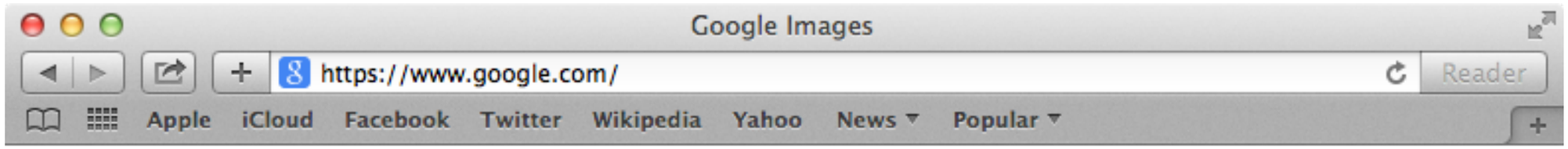
Biodiversity and Evolution

Dean Pentcheff

ARIP 2016



Google
Images

biodiversity

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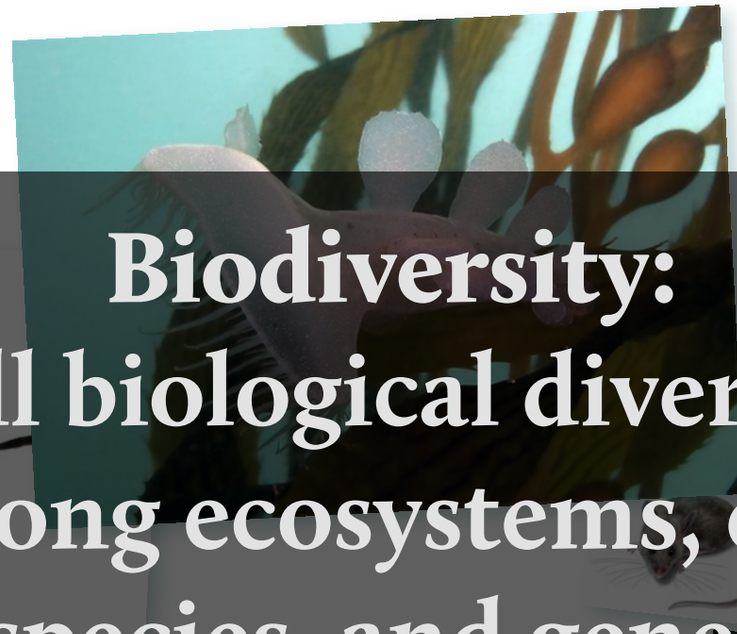
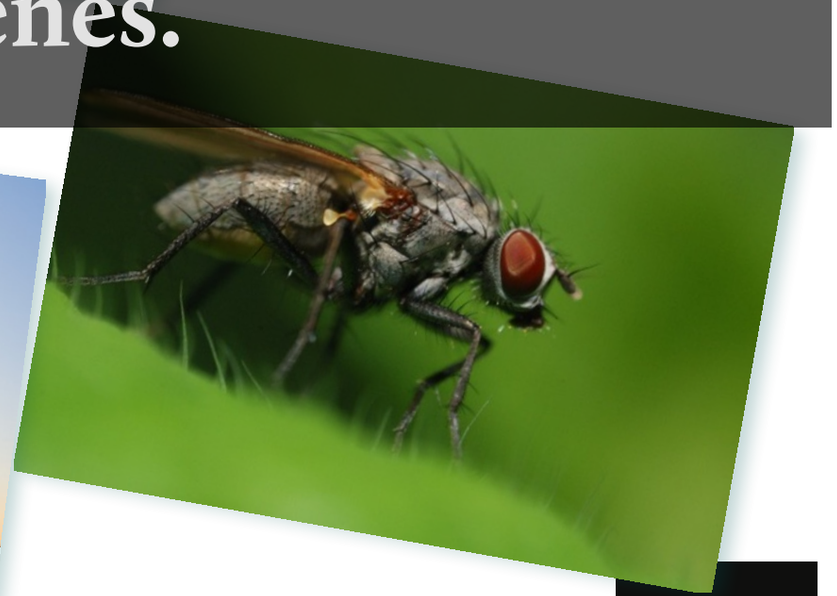


Biodiversity:
The sum of all biological diversity, including diversity among ecosystems, communities, species, and genes.



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How have museums historically studied biodiversity?

- Historically in natural history museums:
  - Collections, Taxonomy, and Systematics

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How have museums historically studied biodiversity?

- Taxonomy — you need to know the players

ZooKeys 504: 11–58 (2015)
doi: 10.3897/zookeys.504.8049
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Status of *Exosphaeroma amplicauda* (Stimpson, 1857), *E. aphrodita* (Boone, 1923) and description of three new species (Crustacea, Isopoda, Sphaeromatidae) from the north-eastern Pacific

Adam R. Wall[1], Niel L. Bruce[2,3], Regina Wetzer[1]

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Corresponding author: *Adam R. Wall* (awall@nhm.org)

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http://zoobank.org/4BD71172-7F03-44B7-9C60-09DEC6109817

Citation: Wall AR, Bruce NL, Wetzer R (2015) Status of *Exosphaeroma amplicauda* (Stimpson, 1857), *E. aphrodita* (Boone, 1923) and description of three new species (Crustacea, Isopoda, Sphaeromatidae) from the north-eastern Pacific.

How have museums historically studied biodiversity?

- Systematics and phylogeny — you'd like to know how they are related to each other

Molecular Phylogeny of the Thalassinidea Based on Nuclear and Mitochondrial Genes

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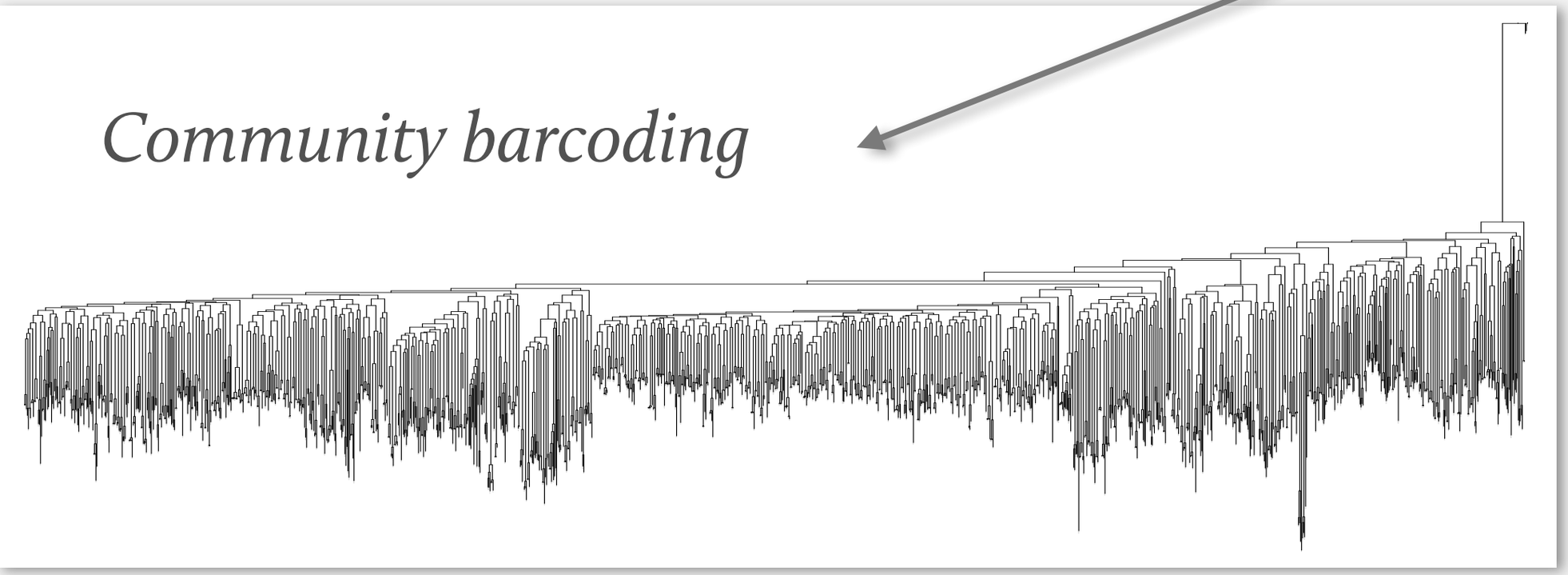
[1]*Department of Biology, University of Louisiana, Lafayette, Louisiana, U.S.A.*
[2]*Biology Department, American University, Washington, D.C., U.S.A.*
[3]*Dritte Zoologische Abteilung, Naturhistorisches Museum, Wien, Austria*
[4]*Department of Natural Sciences, Museum of Victoria, Abbotsford, Victoria, Australia*

ABSTRACT

We conducted a molecularly based phylogenetic analysis with representatives of the thalassinidean families Axianassidae, Axiidae, Callianassidae, Callianideidae, Calocarididae, Ctenochelidae, Laomediidae, Micheleidae, Strahlaxiidae, Thalassinidae, Thomassiniidae, and Upogebiidae, along with

Moving beyond historical approaches

Community barcoding



Liu, S., Y. Li, J. Lu, X. Su, M. Tang, R. Zhang, L. Zhou, C. Zhou, Q. Yang, Y. Ji, D. W. Yu, and X. Zhou. 2013. SOAPBarcode: revealing arthropod biodiversity through assembly of Illumina shotgun sequences of PCR amplicons. *Methods in Ecology and Evolution* 4:1142–1150.

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Studying biodiversity hierarchies

Biodiversity hierarchy

- Richness (number of **species**)

Species	Community I	Community II	Community III
A	90	10	40
B	2	10	25
C	1	10	15
D	1	10	8
E	1	10	5
F	1	10	2
G	1	10	2
H	1	10	1
I	1	10	1
J	1	10	1
Richness	**10**	**10**	**10**

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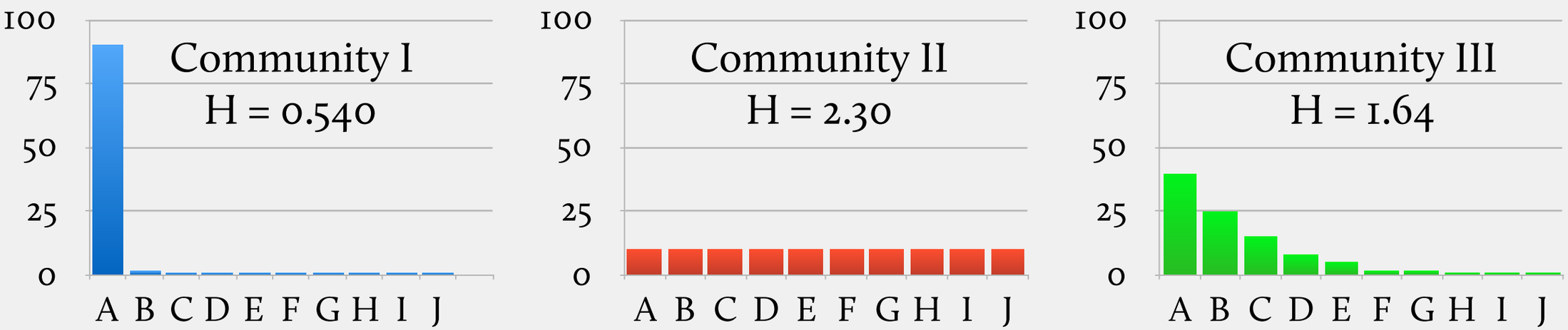
Biodiversity hierarchy

- Evenness (relative abundance of species between **communities**)



Example diversity index (Shannon-Wiener):

$$H = -\sum_{i=1}^{s} (p_i)(\log_e p_i)$$

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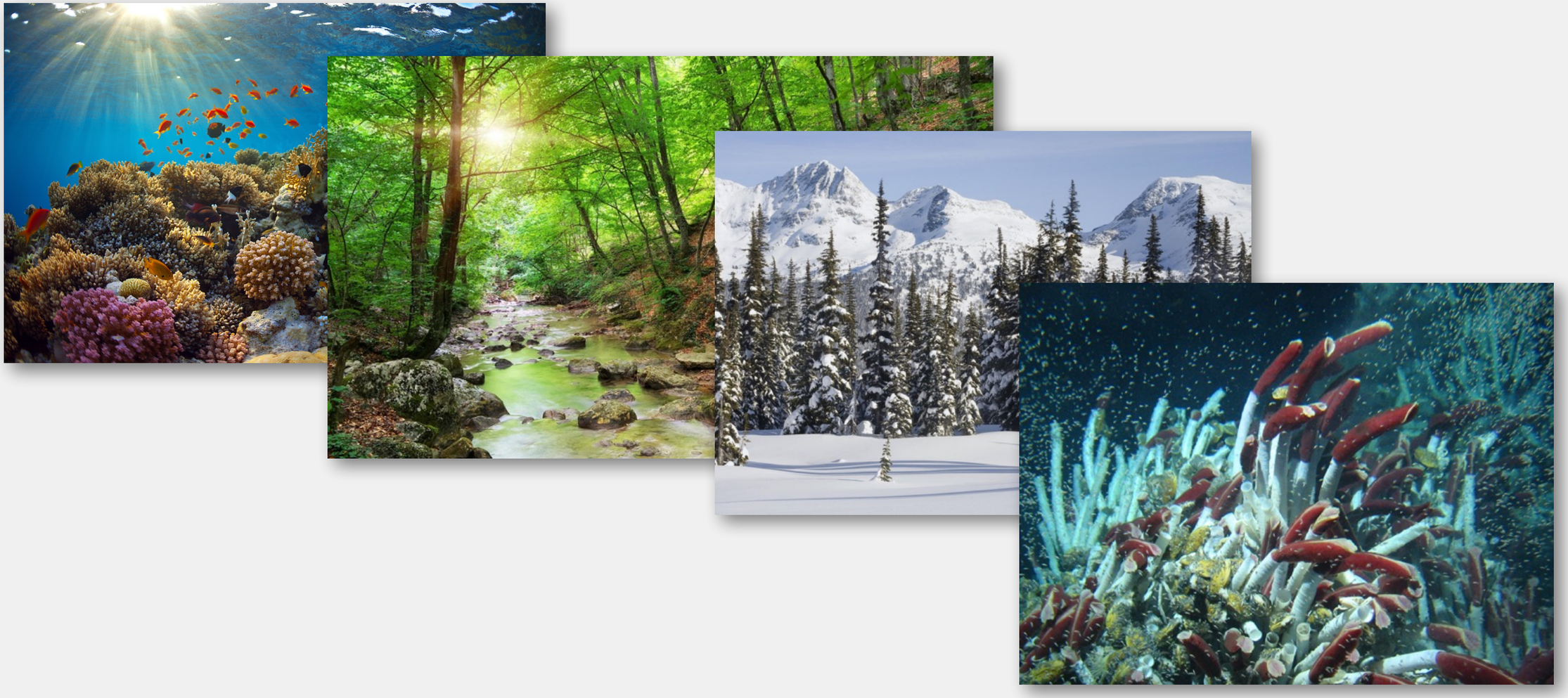
Biodiversity hierarchy

- Diversity comparisons between **ecosystems**



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Where did biodiversity come from?

- Single origin of life on Earth
- Lineages of descent
- Heritable variation
- Natural selection
- A lot of time

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Single origin of life on Earth

- It's a well-supported hypothesis (after all, diversity could have come from multiple origins of life)
  - Abiotic processes generate organic molecules necessary for life
  - Common use of RNA, DNA, ATP, and other key molecules
  - L-amino acid chirality (both L and D exist)
  - Common genetic code

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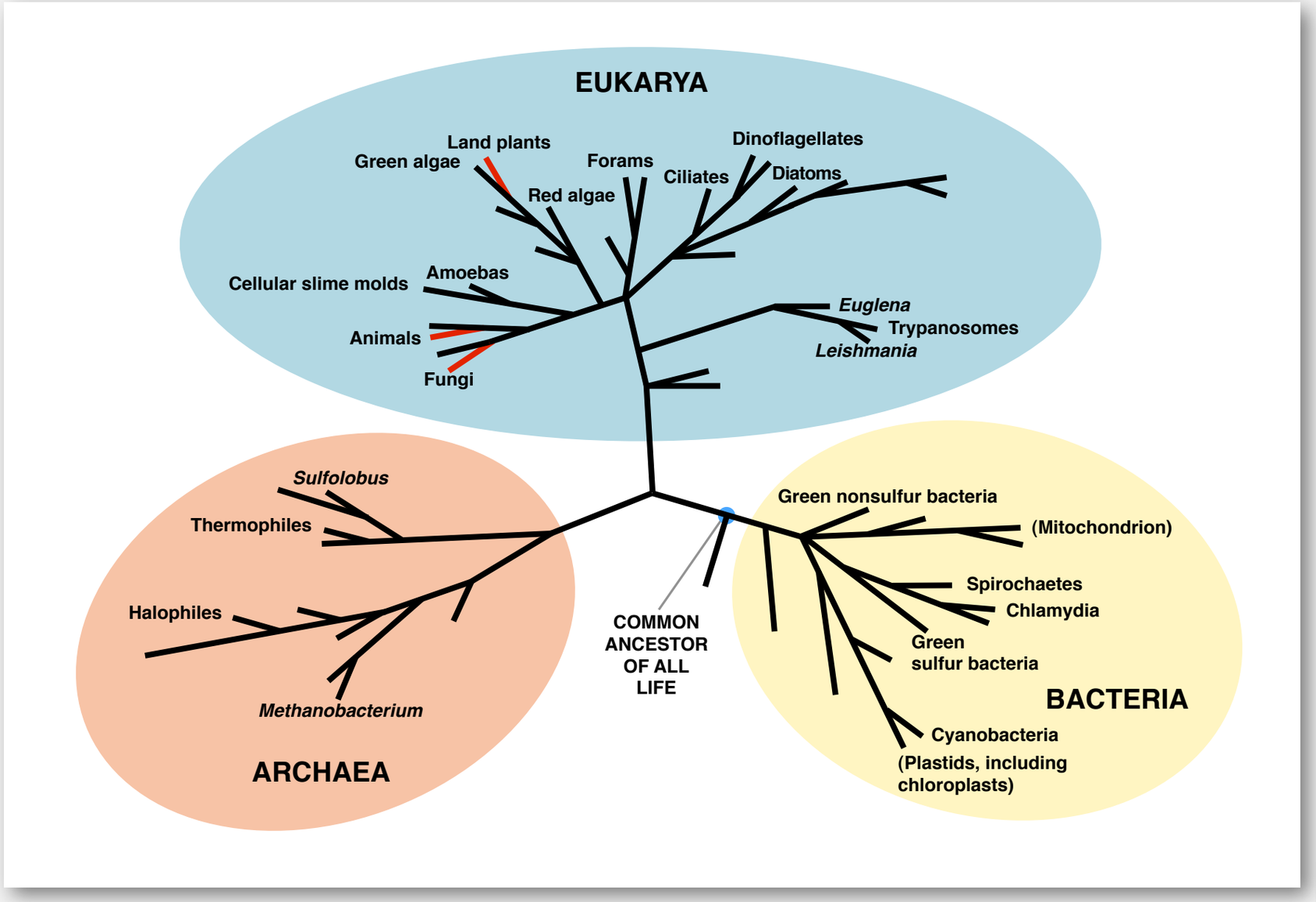
Lineages of descent

- The tree of life



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Lineages of descent

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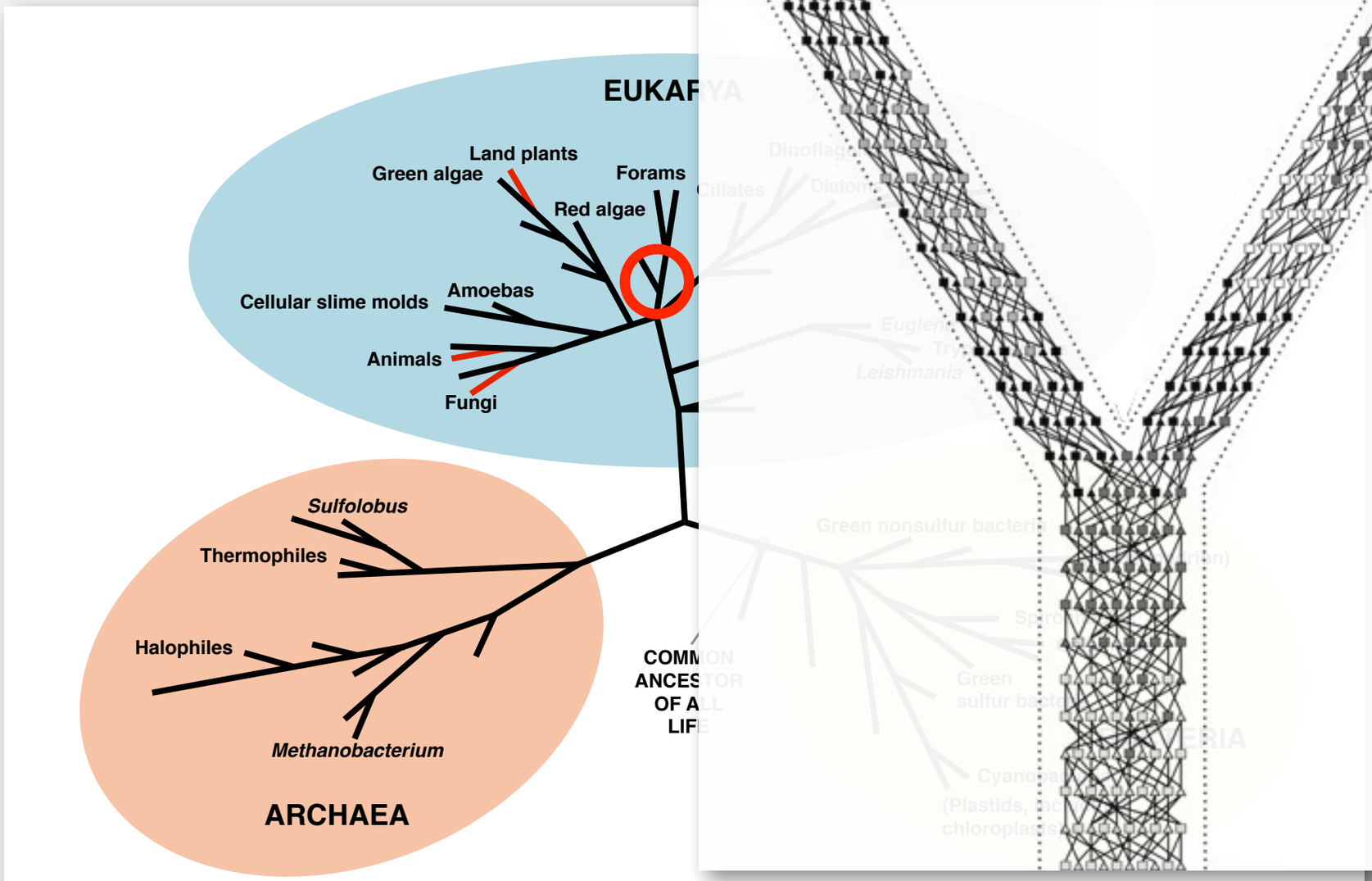

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Heritable variation

- Within-species diversity
  (lowest level of the diversity hierarchy)
- Variation exists (from random mutations)
- Because it is encoded genetically, it's heritable

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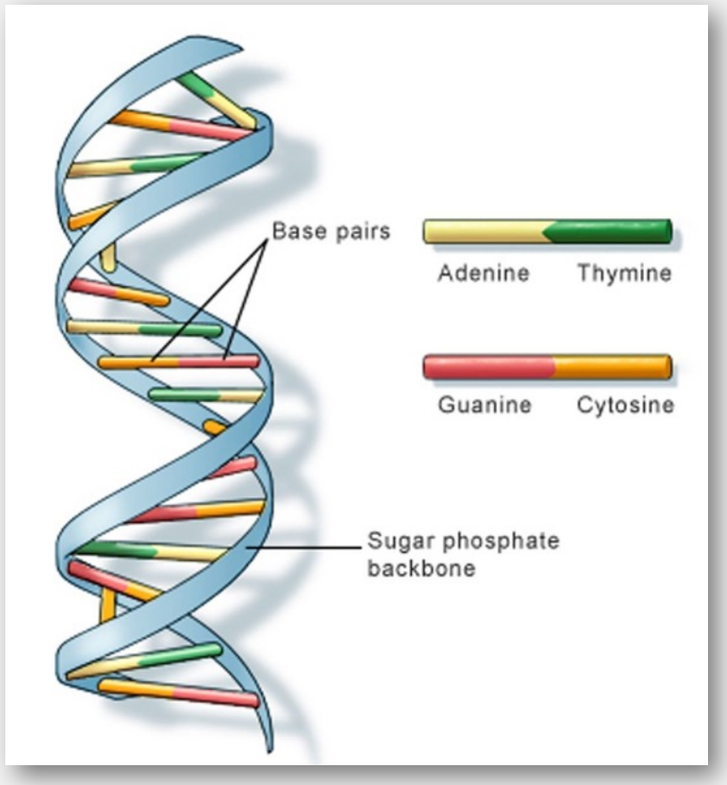
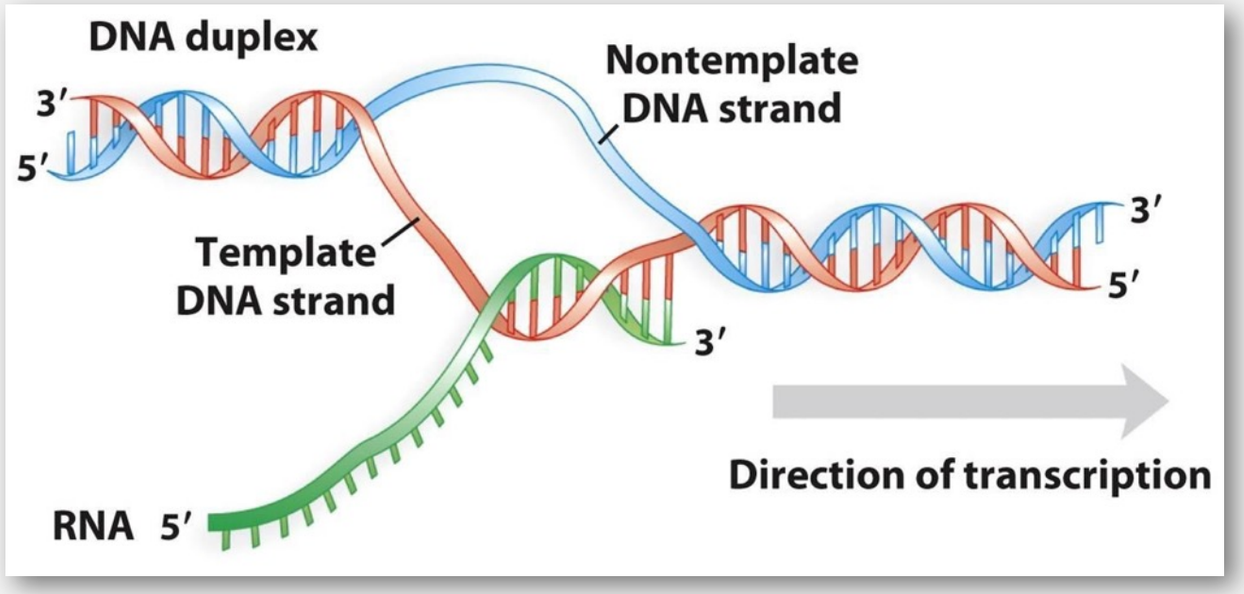
Mechanism of heredity: DNA

- The double helix of deoxyribonucleic acid (base pairs of A & T, C & G)



- Transcribed (read) into RNA



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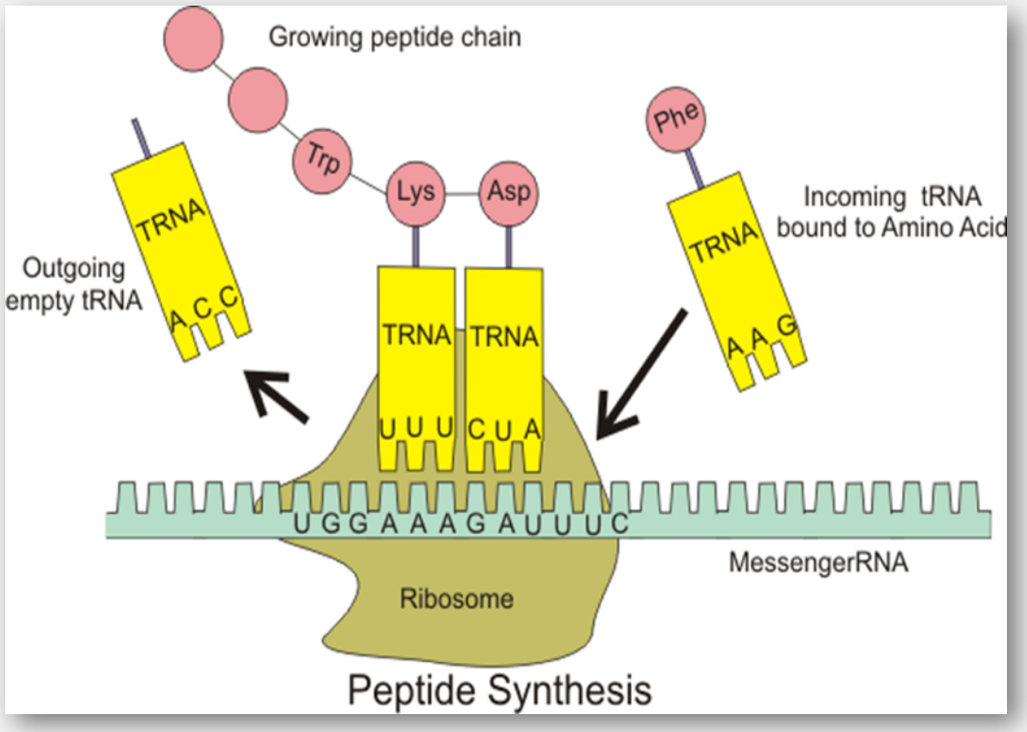
Mechanism of heredity: DNA

- RNA is translated into proteins
- According to the genetic triplet code

First Letter	Second Letter U	Second Letter C	Second Letter A	Second Letter G	Third Letter
U	Phenylalanine	Serine	Tyrosine	Cysteine	U
	Phenylalanine	Serine	Tyrosine	Cysteine	C
	Leucine	Serine	Stop	Stop	A
	Leucine	Serine	Stop	Tryptophan	G
C	Leucine	Proline	Histidine	Arginine	U
	Leucine	Proline	Histidine	Arginine	C
	Leucine	Proline	Glutamine	Arginine	A
	Leucine	Proline	Glutamine	Arginine	G
A	Isoleucine	Threonine	Asparagine	Serine	U
	Isoleucine	Threonine	Asparagine	Serine	C
	Isoleucine	Threonine	Lysine	Arginine	A
	Start Methionine	Threonine	Lysine	Arginine	G
G	Valine	Alanine	Aspartic acid	Glycine	U
	Valine	Alanine	Aspartic acid	Glycine	C
	Valine	Alanine	Aspartic acid	Glycine	A
	Valine	Alanine	Aspartic acid	Glycine	G



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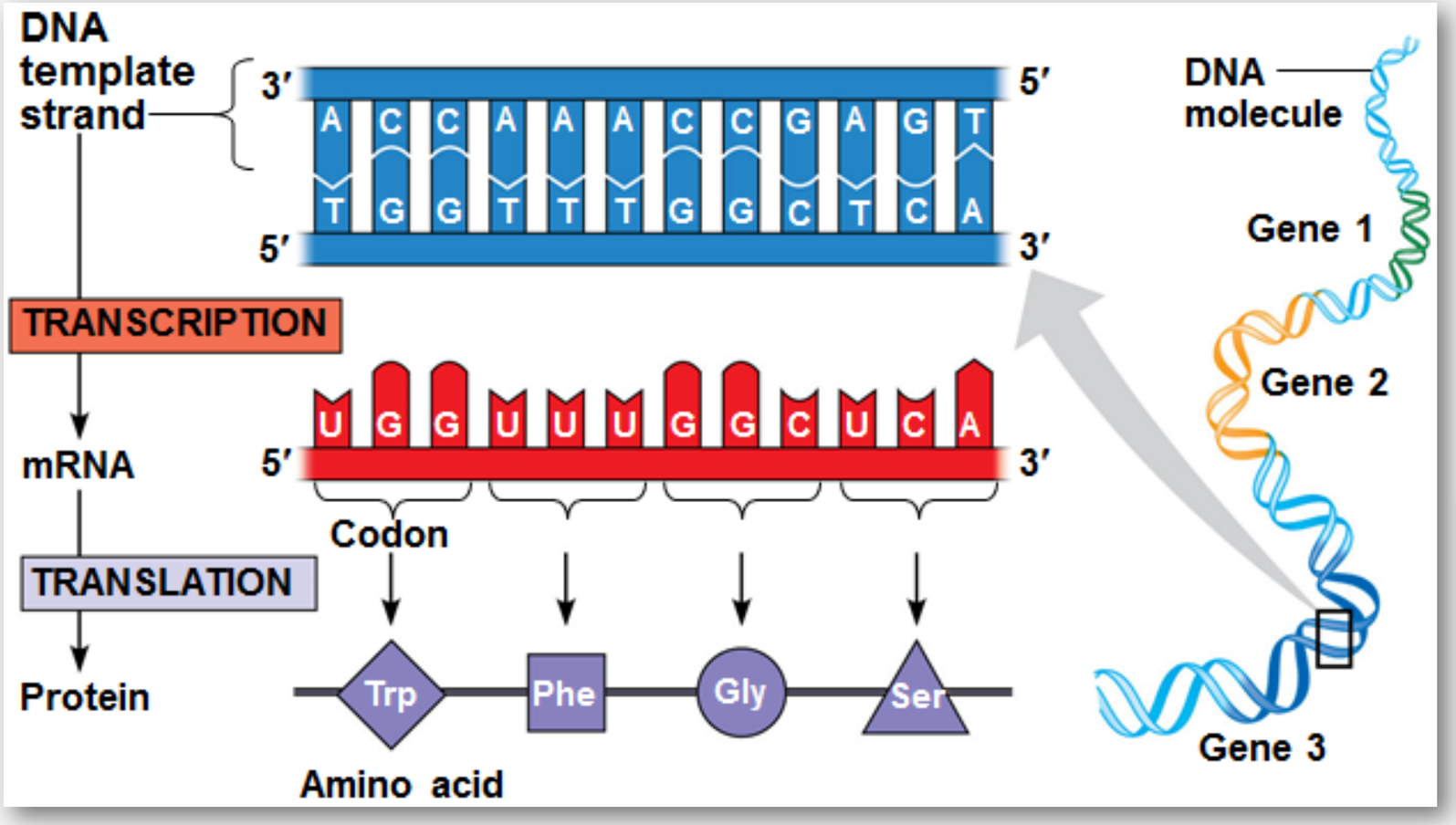
Mechanism of heredity: DNA

- DNA → mRNA → protein



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	Leucine	Serine	Stop	Tryptophan	G
C	Leucine	Proline	Histidine	Arginine	U
	Leucine	Proline	Histidine	Arginine	C
	Leucine	Proline	Glutamine	Arginine	A
	Leucine	Proline	Glutamine	Arginine	G
A	Isoleucine	Threonine	Asparagine	Serine	U
	Isoleucine	Threonine	Asparagine	Serine	C
	Isoleucine	Threonine	Lysine	Arginine	A
	Start Methionine	Threonine	Lysine	Arginine	G
G	Valine	Alanine	Aspartic acid	Glycine	U
	Valine	Alanine	Aspartic acid	Glycine	C
	Valine	Alanine	Aspartic acid	Glycine	A
	Valine	Alanine	Aspartic acid	Glycine	G

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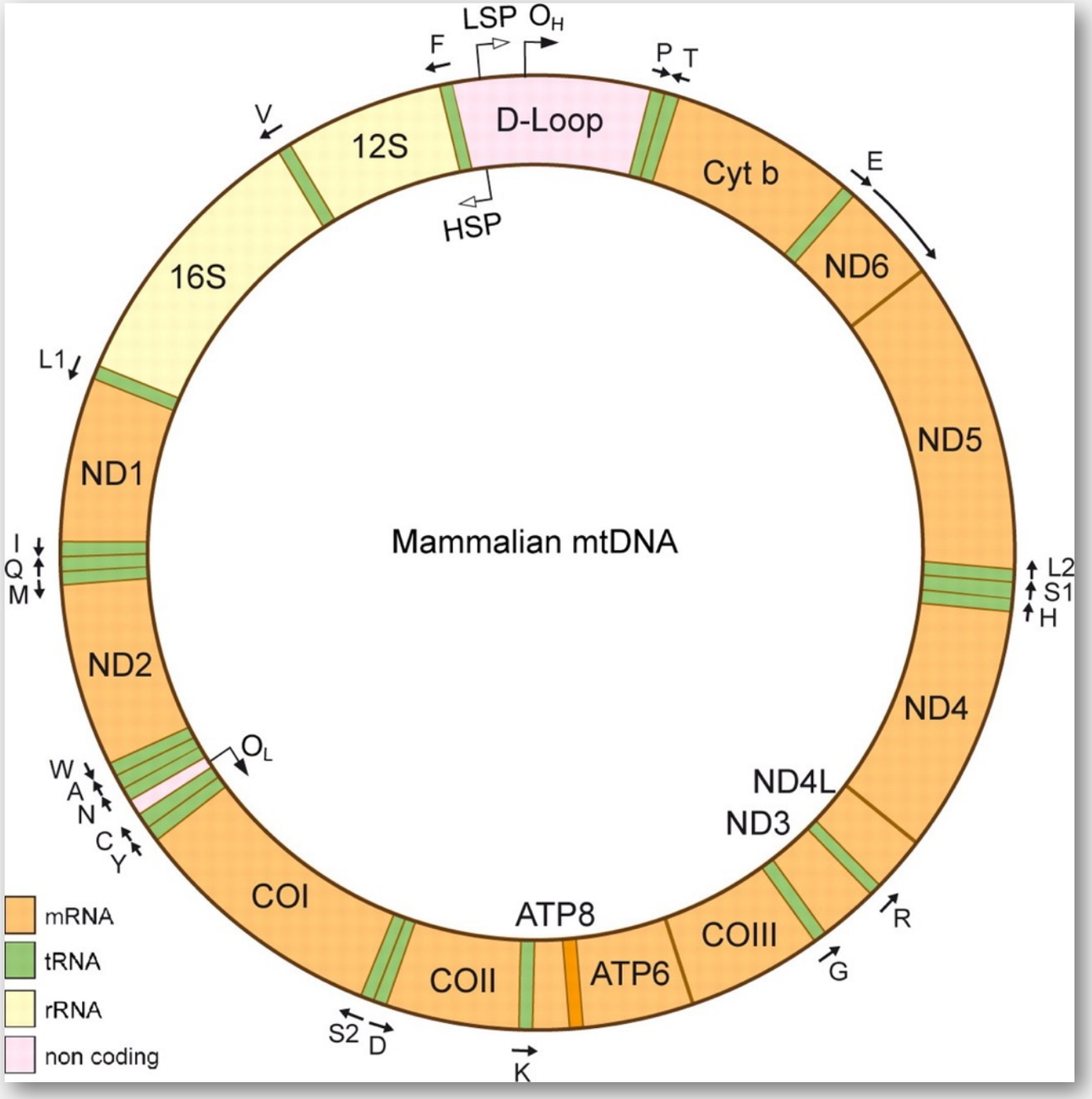
Mechanism of heredity: DNA

- A particular coding region of DNA is a *gene*



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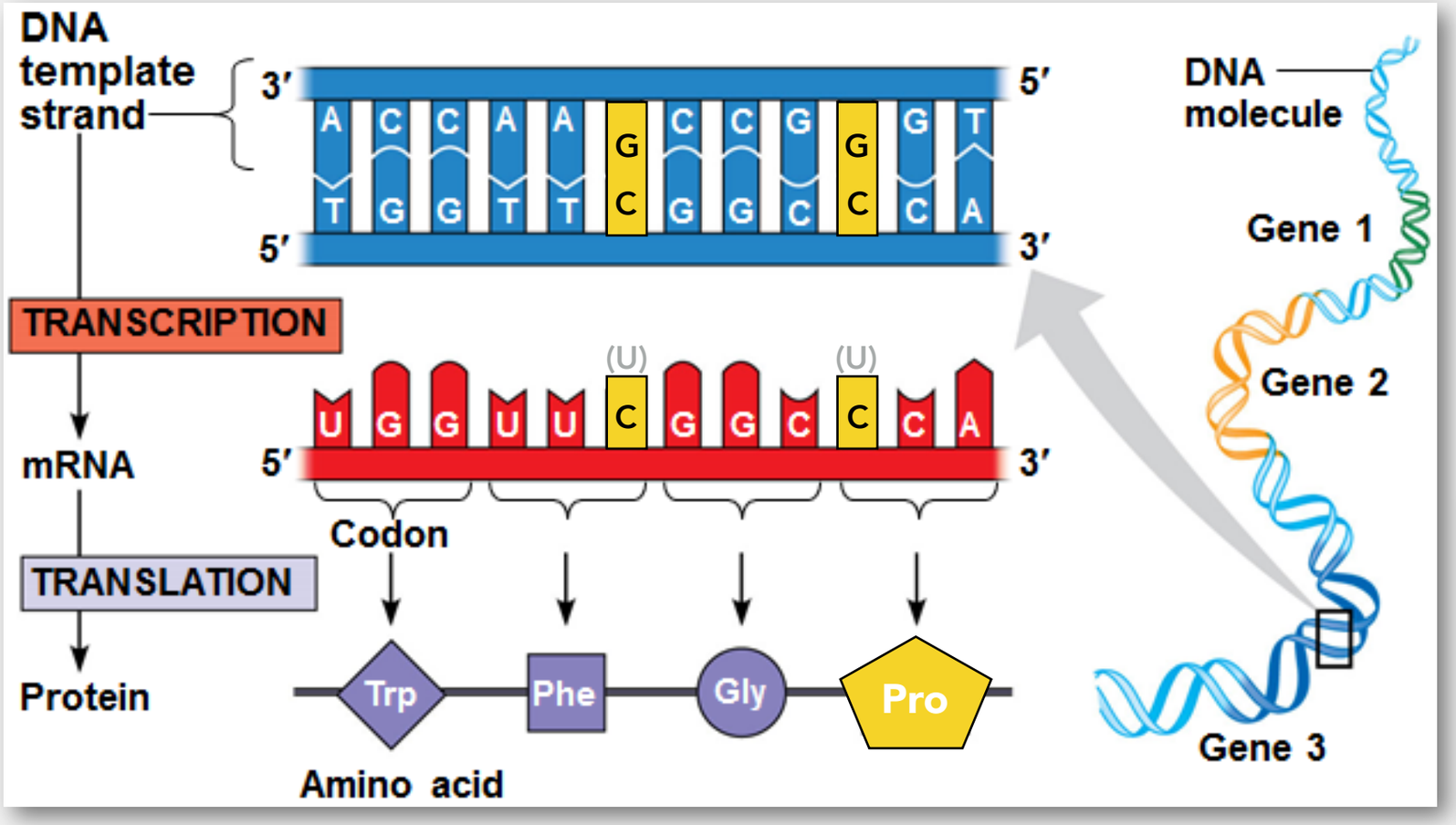
Mechanism of heredity: DNA

- Changes in a gene sequence are *mutations*



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	Leucine	Serine	Stop	Stop	A
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C	Leucine	Proline	Histidine	Arginine	U
	Leucine	Proline	Histidine	Arginine	C
	Leucine	Proline	Glutamine	Arginine	A
	Leucine	Proline	Glutamine	Arginine	G
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	Isoleucine	Threonine	Lysine	Arginine	A
	Start Methionine	Threonine	Lysine	Arginine	G
G	Valine	Alanine	Aspartic acid	Glycine	U
	Valine	Alanine	Aspartic acid	Glycine	C
	Valine	Alanine	Aspartic acid	Glycine	A
	Valine	Alanine	Aspartic acid	Glycine	G

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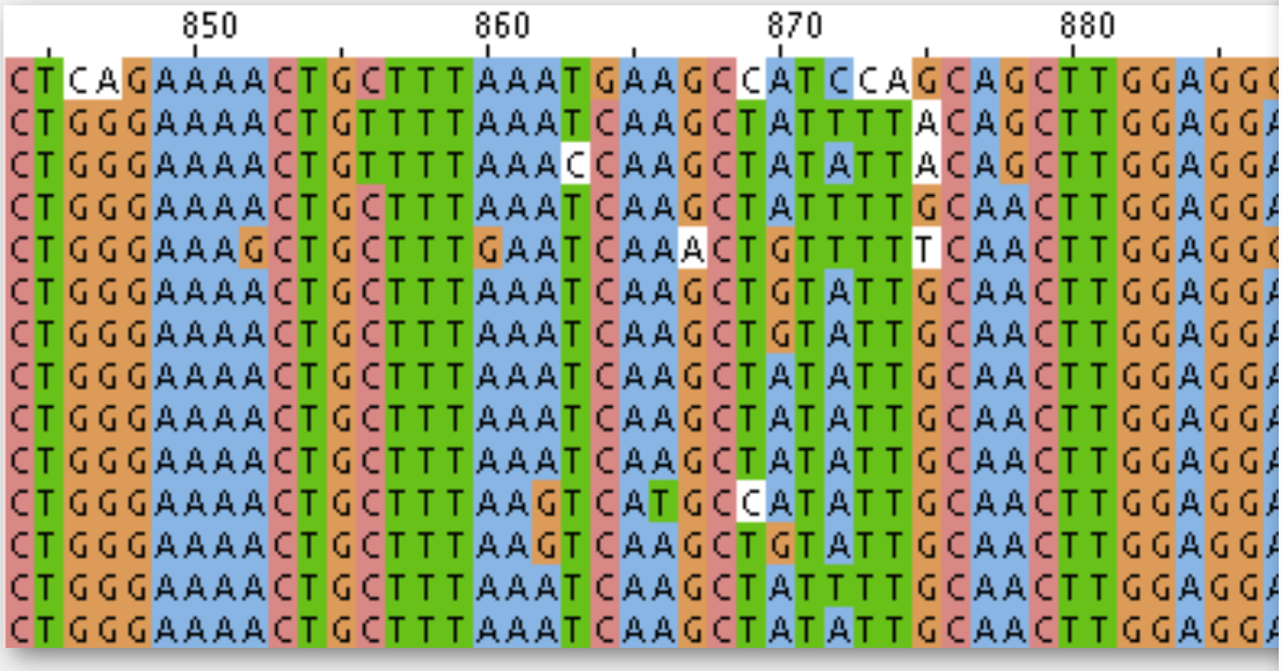
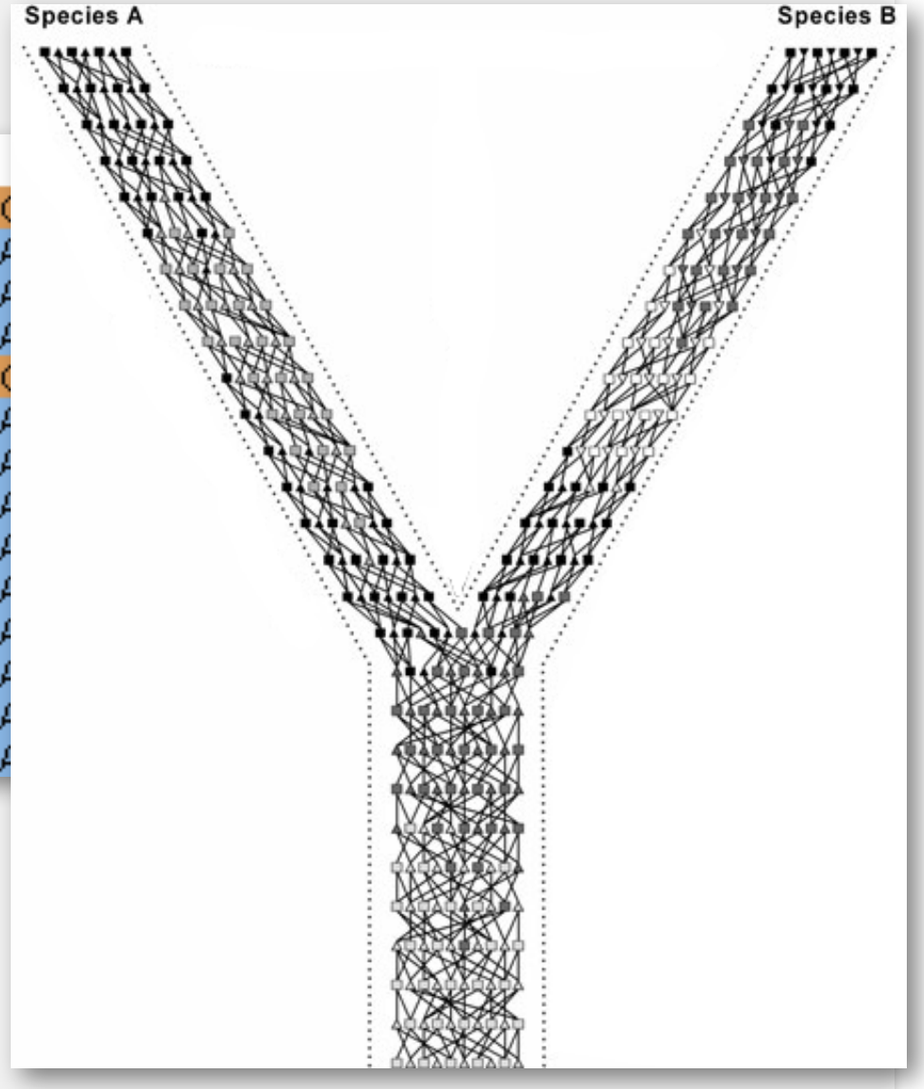
Back to heritable variation

- Different versions of a gene's sequence in the population are called *alleles*





- Populations accumulate multiple alleles

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How do you get species diversity?

- Given heritable variation,
  Darwin (and Wallace) had the key insight:
  Add *natural selection*
  (differential reproductive success)

heritable variation + natural selection
= change in heritable characters

- That is: **evolution of diversity**

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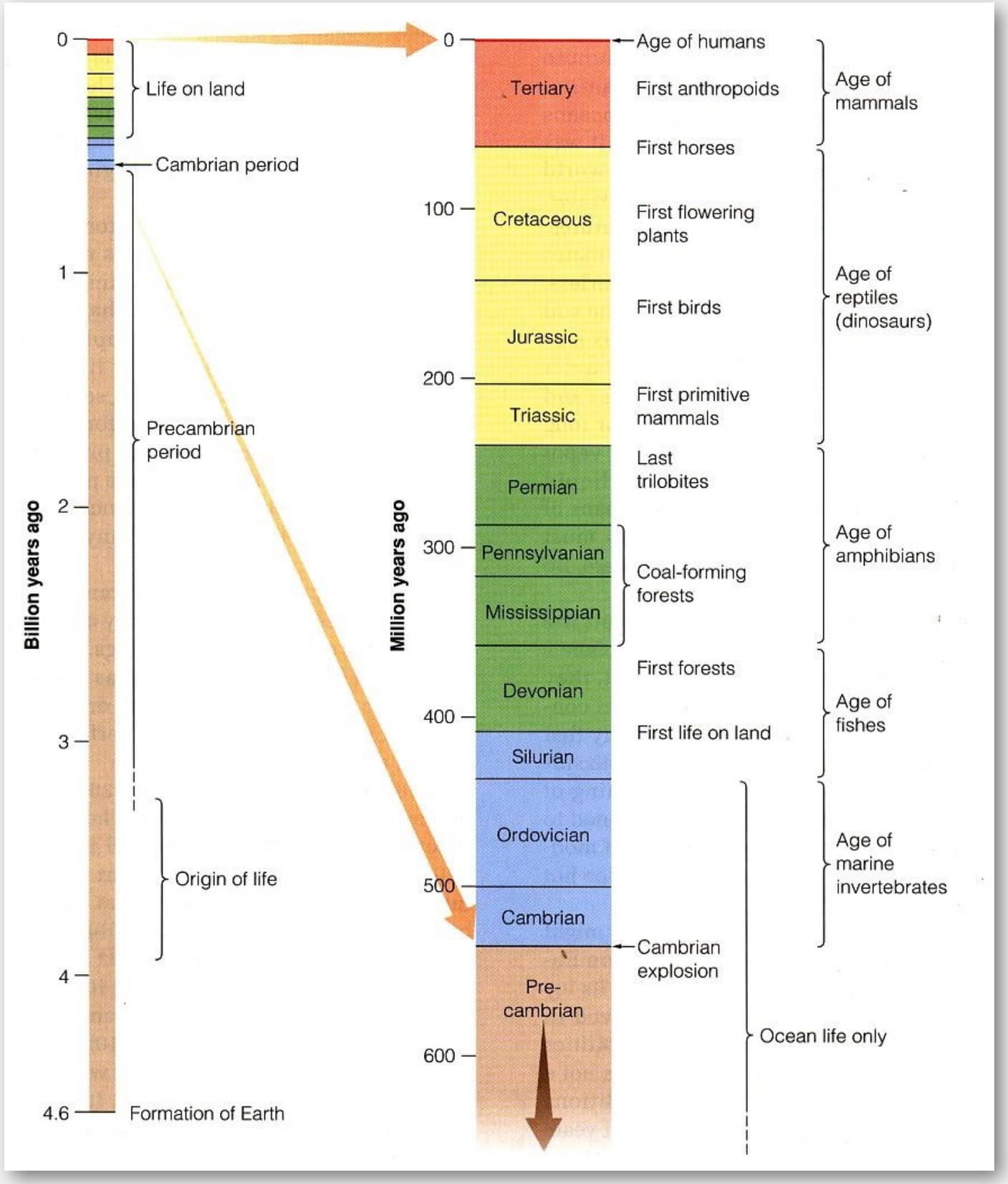
A lot of time



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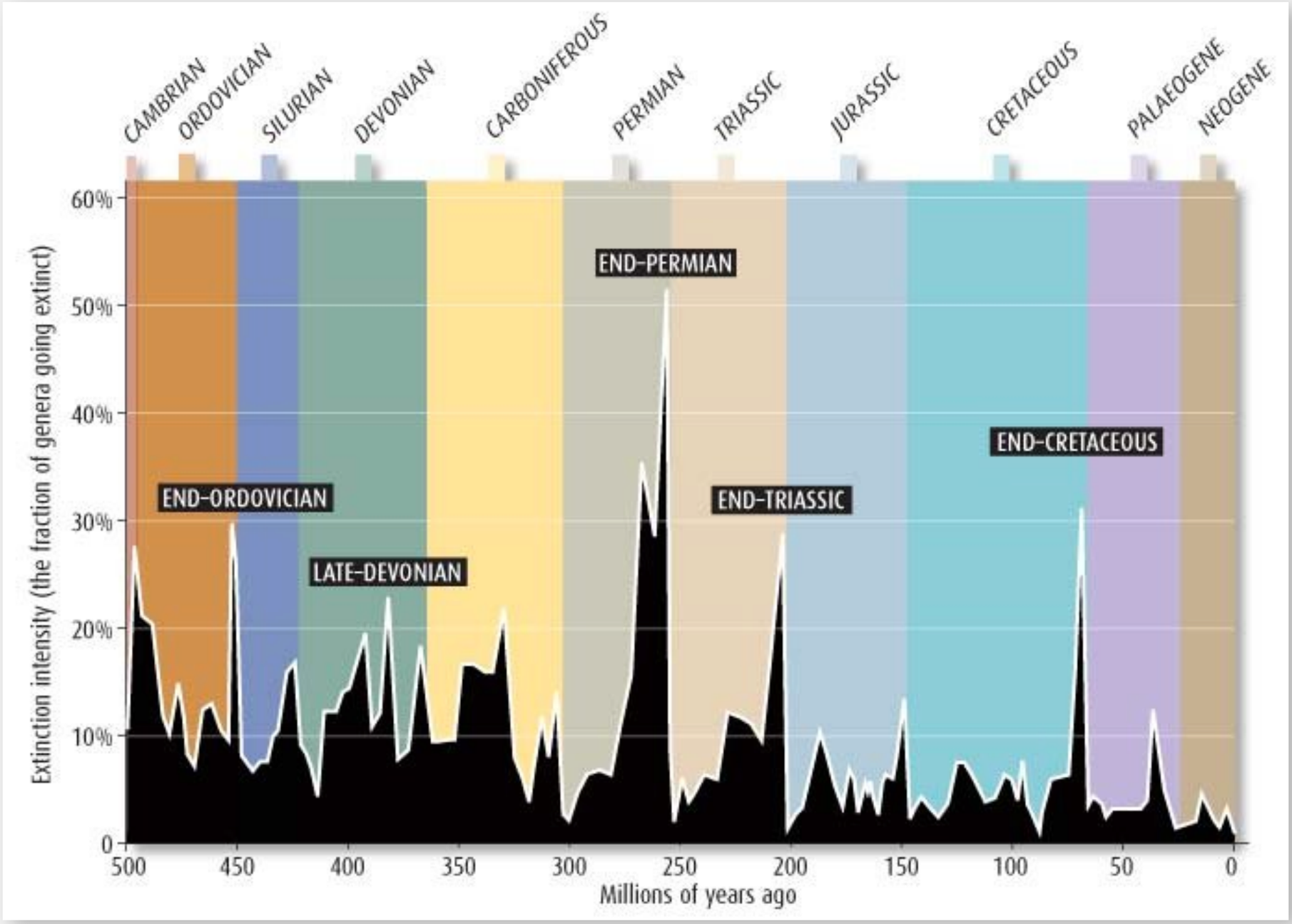
It’s not all been easy



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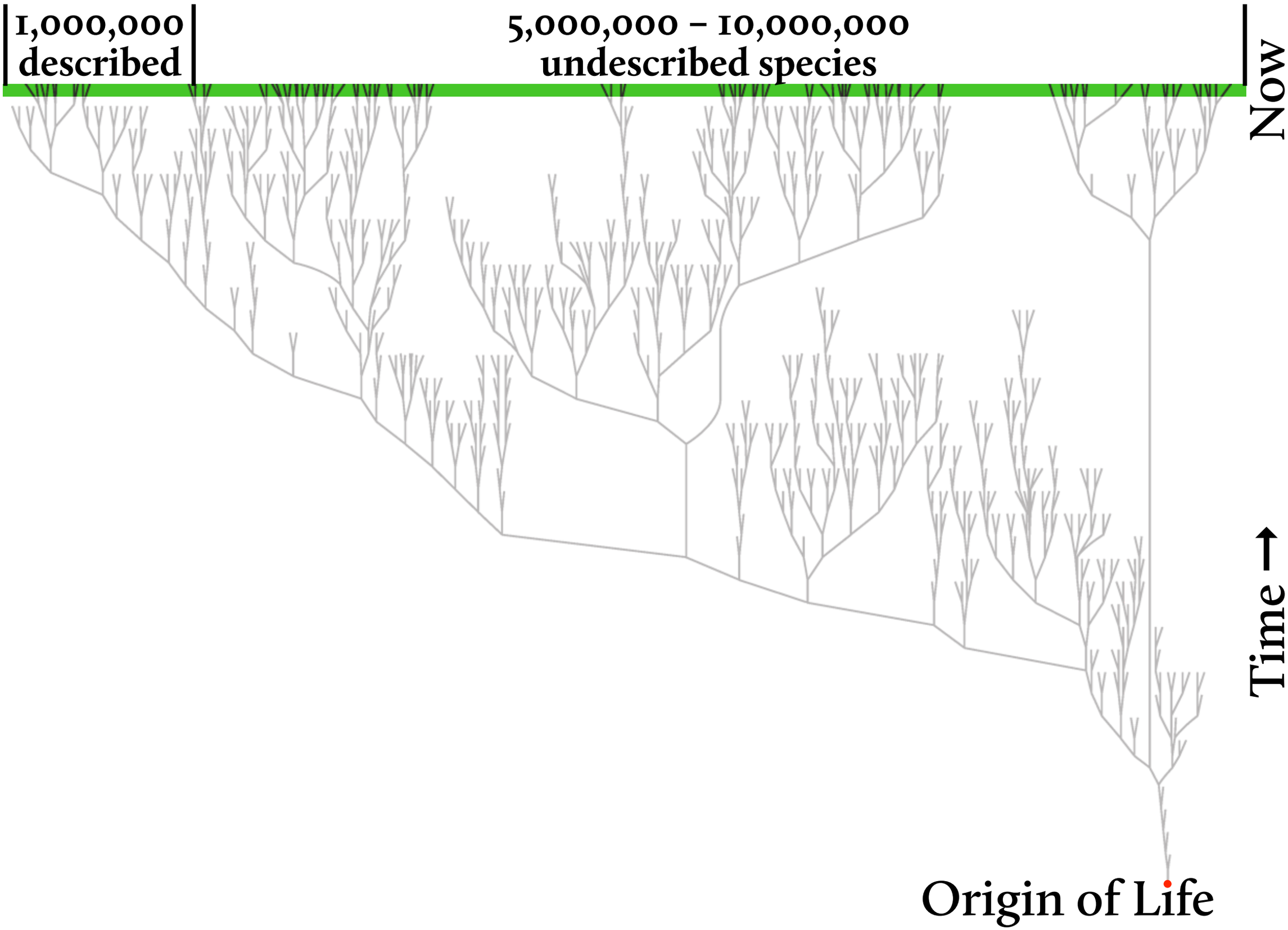
So, when all is said and done, how much diversity is there today?


1,000,000
described
5,000,000 – 10,000,000
undescribed species
Now
Time
Origin of Life

What's the "biodiversity crisis"?

- With all that diversity, what could possibly be the problem?

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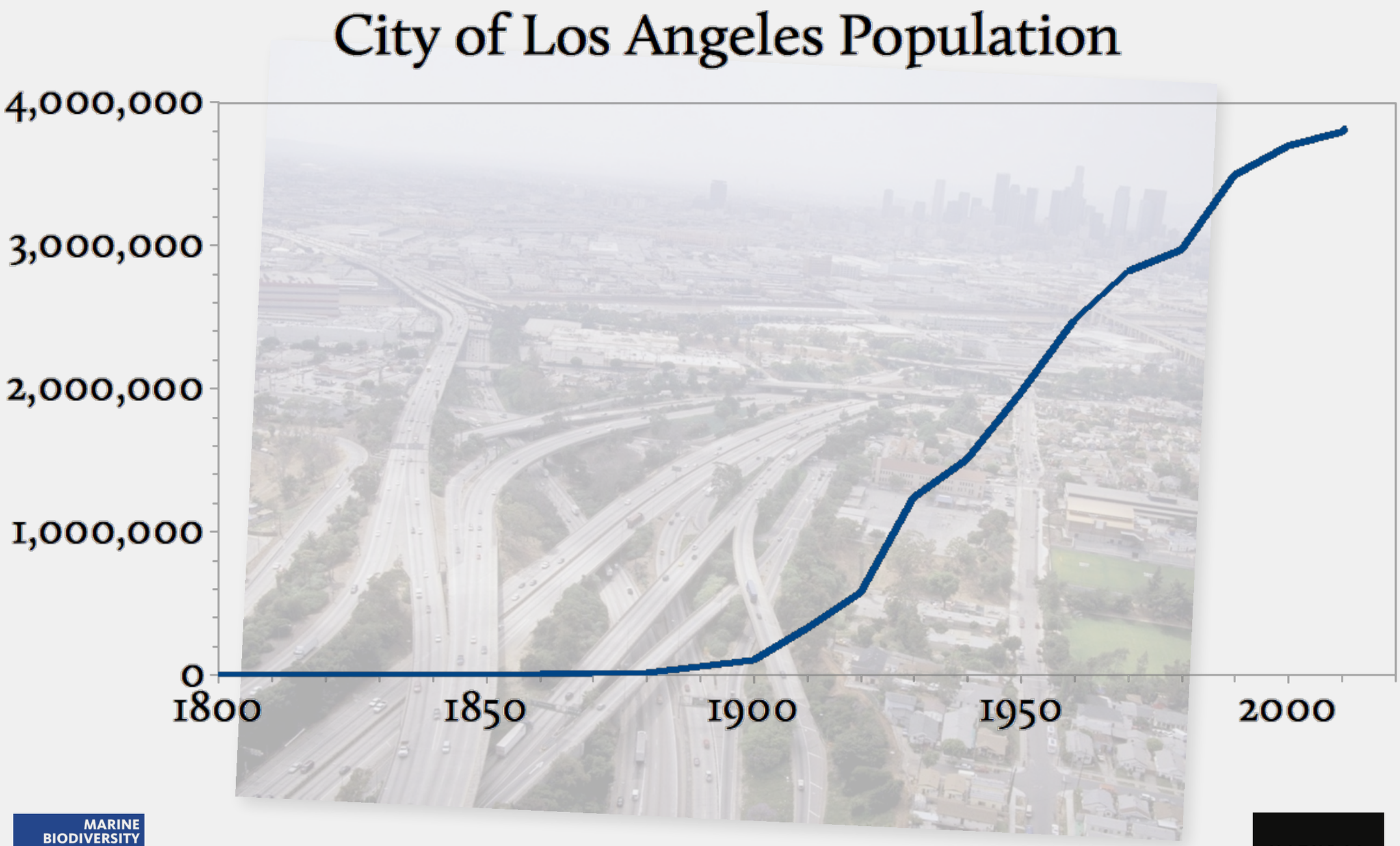
There are a lot of us



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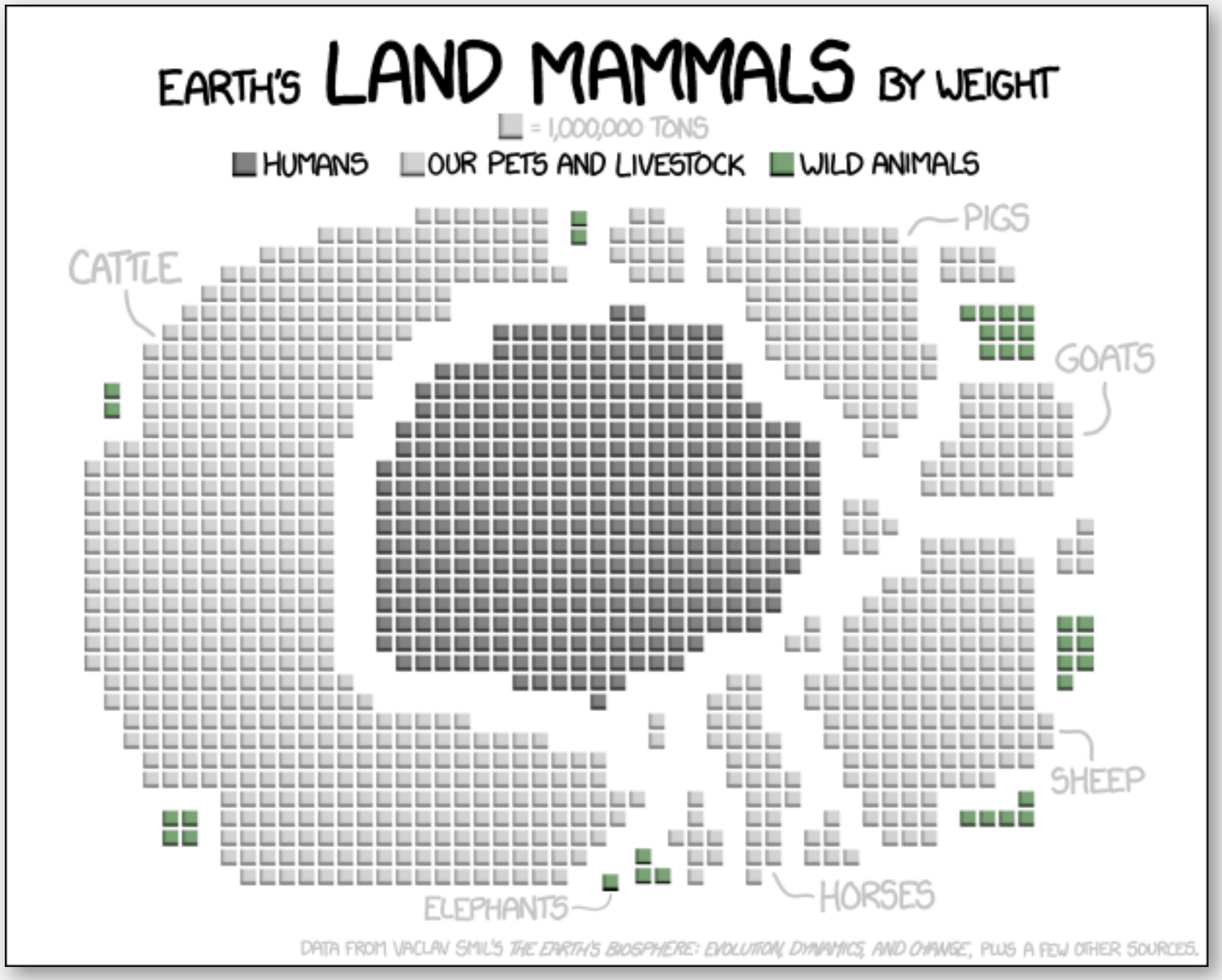
We use the Earth. A lot of it.



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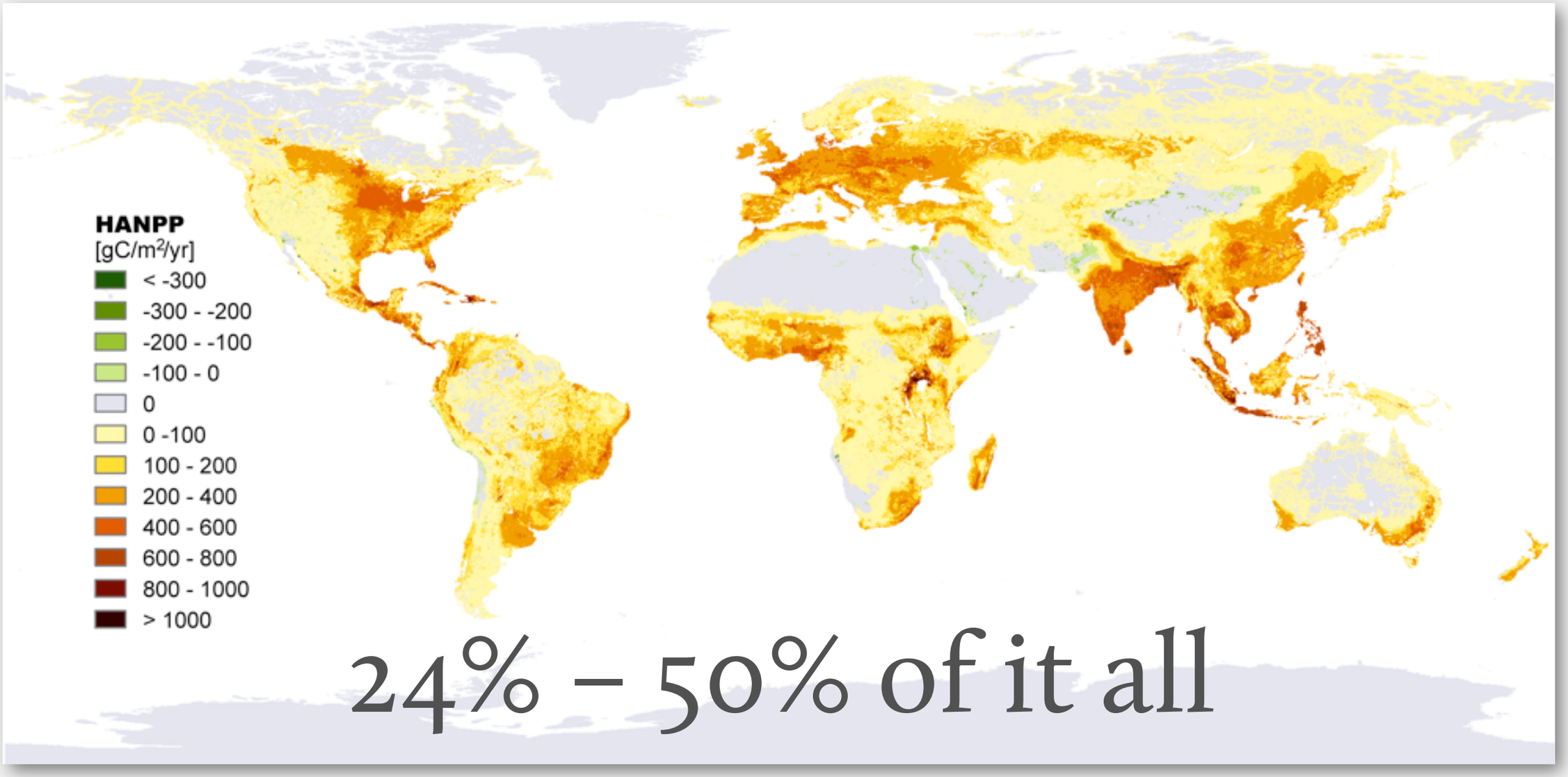
How much of it?

Human appropriation of net primary production (HANPP)



24% – 50% of it all

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H. Haberl, K.-H. Erb, F. Krausmann, V. Gaube, A. Bondeau, C. Plutzar, S. Gingrich, W. Lucht and M. Fischer-Kowalski. 2007. Quantifying and mapping the global human appropriation of net primary production in Earth's terrestrial ecosystem. *Proceedings of the National Academy of Sciences of the USA*. 104: 12942-12947.

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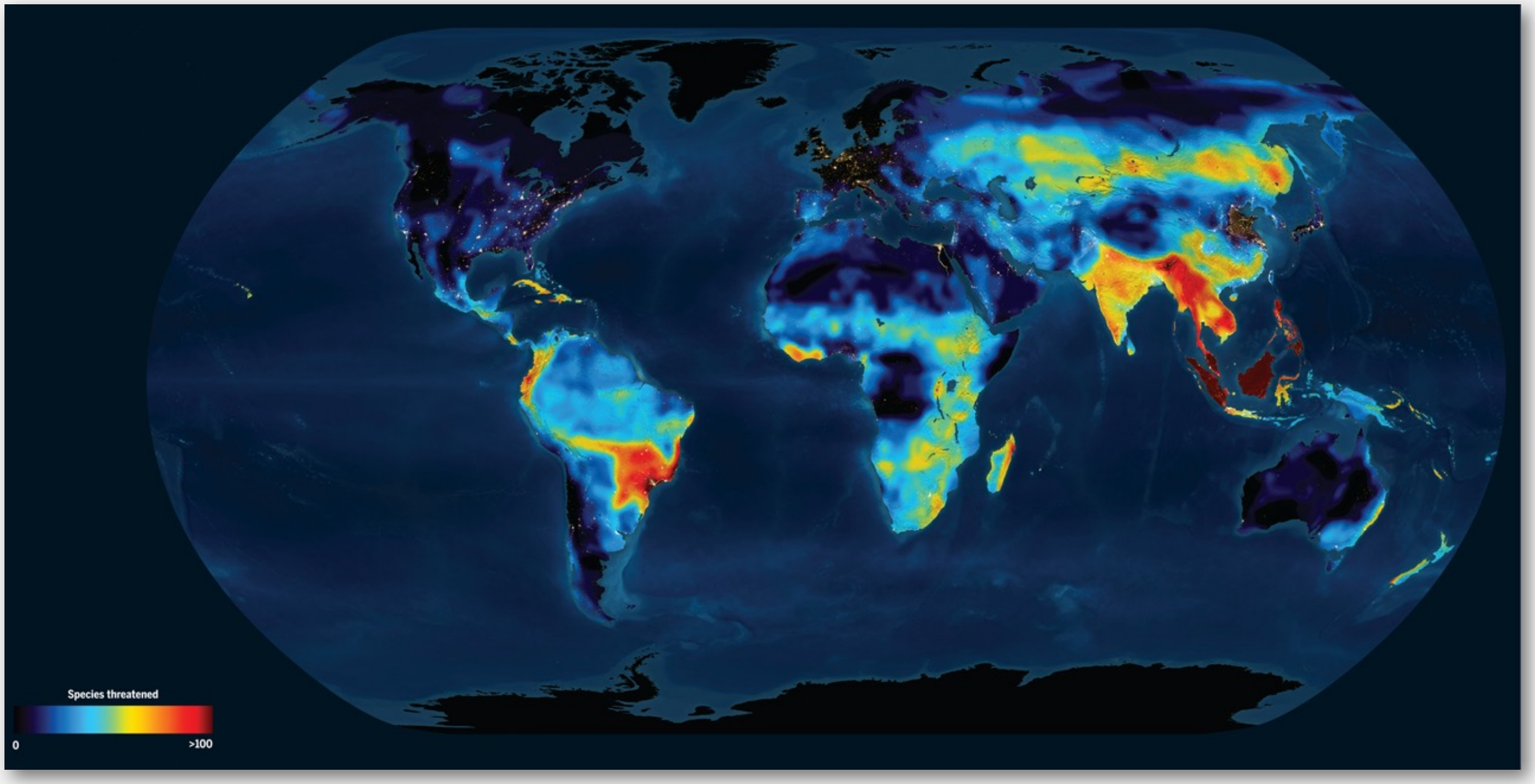
What's the effect?



Vignieri, S. 2014. Vanishing fauna. *Science* 345(6195): 392–395.
Dirzo, R. *et al.* 2014. Defaunation in the Anthropocene. *Science* 345(6195): 401–406.

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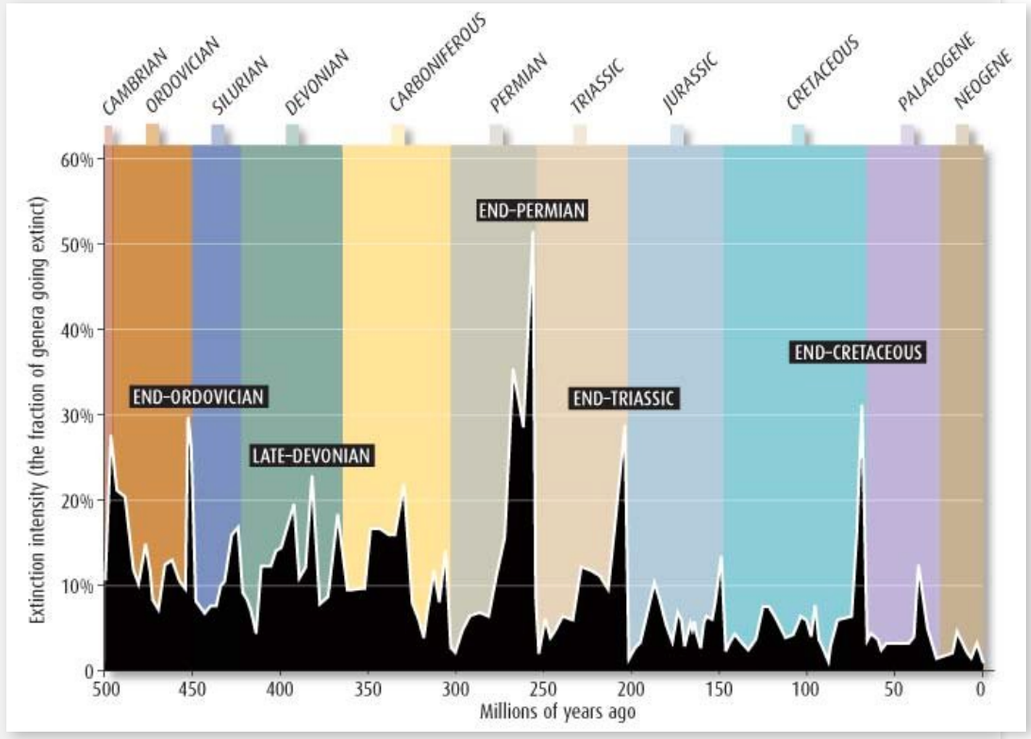
Why worry?
Weren't there crises before?

- We *do* need to worry:
  Earlier extinction events were not nice times
- Evolutionary diversification cannot replace lost diversity on human timescales



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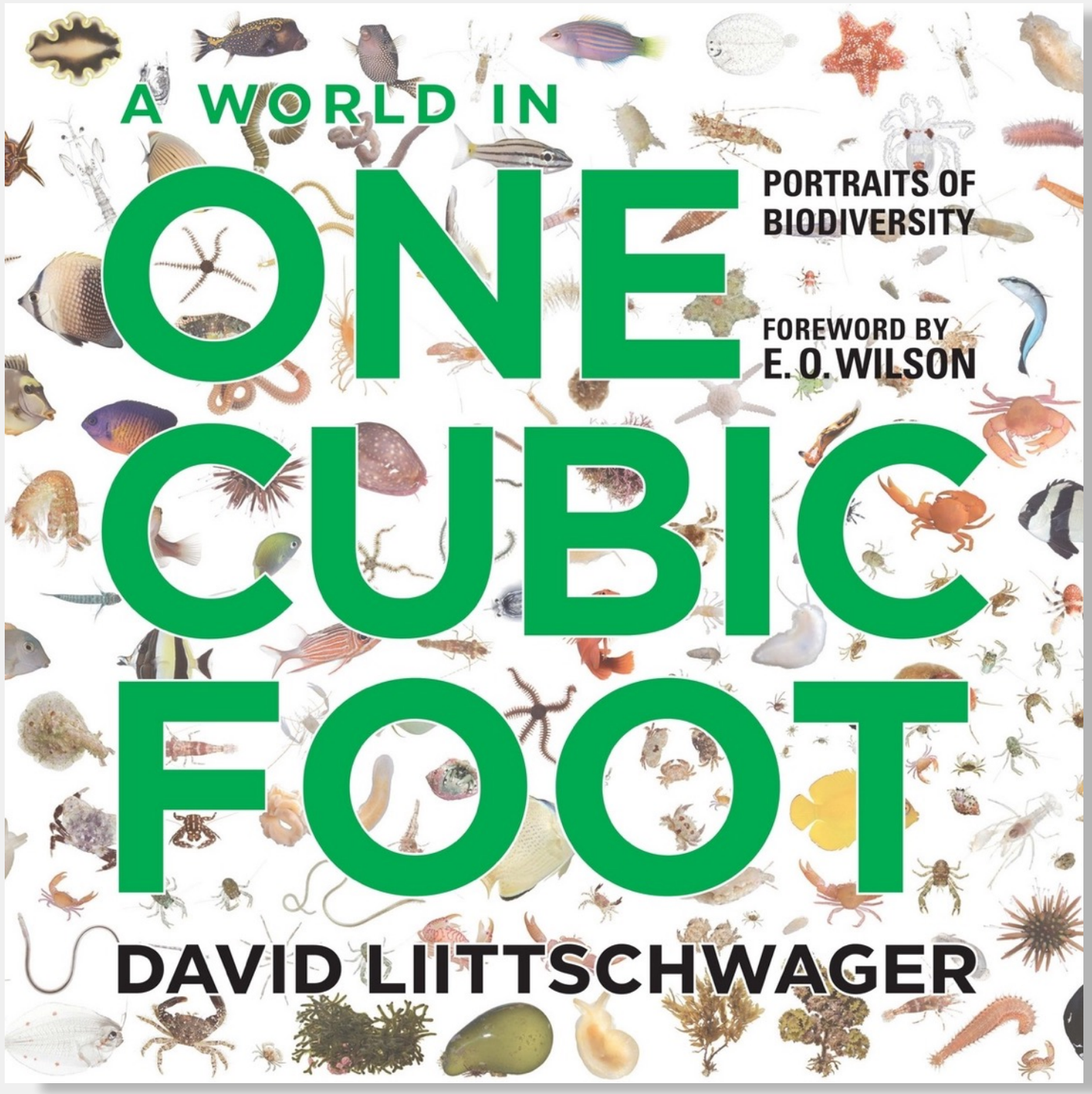
Now
Time →
Origin of Life

Why is it our job to fix it?



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Why is it our job to fix it?

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Why is it our job to fix it?

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Is it all hopeless? No.

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Is it all hopeless? No.

- Elliot Norse, in the 1990s

G.W. Bush: 2006

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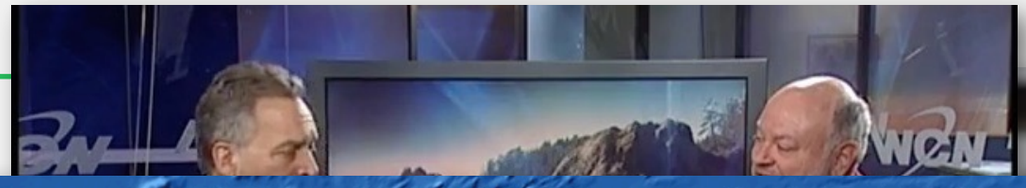
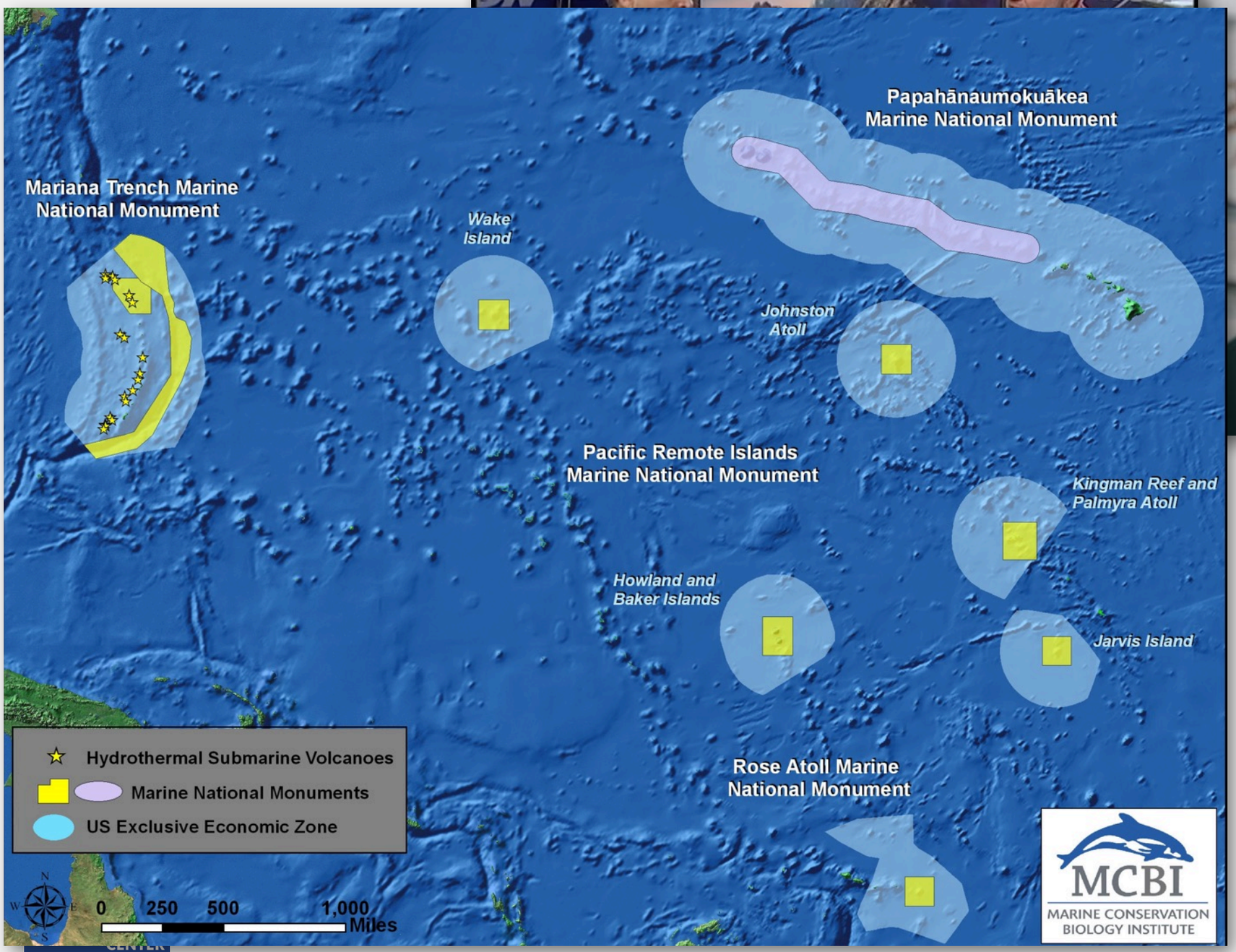
Is it all hopeless? No.





G.W. Bush: 2006

B. Obama: 2014

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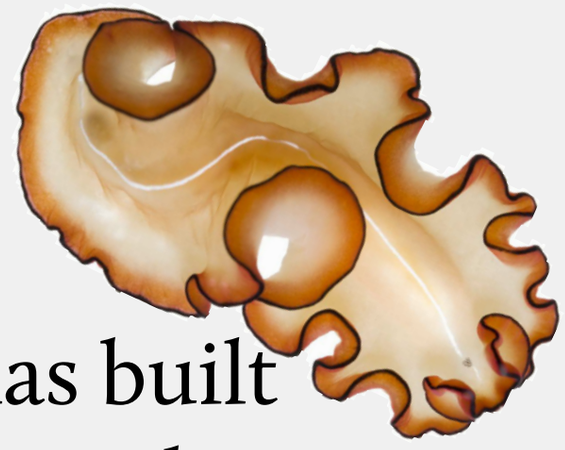
Closing thoughts



> If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.
>
> — Aldo Leopold *Round River: From the Journals of Aldo Leopold*

> We are as gods, and might as well get good at it.
>
> — Stewart Brand *The Last Whole Earth Catalog: Access to Tools*