

Origin and Evolution of Life



The Handfish
-BBC Blue Planet

**OCN 201 Science of the Sea
Biology Lecture 2**

Evolution

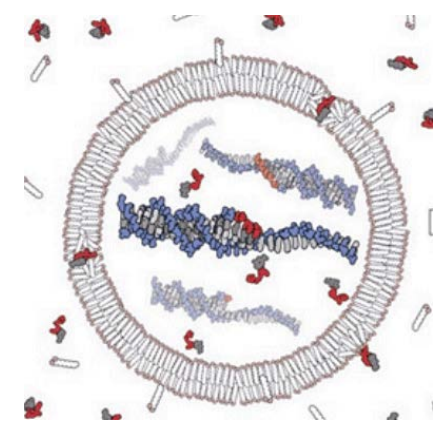
Nothing in biology makes sense except in the light of evolution

I am a creationist and an evolutionist. Evolution is God's, or Nature's method of creation. Creation is not an event that happened in 4004 BC; it is a process that began some 10 billion years ago and is still under way.

- *Theodosius Dobzhansky (1973)*

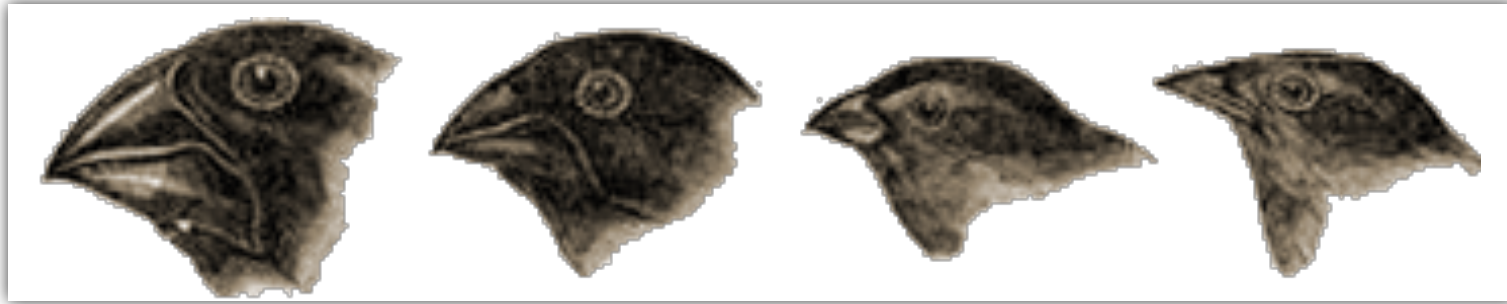
https://www.pbs.org/wgbh/evolution/library/10/2/text_pop/l_102_01.html

Mechanism of Evolution of Life



- However the first self-replicating cell came into existence over 3.5 billion years ago it would be immediately subject to the process of **Evolution by Natural Selection**
- This is is the mechanism by which one type of organism gives rise to two different types of organism

Basis of Evolution by Natural Selection

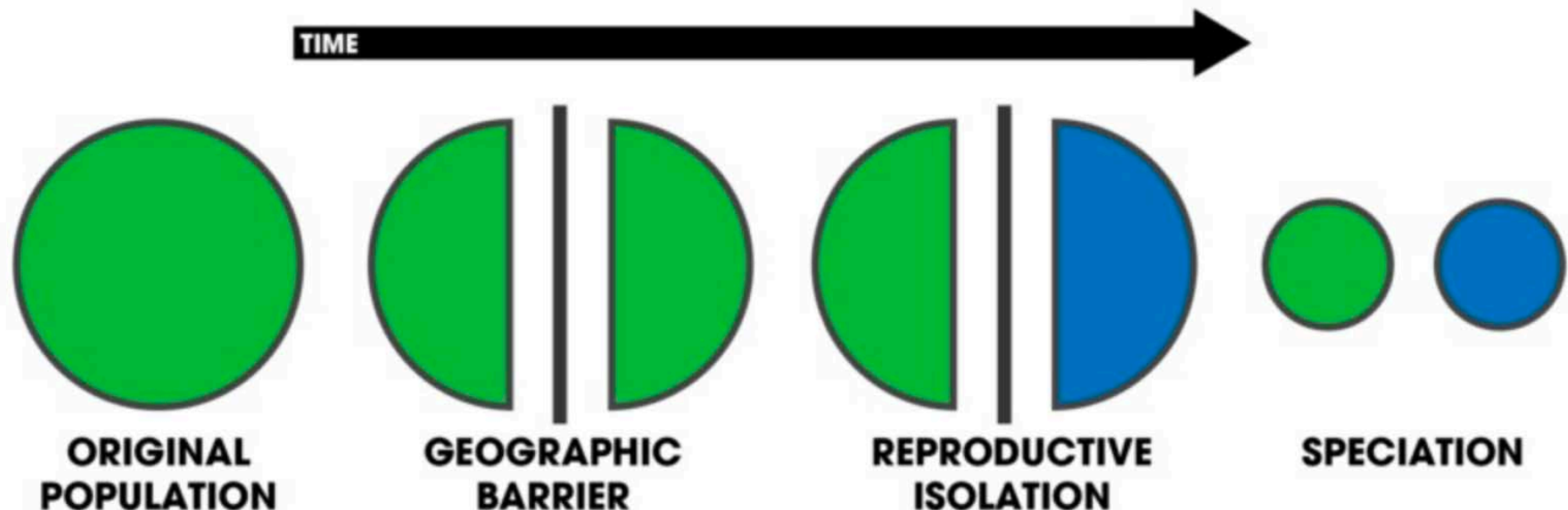


- ▶ **Heritability** of traits from parent to offspring
- ▶ **Variability** among offspring (mutations, recombination)
- ▶ **Over-production** of offspring
- ▶ **Selection** by the environment: More individuals with favorable traits will survive and reproduce than those with unfavorable traits

Speciation

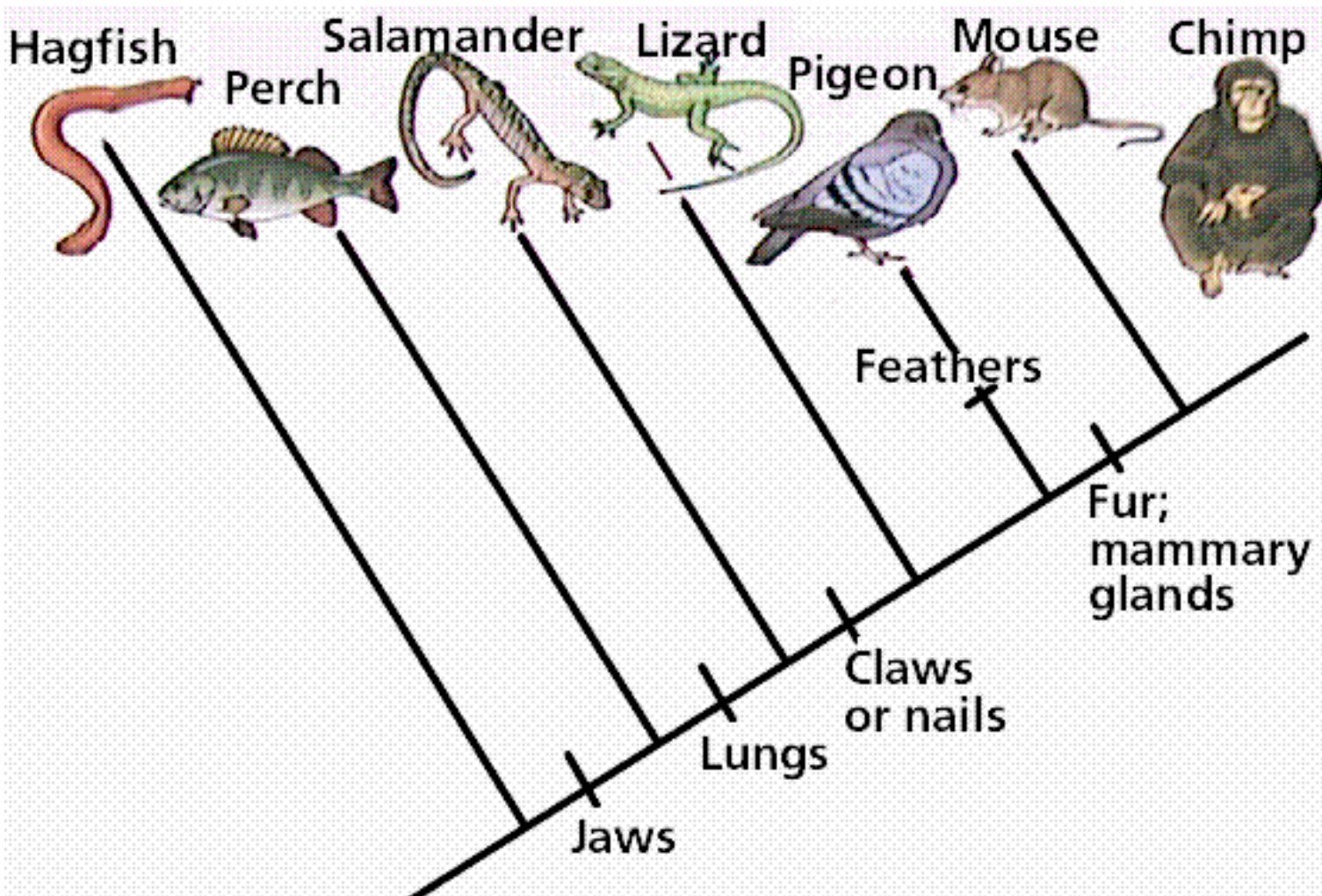
Evolutionary drift can lead to new species when a population becomes split into sub-populations

- **Separated sub-populations continue to evolve**
- **They slowly become more and more different until they are so divergent they become different species**



Classification of Life

The splitting of one species into two leads to a nested hierarchy of characteristics that can be shown as a branching tree

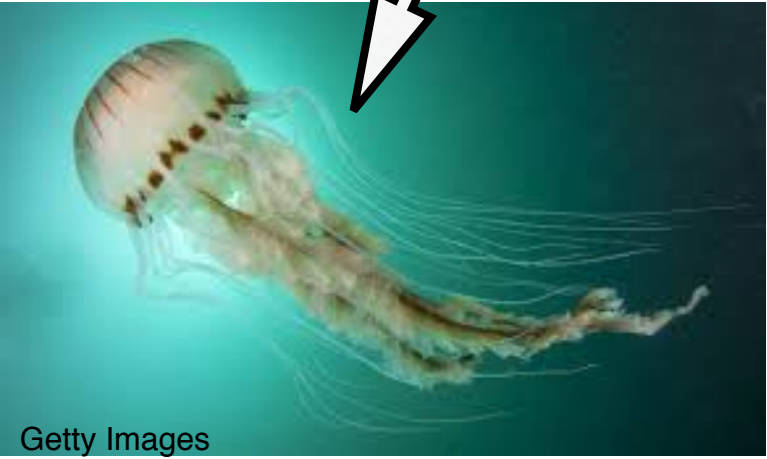
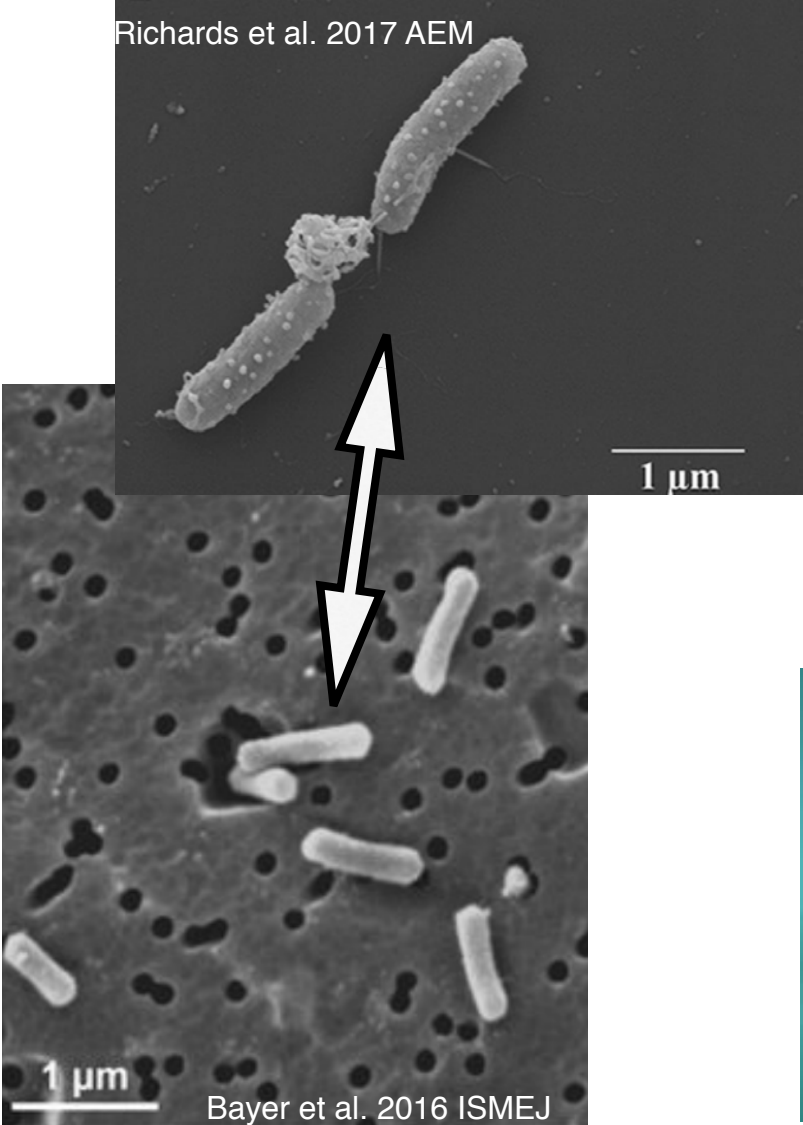


Expanding evolution to microorganisms

- ▶ Early evolutionary theory focused on big things (multicellular eukaryotes)
- ▶ Diversity of microorganisms was not appreciated because their differences were hidden

These look similar, but are **VERY** distant relatives

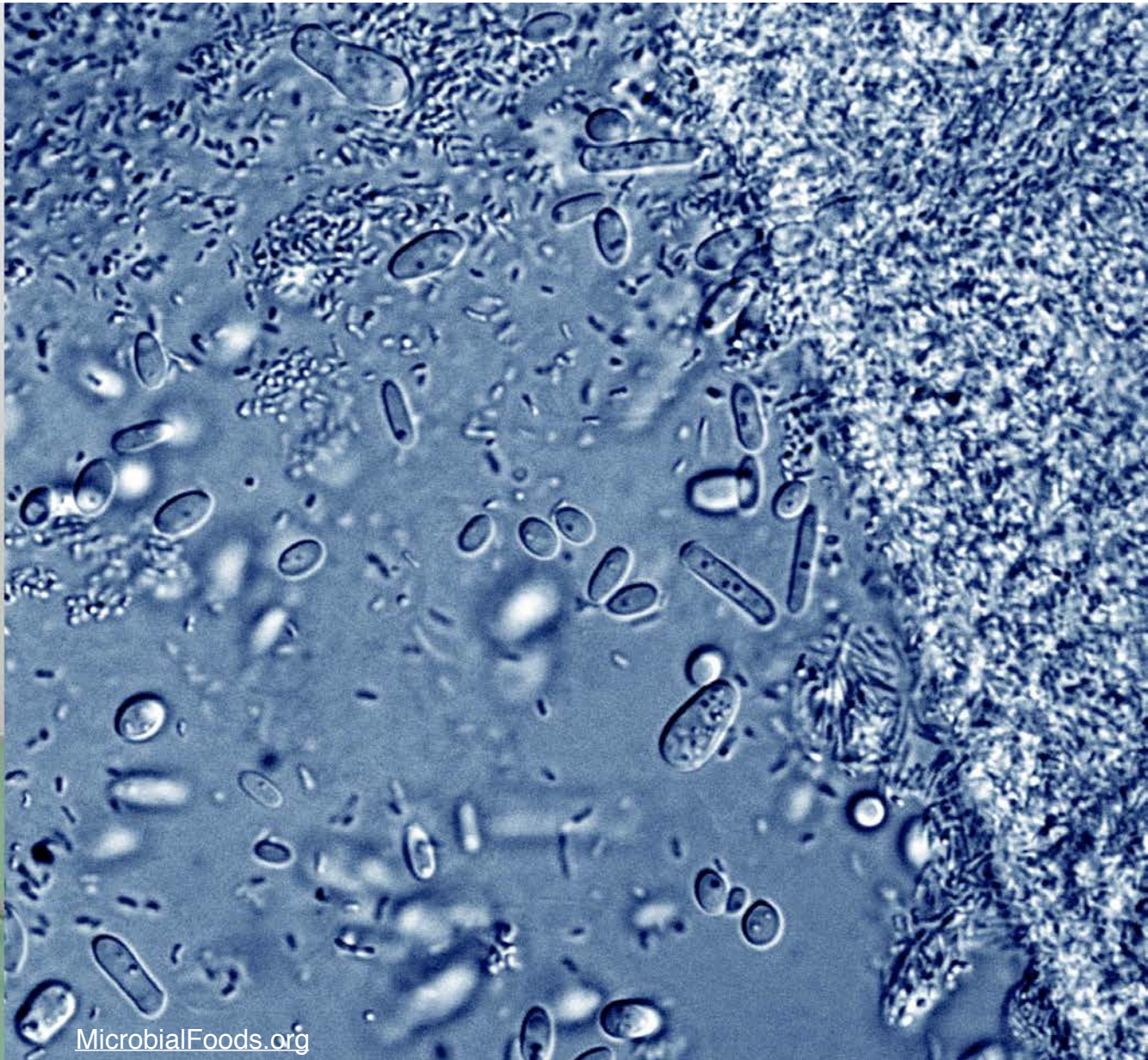
These look very different, but are much closer relatives



How do we deal with microbes?



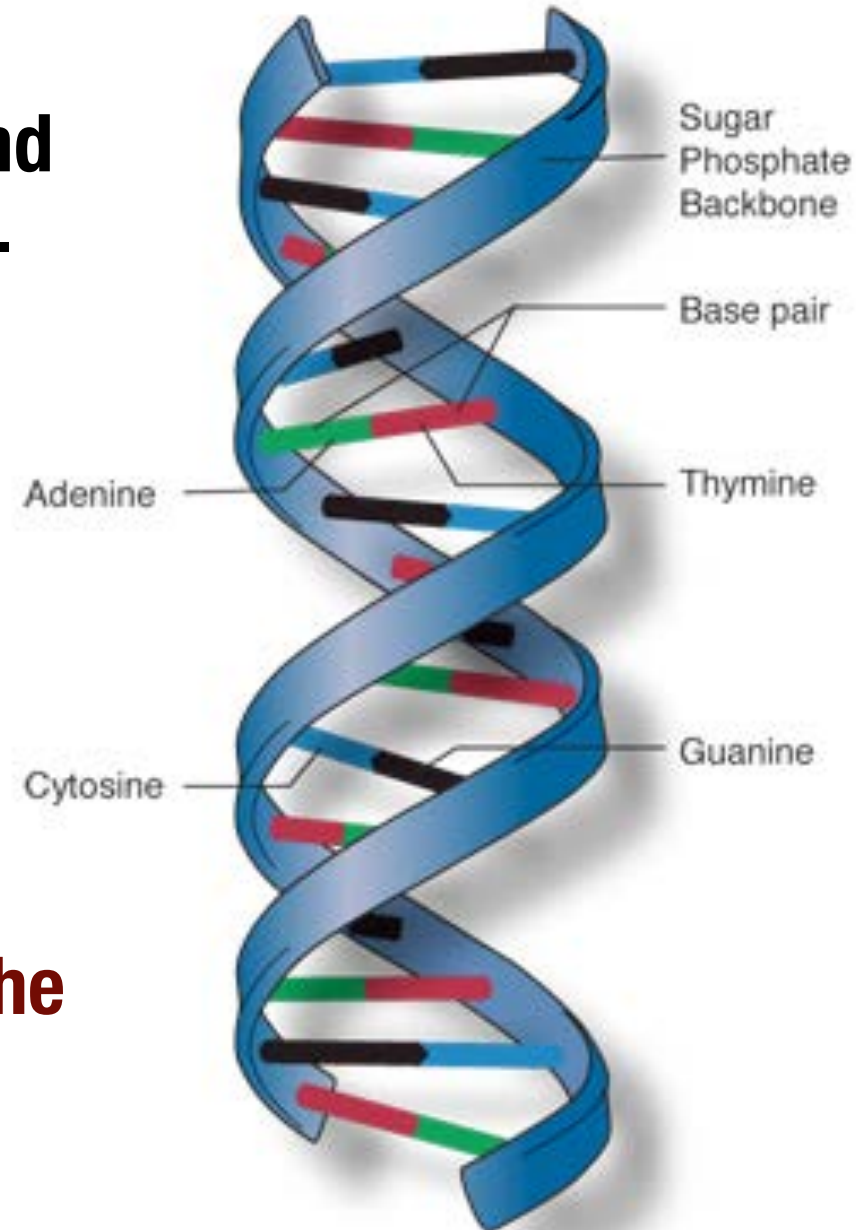
Microscope photo from Wikipedia user "Moisey"



MicrobialFoods.org

Fossil vs Molecular Evidence

- ▶ **Early work focused on plants and animals - detailed morphology - easy to compare**
- ▶ **The evolutionary history of microbes was unclear**
- ▶ **Breaking of the genetic code changed everything!**
- ▶ **The history of life is written in the DNA of all living things**

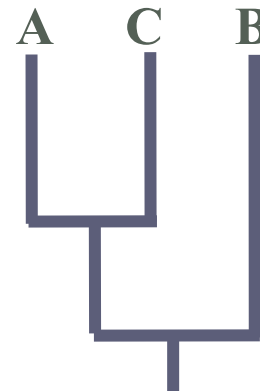


Sequence Comparisons

1 [2 [Seq. A ATACGGTCAC . .
2 [Seq. B ATTCGCTCAC . .
2 [Seq. C ATGCGGTCAC . .

	A	B	C
A			
B	2		
C	1	2	

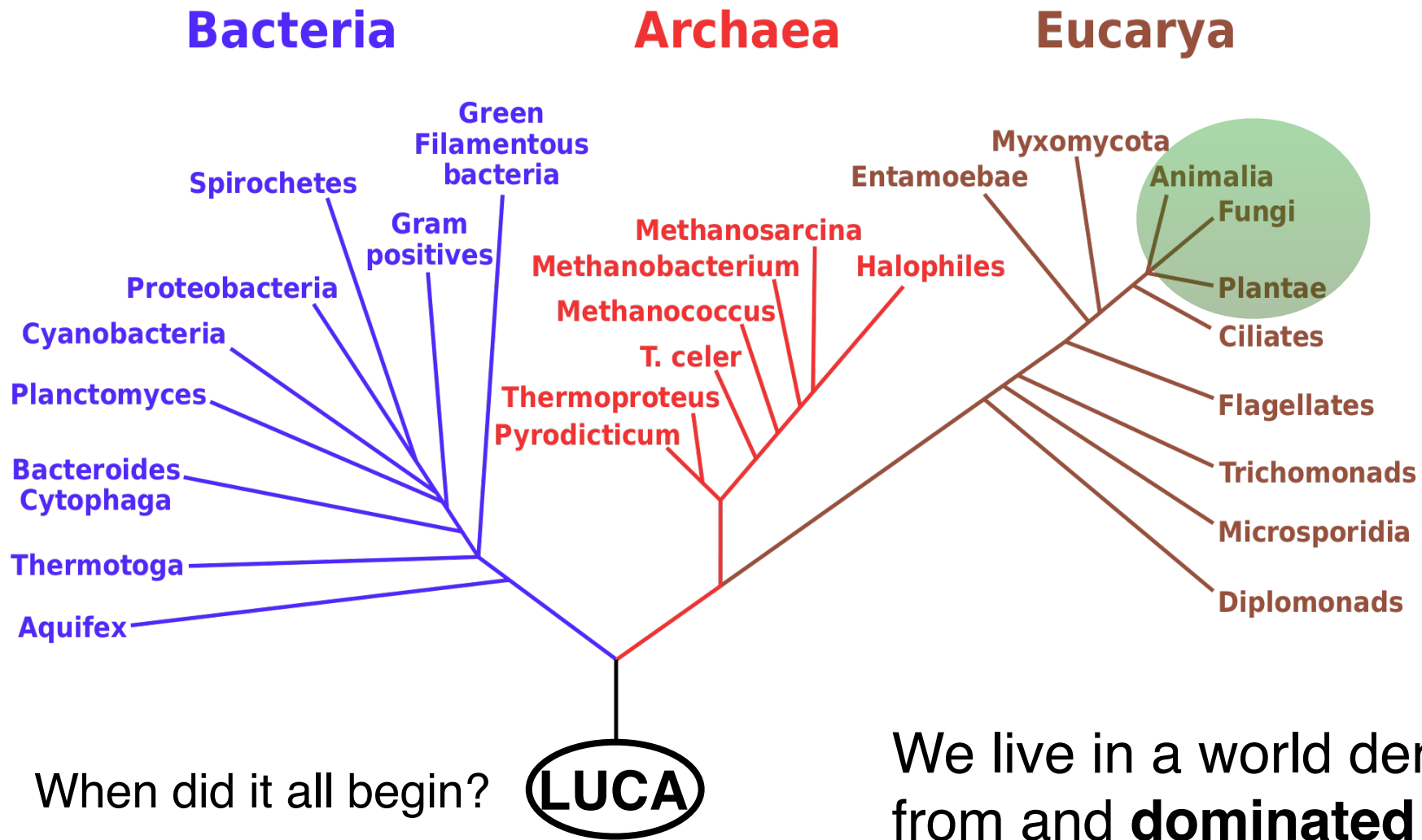
Distance matrix can then
be used to build a
phylogenetic tree



DNA-based view of the Tree of Life

- DNA evidence confirmed inferred relationships among plants, animals, and fungi, and supported fossil evidence
- **...but it revolutionized our view of the microbial world**

Phylogenetic Tree of Life



When did it all begin?

LUCA

Last universal common ancestor

We live in a world derived from and **dominated** by microorganisms!

First Evidence of Life

- **Earth formed about 4.5 billion years ago (bya) and crust solidified 4.1 bya**
- **Mineral deposits, produced only by biological activity, dated at 3.8 bya**
- **Fossils resembling present-day mats of marine microorganisms found at about 3.5 bya**

Fossils of early microbial life

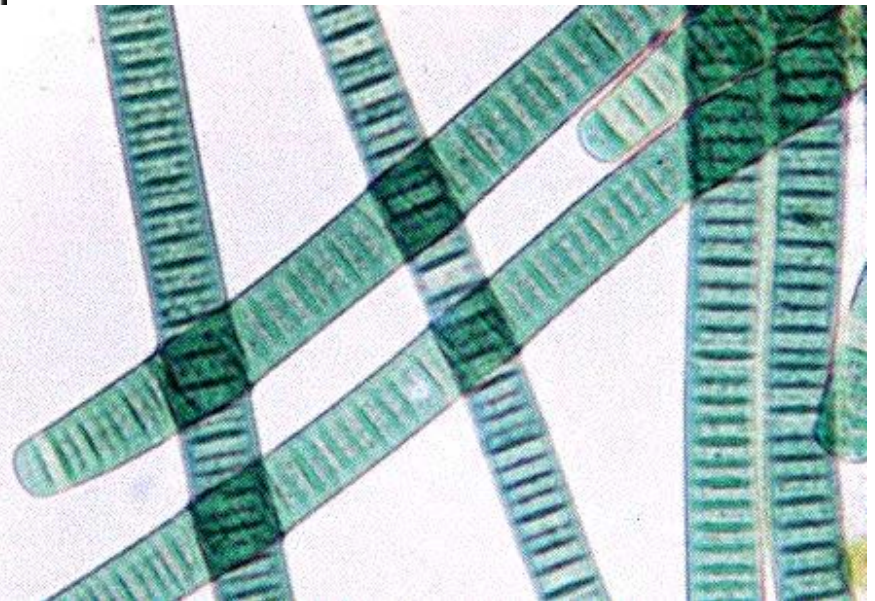
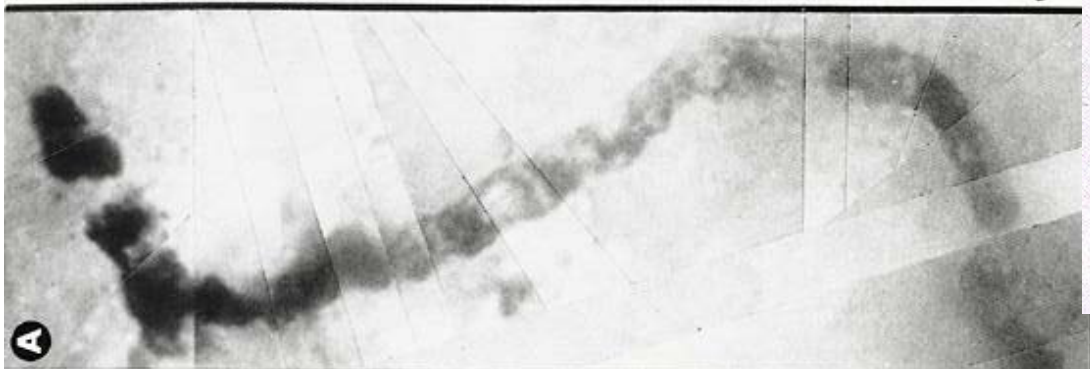
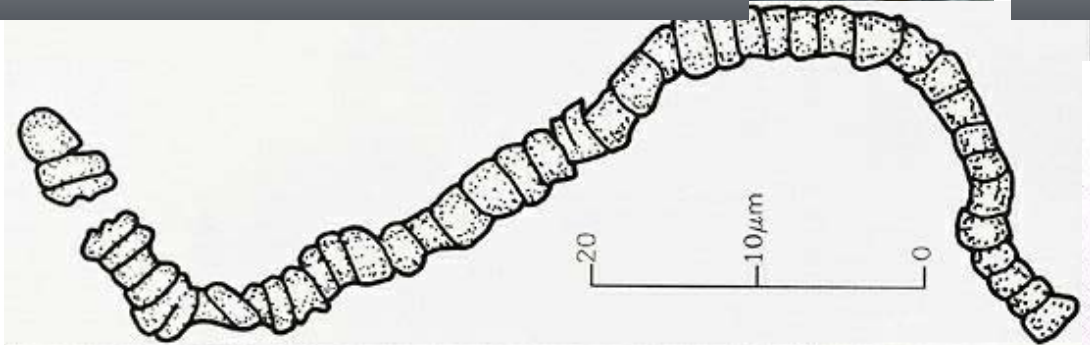


Fossil Stromatolites



Modern Stromatolites

A. Bourque



Evolution of Life

All scientific evidence points toward the diversity of present-day life arising through the process of evolution over time

- **Common chemistry and building blocks**
- **Genetic history traces back to common origin**
- **Simple forms of life appear before more complex forms**

Evolutionary History of Life

Complexity appears gradually over time

Prokaryotes

Eukaryotes

BACTERIA & ARCHAEA

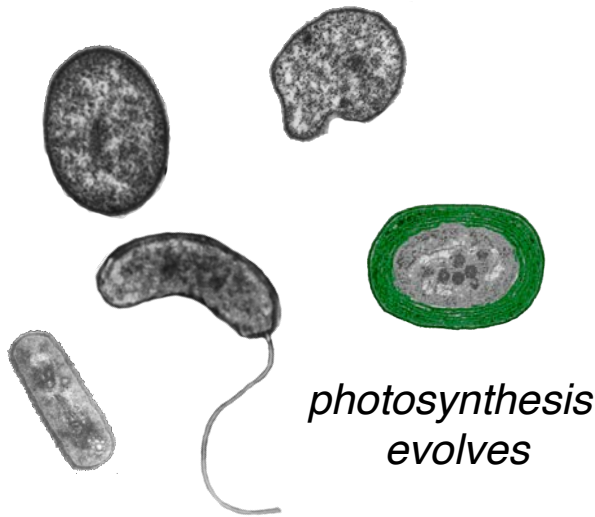
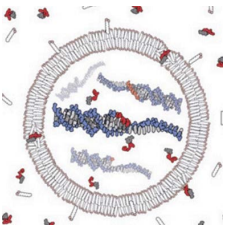
EUKARYA

Protists

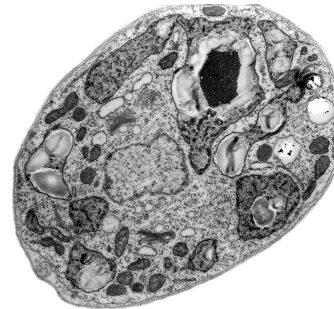
animals, plants, fungi

Multicellular Life

Protocell



photosynthesis evolves



single-cell

colonial



3.8 bya

2.5 bya

2 bya

0.7 bya

TIME

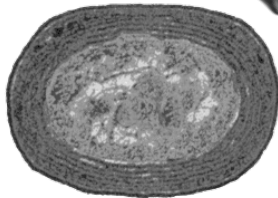
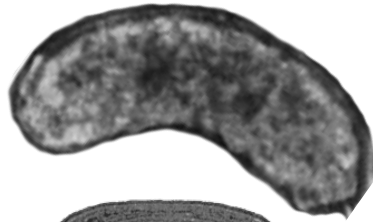
A Fundamental Division

Eukaryotic cells have complicated structure

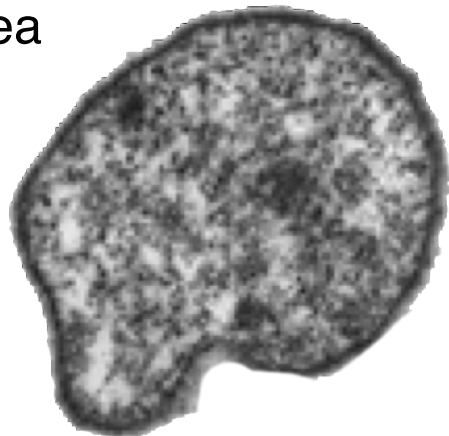
Prokaryotes



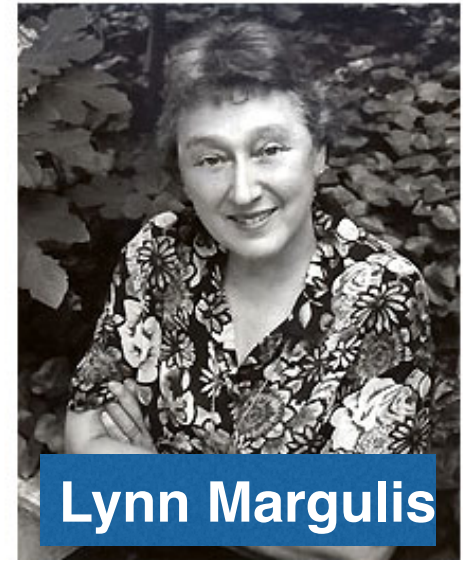
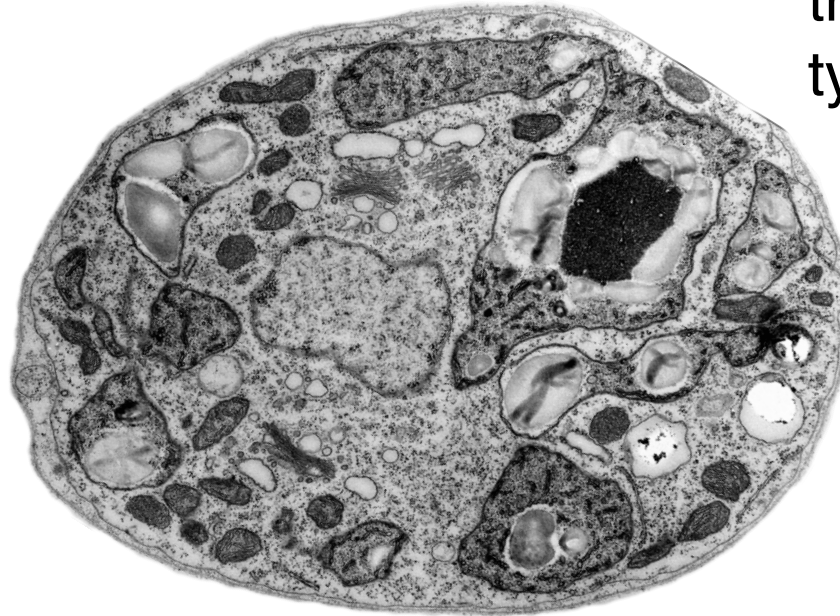
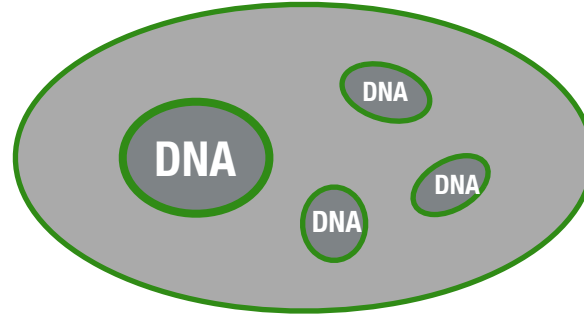
Bacteria



Archaea



Eukaryotes

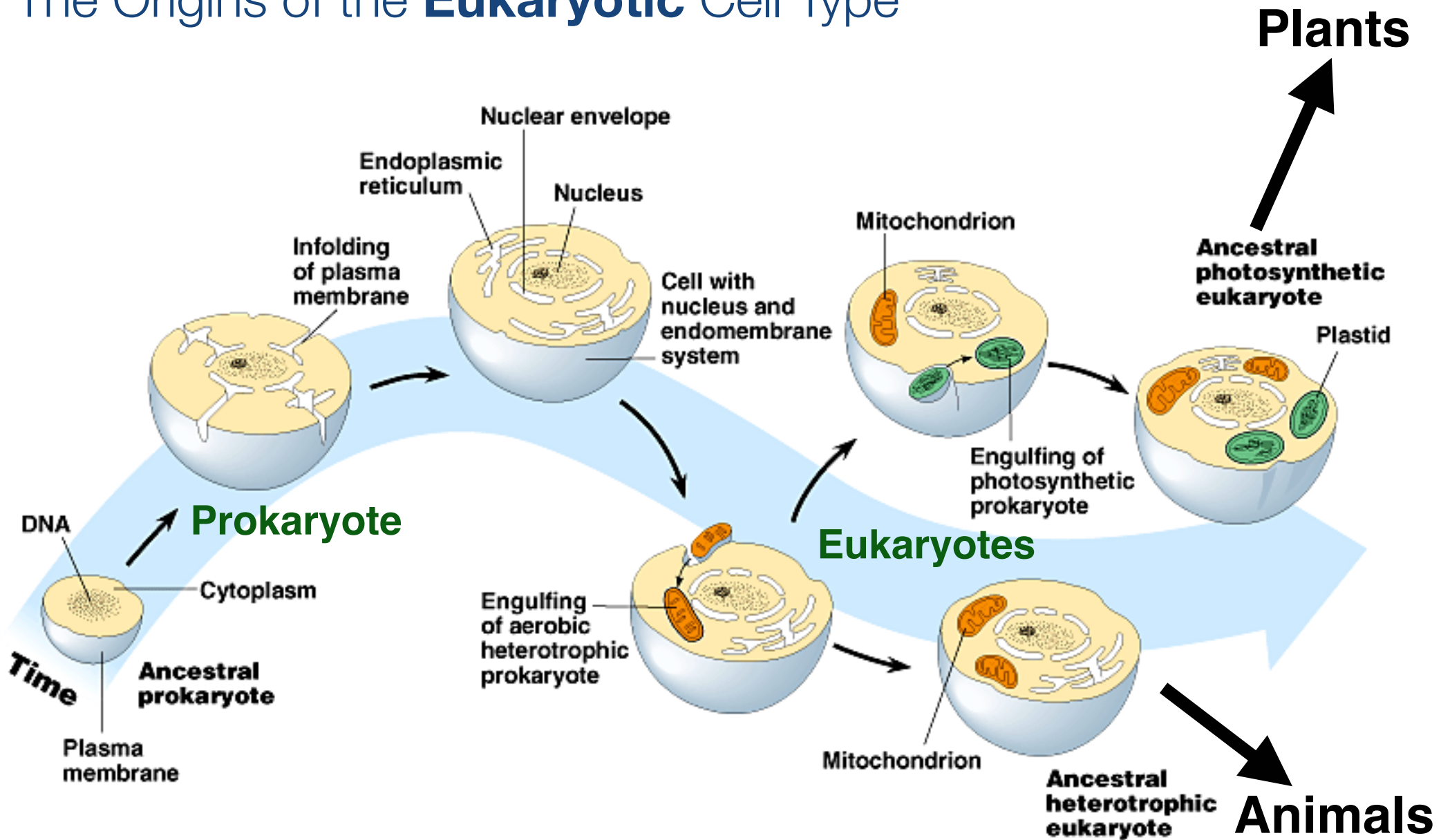


Lynn Margulis

Proposed a theory about the origin of the eukaryotic cell type

Serial Endosymbiosis Theory

The Origins of the **Eukaryotic** Cell Type

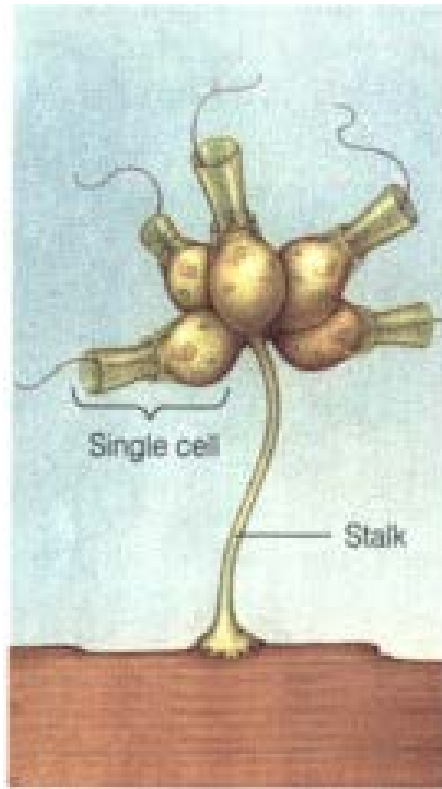
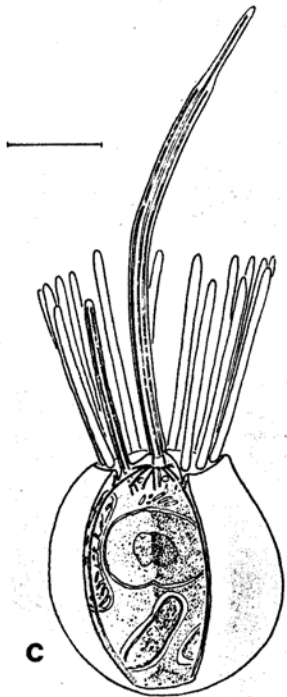


Origins of Animals

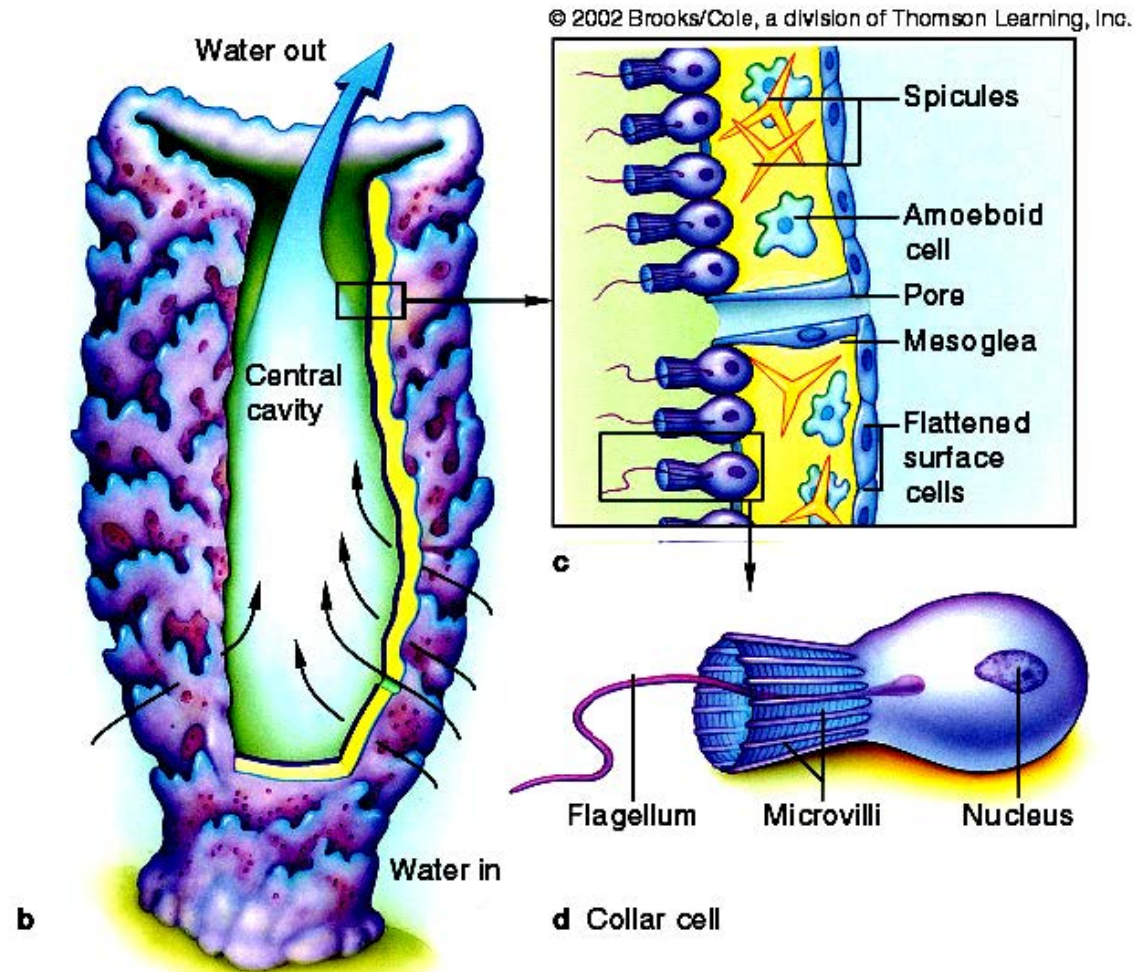
Multicellular

Colonial

Unicellular



D. A choanoflagellate colony



Origins of Plants

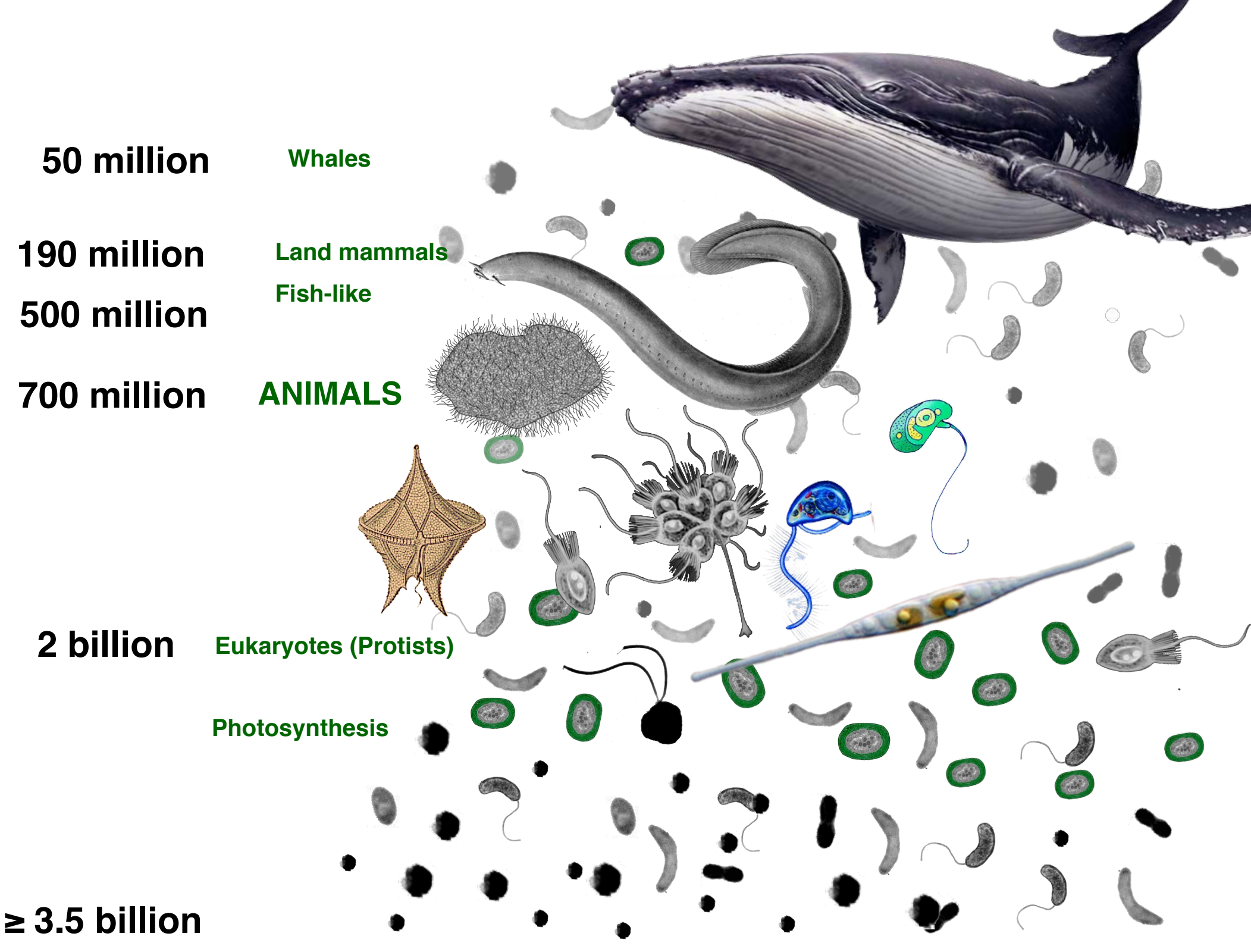
Multicellular
marine alga

terrestrial moss

Colonial



Unicellular
Eukaryote



Key Points

- Evolution is not uni-directional...**but**
- Simple things came first - complexity accumulates slowly through trial and error via many known mechanisms
- Eukaryotes arose through **Serial Endosymbiosis**
- The simple and the complex continue to co-exist
- As the earth changes, species die off and new ones emerge

