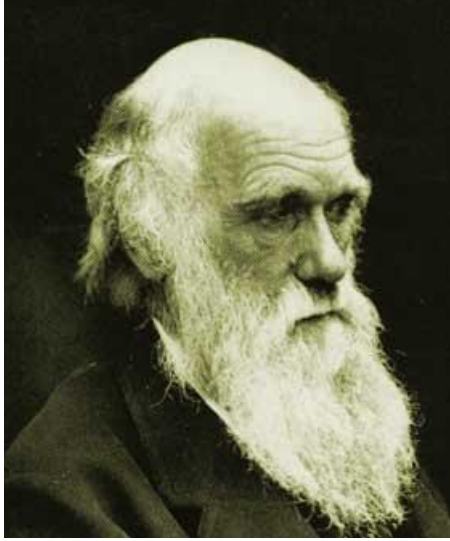


Life: The Evolving Story

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Charles Robert Darwin

**12 February 1809 – 19 April
1882**



Alfred Russel Wallace

**8 January 1823
– 7 November 1913**

What is this evolution?

- **How is there such diversity of life on earth?**
 - > **Random genetic variations**
 - > **Reproduction**
 - > **Propagation of genetic material**
 - > **Selection**
 - by **environmental, ecological , food availability factors**
- **Life forms exist because of evolution**
 - > **No creator or magic or scriptures needed**
- **Common Origins of Life**
 - > **All life on earth are related**
 - **So all humans are related**
- **A tree rather than a line or ladder**
 - > **all life forms are suited for their niche**
 - **nothing is higher or divine compared to another**

Evolution is about Relatedness: A tree rather than a line

Bacteria

Archaea

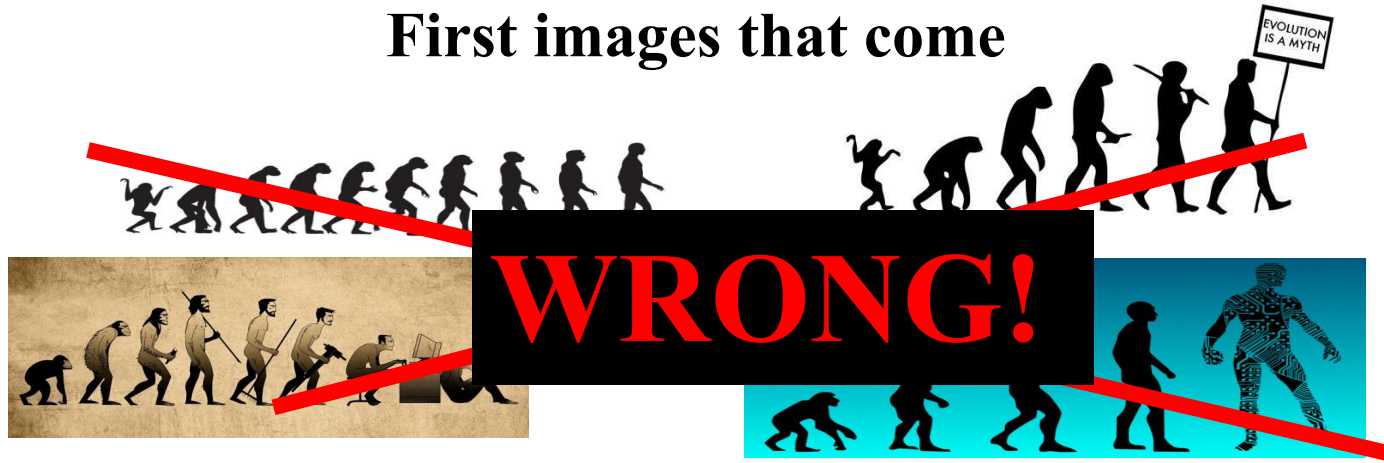
Eukarya



“Forms
made of cells
and
molecules”

**Molecular viewpoint
provides:
The Unity in diversity**

**Search google for “evolution”
First images that come**



**Chimpanzees and humans shared a last common ancestor perhaps 6 to 4 Million years ago (Mya) (60 to 40 lakh years ago).
They continue to exist. And we also exist.
We should really be called the “Third Chimpanzee”
(see book by Jared Diamond)**

99.9% similarity in DNA
within 'Us'

'Us'

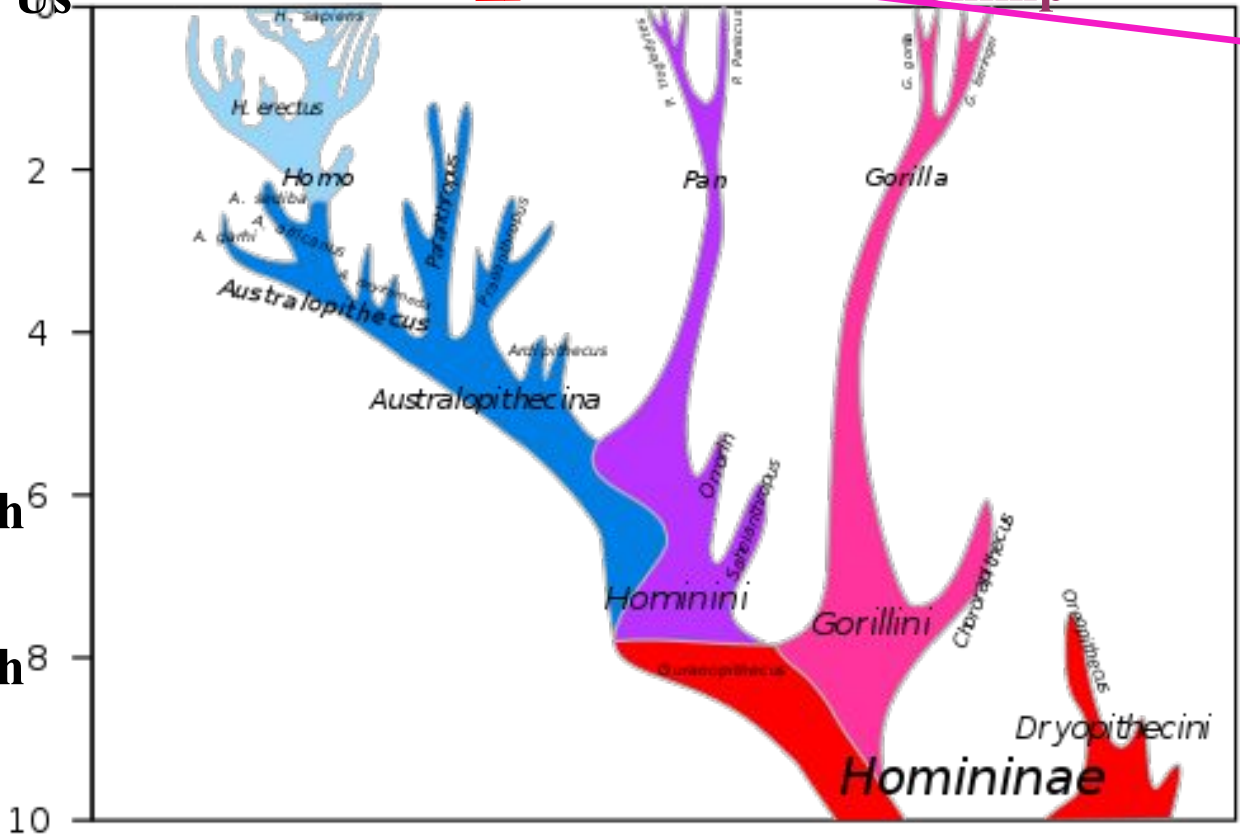
99% similarity in DNA
'Chimp'

'Gorilla'
98%
Similarity
in DNA

Mya

60 Lakh

80 Lakh



Evidences for evolution

- Biogeography
- Comparative anatomy
- Comparative embryology
- Comparing molecular data



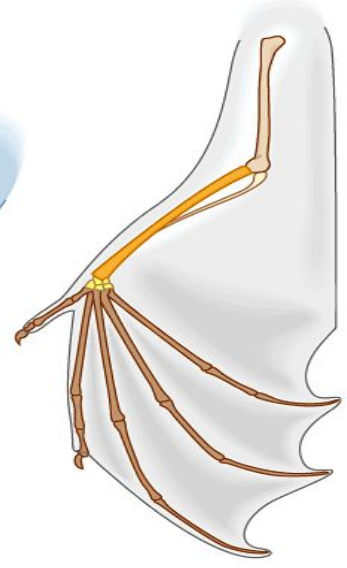
Human



Cat



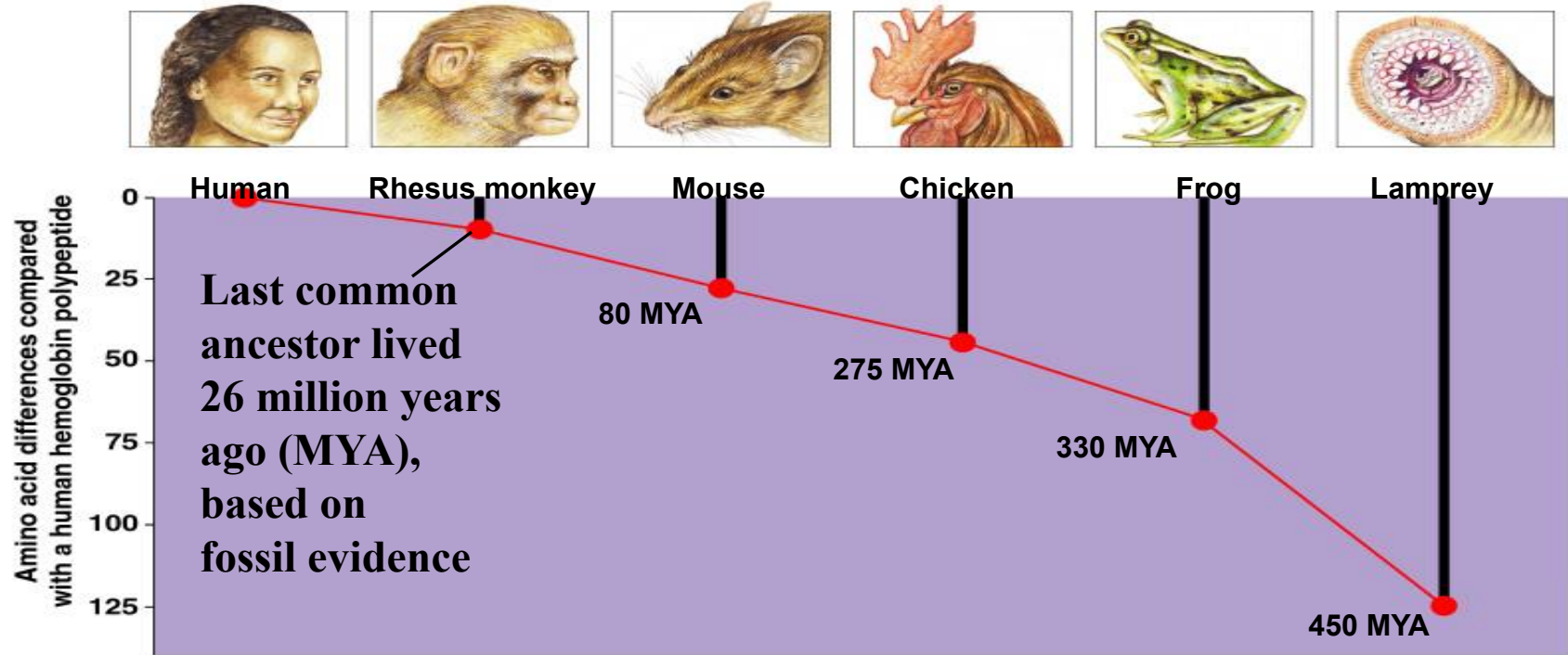
Whale



Bat

○ Molecular comparison - protein “clocks”

Based on amino acid differences in hemoglobin protein



Evolution explains the unity and diversity of life

- Charles Darwin synthesized the theory of what we call “evolution by natural selection”.
- **Darwin published in 1859 “Origin of Species”**
- Evolution is the core theme of biology

Theory

(reasoning with data)

vs

Imagination

(eg: mythology)

Populations are the units of evolution

- A population is a group of interbreeding individuals
- A species is a group of populations whose individuals can interbreed and produce fertile offspring

What is evolving?

- **gene pool** = total collection of genes in a population at any one time
- **Microevolution** is a **change in the relative frequencies of alleles** (two or more alternate forms of a gene) in a gene pool

What is an organism's evolutionary fitness?

- **Darwinian fitness is an individual's contribution to the gene pool of the next generation compared to other individuals: i.e., number of progeny**
- **Production of fertile offspring is the only score that counts in natural selection**

Social Darwinism: ALL WRONG
Caste, Eugenics

**Natural selection
does NOT
fashion perfect organisms!!**

- Due to:
 - **historical constraints**
 - **adaptive compromises**
 - **chance events**
 - **availability of variations**

Not all genetic variation may be subject to natural selection

Some variations may be neutral:

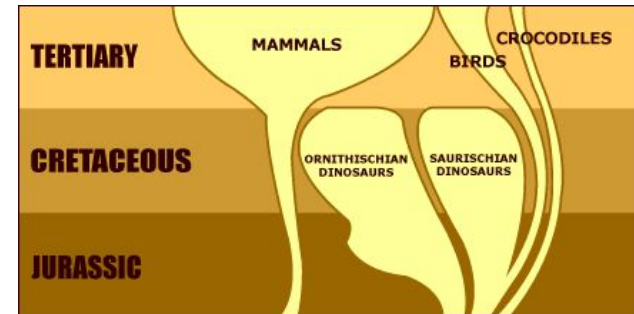
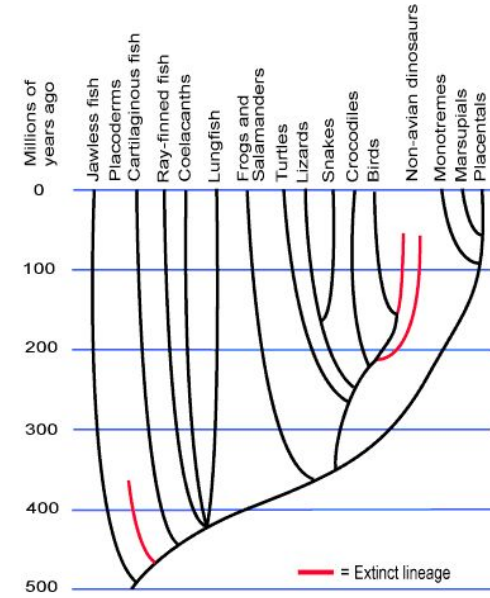
providing no apparent advantage or disadvantage

- **Example: human fingerprint patterns**



Adaptive evolution

- **Mammals filled ecological niches vacated by dinosaurs**
- Greatest mass extinction occurred millions of years before us- the dinosaurs
- More than 90% of all species died out – the animals that remained filled the gap



Placental mammals due to Endogenous Retro Virus insertions

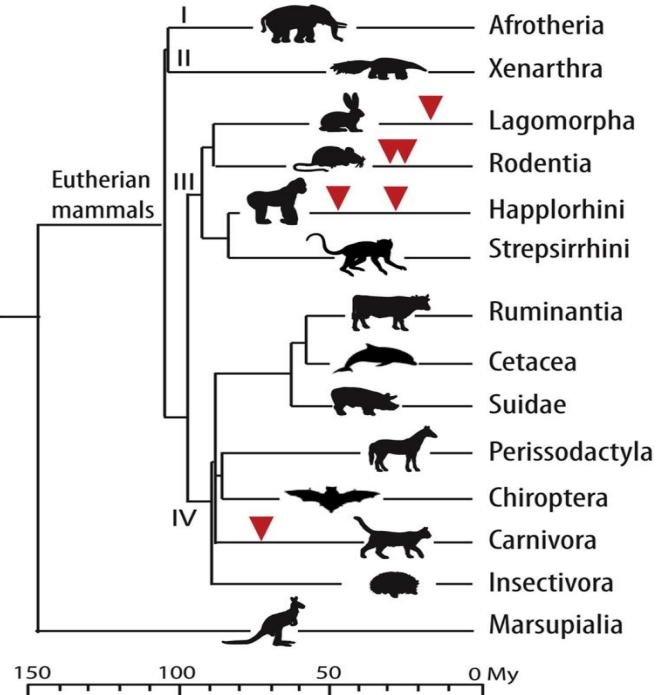
*Existence of Humans
became possible because of
dinosaur extinction (random
event) and retrovirus
insertion (random event)*

OVIPARITY → PLACENTATION



**FOUNDING
RETROVIRAL ENV CAPTURE ?
(immunosuppression-
fetomaternal tolerance)**

**MULTIPLE SYNCYTIN CAPTURES
(variable extent of syncytialization)**



Some factors affecting evolution

Ecological disasters - major catastrophes

Viruses – by modification/insertion of genetic elements

Microbiomes – composition of microbes in organisms

Epigenetics – inheritable modulation of gene expression

Climate change – providing stress for adaptation

TIME FOR A CHANGE

Adaptation drives evolution, but timelines for those changes vary wildly.

WHALES

Blowhole migrated from the snout to the top of the head.
3 million years



POLAR BEARS

Developed the ability to survive on a high-fat diet of seal blubber.
300,000 years



CHINOOK SALMON

Body size shrank in response to commercial fishing.
90 years



- **Today evolutionary biologists have the analytic power to track species adaptation.**
- Advances in molecular biology allow them to identify the genes that help individuals move away from their ancestors as they adapt to new conditions.
- *For example*, a team of scientists at Harvard Medical School and Princeton University identified **Bone Morphogenetic Protein 4 (*BMP4*)** as the key gene that **shapes the beaks of the Galapagos finches** (the beak shapes that helped Darwin shape his ideas!)

Evolution is an ongoing process

- **In the lab:** *work on E.coli by Richard Lenski*

- **In the wild:**

work on guppies by David Reznick

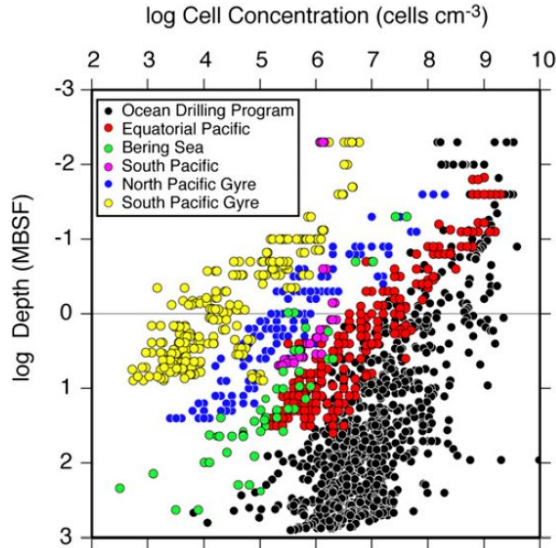
work on Sand Hills deer mice and Agouti locus by Barrett et al

- **In humans:** *brain size reduction ~10kya,*
lactase persistence ~5kya dairy farming

- **Due to humans:** *peppered moth,*
chinook salmon,
italian wall lizard

- **Due to climate change:** *tawny owls in finland*

Challenging our concept of defining life - Intraterrestrials



PNAS August 27, 2012

109 (40) 16213-16216

<https://doi.org/10.1073/pnas.1203849>

109

*Nature Microbiology volume 10,
p 1555–1557 (June 2025)*

Microbes seen at depth of 5000 metres

Chinese Continental Scientific Drilling (CCSD) project in eastern China

Geobiology Feb 2021

<https://doi.org/10.1111/gbi.12430>

Aeonophiles

Newly proposed category of ultra-slow-growing microorganisms, often found deep underground, that exist in a near-dormant state, metabolically active but dividing extremely slowly (doubling times from months to potentially thousands of years).

Challenging our concept of defining life - Intraterrestrials

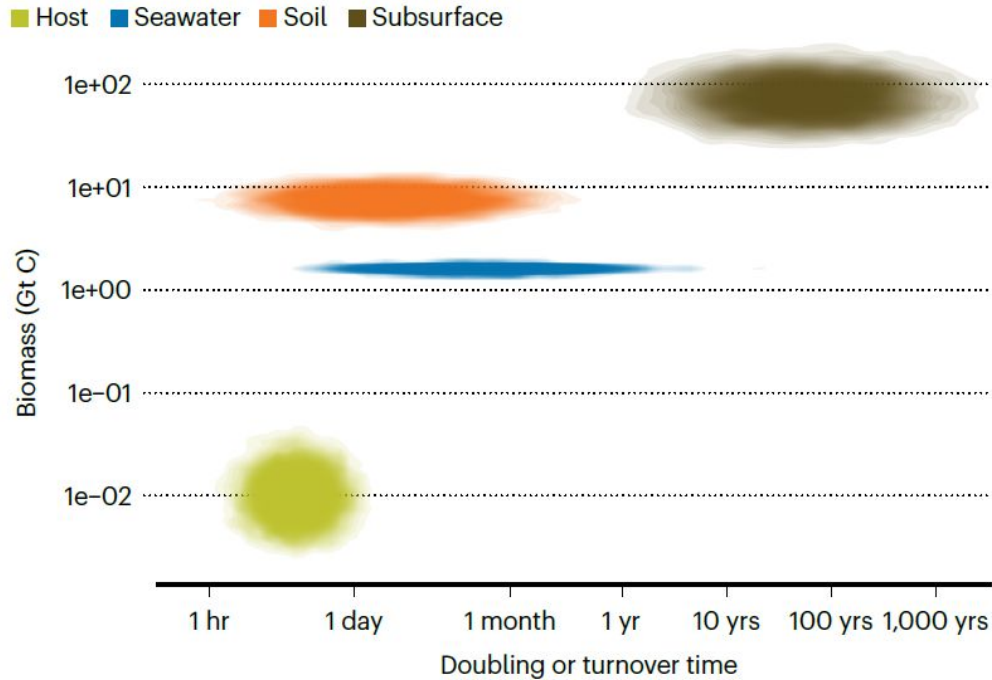


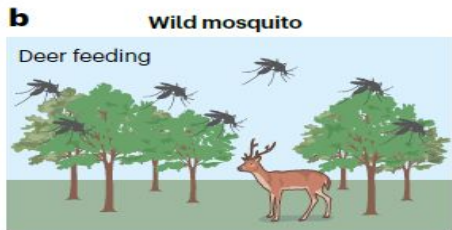
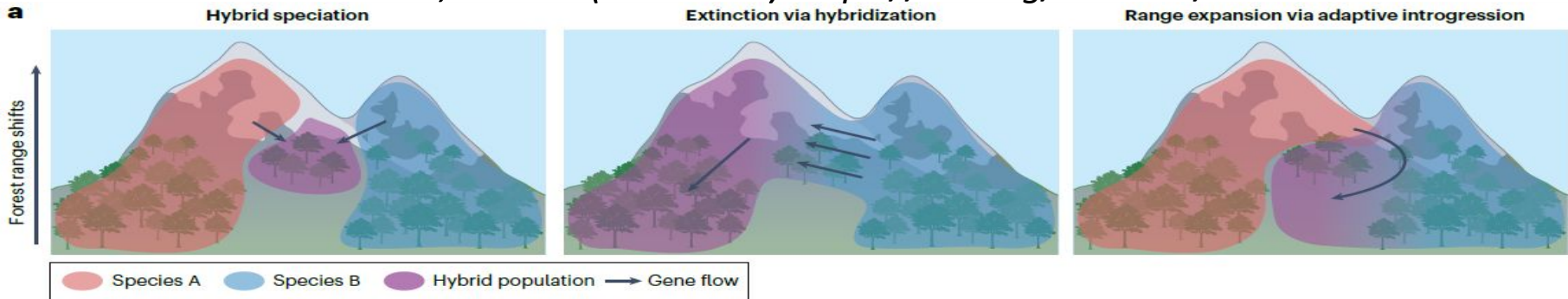
Fig. 1 | Global estimates of microbial biomass in biomes where organisms have different turnover times. Global estimates of the amount of microbial biomass (measured in gigatonnes of carbon) in animal and plant hosts, seawater, soil or subsurface environments plotted against a selection of published doubling or turnover times for the microorganisms in these environments. Data sources and calculations are listed at <https://github.com/adsteen/aeonophiles>.

Challenging our concept of defining life - Intraterrestrials

- organisms that can persist for vast geological timescales, influencing deep-earth biogeochemical cycles
- potentially offering novel stable biomolecules
- Life can exist on orders of magnitude lower power and sustain their living cells for orders of magnitude more years than previously thought possible.
- How did these organisms evolve to stop growing for thousands of years?

The species problem evolving in the Anthropocene

Nat. Rev. Biodivers. 2, 40–55 (Jan 2026) <https://doi.org/10.1038/s44358-025-00125-x>



Different mating cues and limited gene flow



c Intentional interventions



Domestication

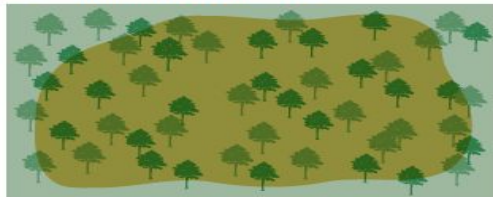


De-extinction



Laboratory-made species

d Fragmentation and drift



Pre-Anthropocene range

Habitat change, urbanization



Anthropocene range

No drops, mutations fix, DMIs arise



Anthropocene speciation

New, genetically eroded species

The species problem evolving in the Anthropocene

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what are species?

how do they originate?

how are they delimited?

✓ Global

- change alters the intensity and trajectory of natural processes such as hybridization,
- introduces new niches through urbanization & domestication

✓ new species are even being created in the laboratory

In the realm of conservation

- unclear whether species stand apart from other facets of biodiversity in having a unique intrinsic value of their own.

Understanding evolution helps

- **Us to learn that humans are not the centre of the earth full of organisms**
- **Fight superstition, mythology**
- **Show that caste, race, religious divisions are artificial barriers**
- **Biotechnology – medicine, agriculture**
- **Realise the role of ecosystems**

Evolution is about Relatedness: A tree rather than a line

Bacteria

Archaea

Eukarya



“Forms made
of cells and
molecules”



**Molecular viewpoint provides:
The Unity in diversity**