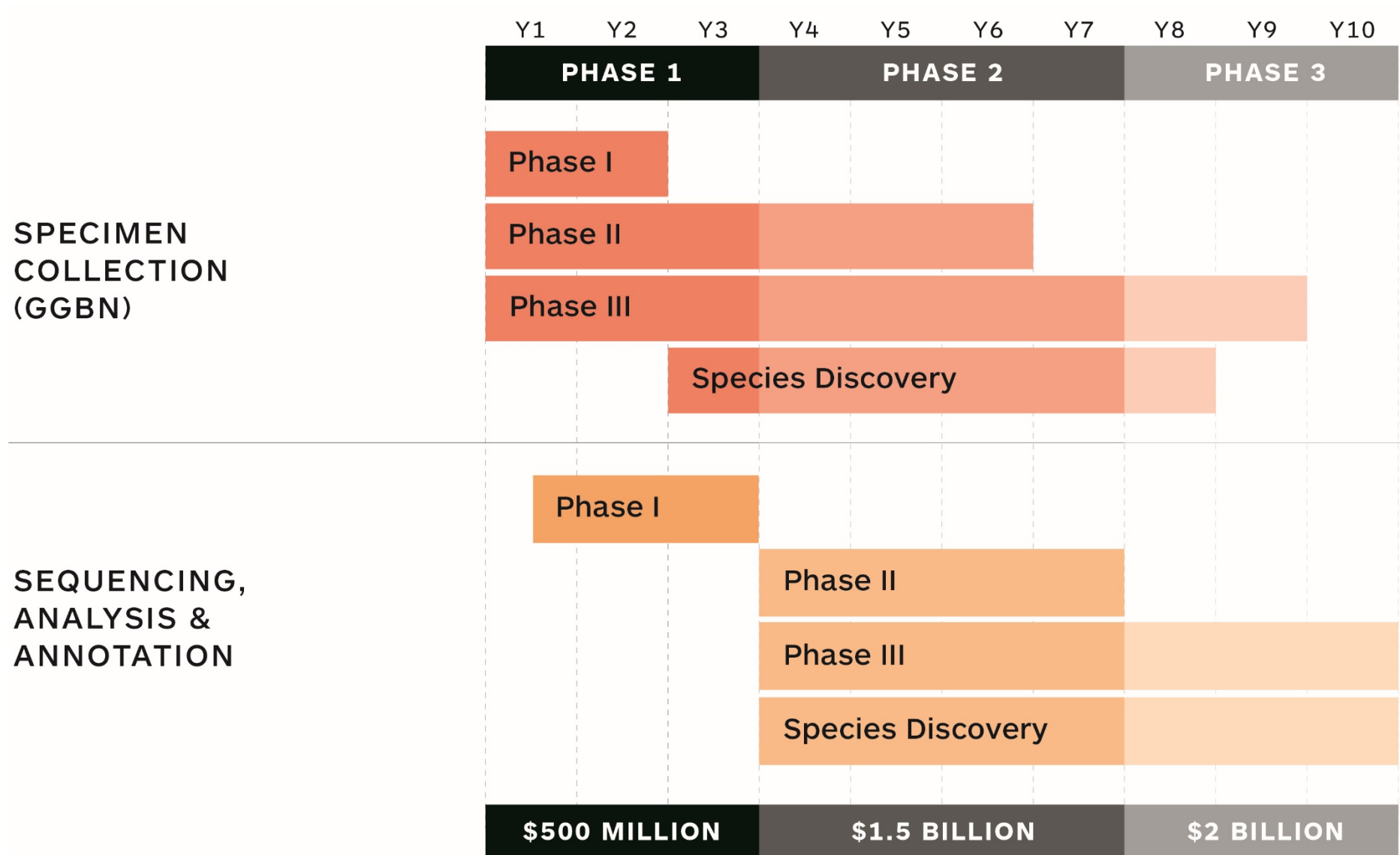
Twitter:
1-17 petabytes/year

Astronomy:
1,000 petabytes/year

YouTube:
1,000-2,000 petabytes/year



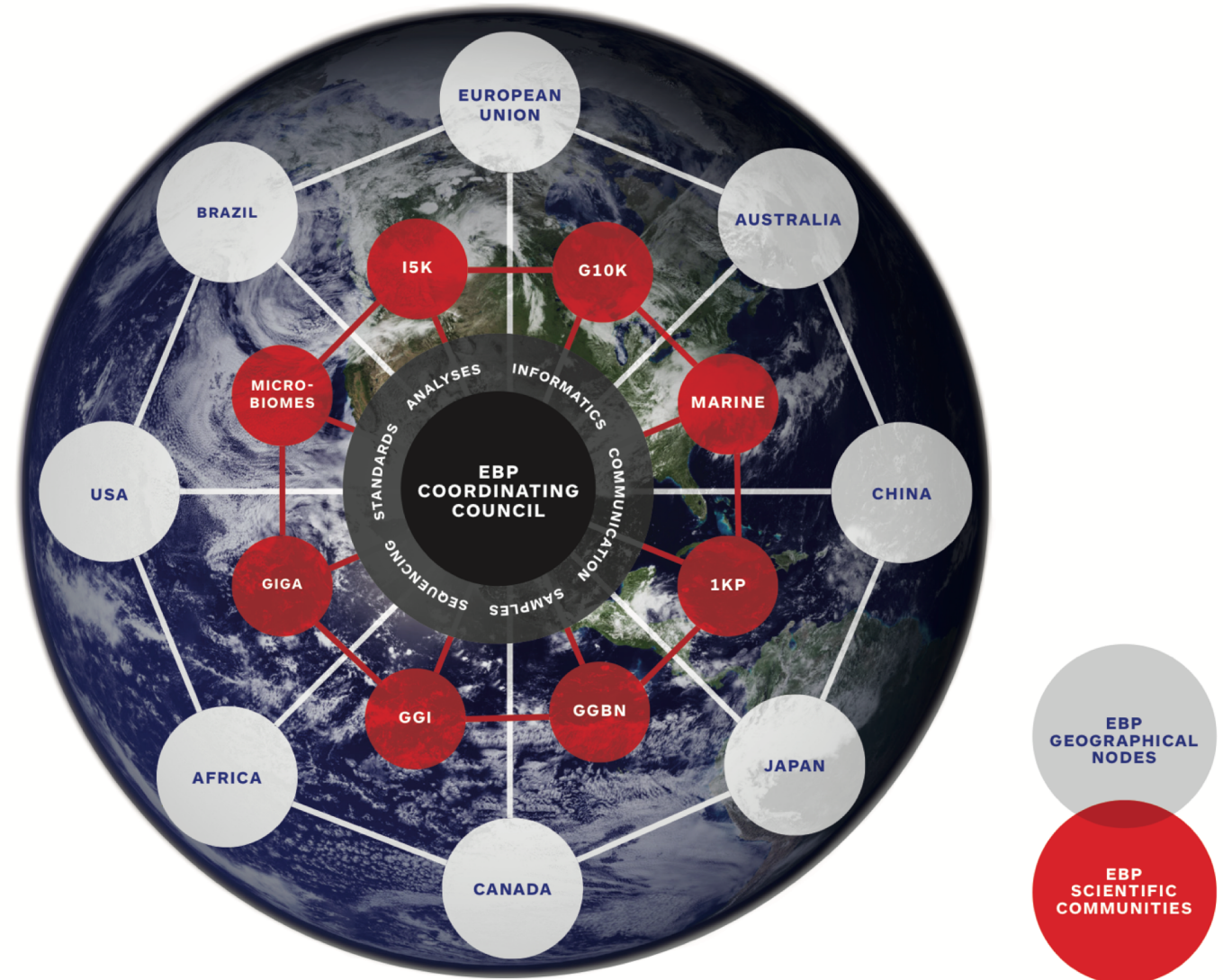
PROJECT ROADMAP



GLOBAL NETWORK OF NETWORKS

Open access

Compliance with the Convention on Biological Diversity and the Nagoya Protocol on Access and Benefit Sharing (ABS)



Participating Institutions



International Consortium Officially Launches Earth BioGenome Project in London November 1, 2018



Thursday, 13 September 2018

VGP announces first data release of 15 reference genomes

Phase 1 VGP Genomes: 1st data release of 15 genomes, 14 species



Mammals
(4 species)



GREATER HORSESHOE BAT



SPEAR-NOSED BAT



CANADIAN LYNX



PLATYPUS



Birds
(3 species)
4 genomes)



ANNA'S HUMMINGBIRD



ZEBRA FINCH
(male) (female)



KAKAPO



Reptiles
(1 species)



GOODE'S DESERT TORTOISE



Amphibians
(1 species)



TWO-LINED CAECILIAN



Fishes
(5 species)



FLIER CICHLID



EASTERN HAPPY



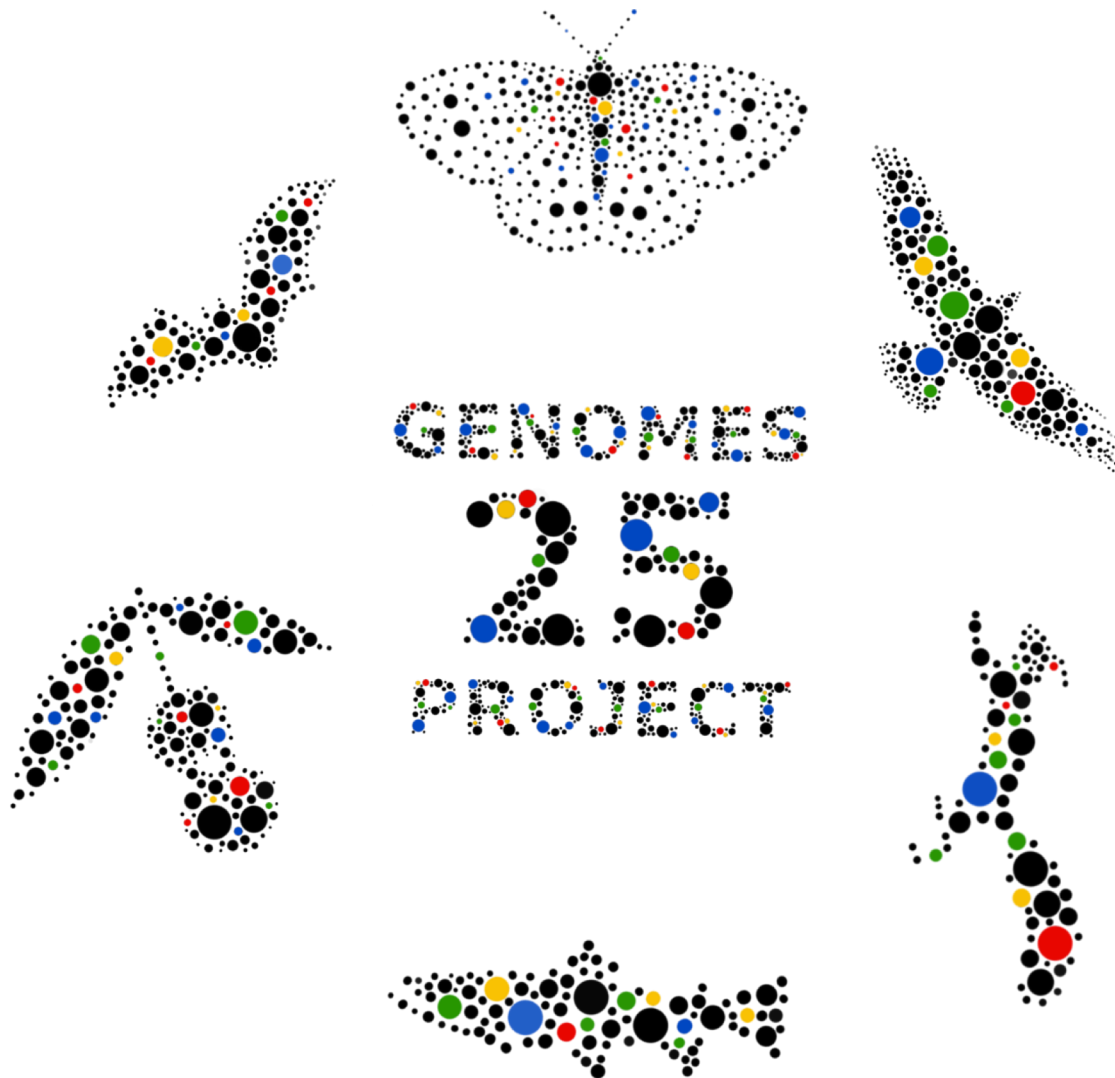
CLIMBING PERCH



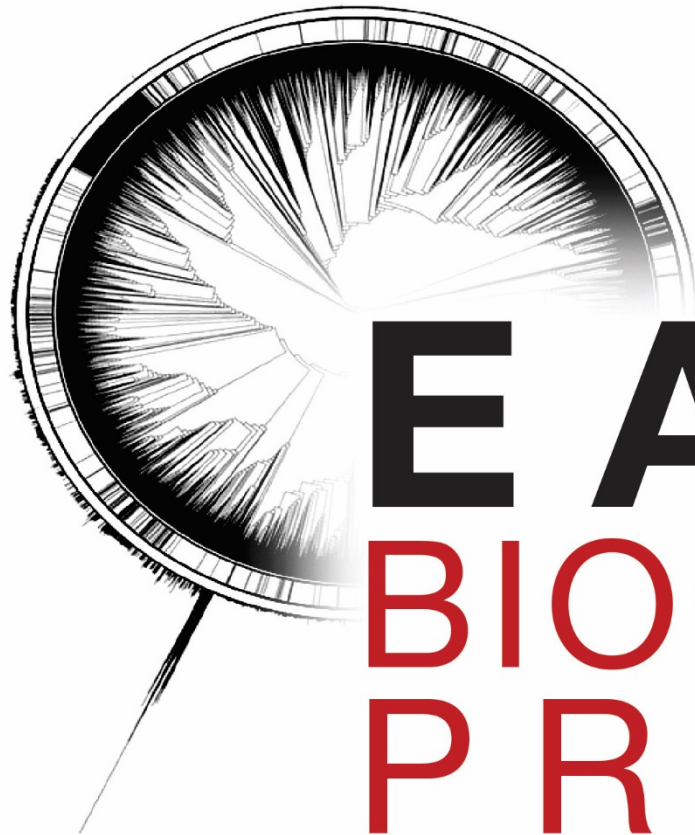
TIRE TRACK EEL



BLUNT-SNOUTED
CLINGFISH

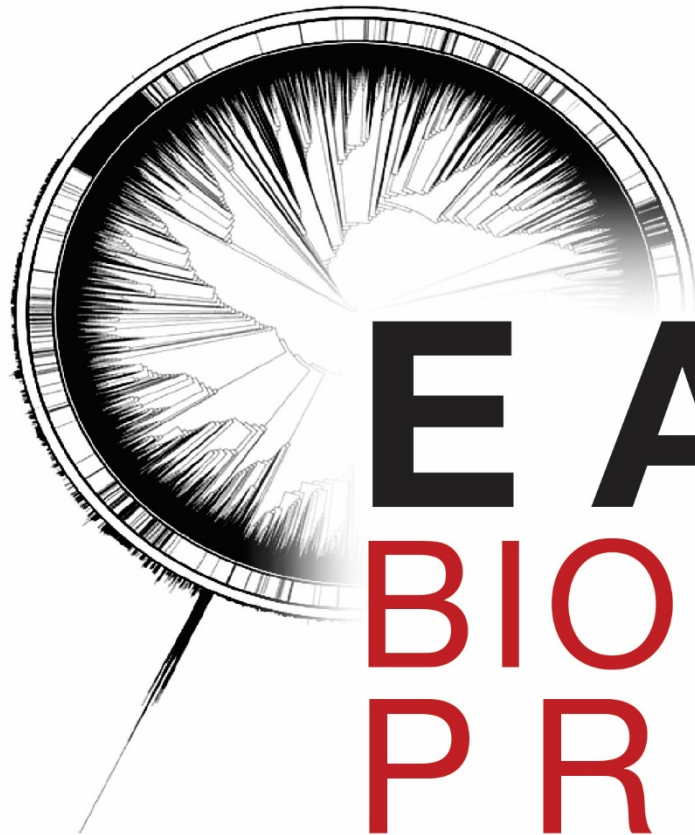


**EARTH BIOGENOME PROJECT WILL CREATE
A DIGITAL GENOME REPOSITORY
OF LIFE ON EARTH**



**EARTH
BIOGENOME
PROJECT**

**EARTH BIOGENOME PROJECT WILL CREATE
A NEW REVOLUTION IN BIOLOGY!**



**EARTH
BIOGENOME
PROJECT**