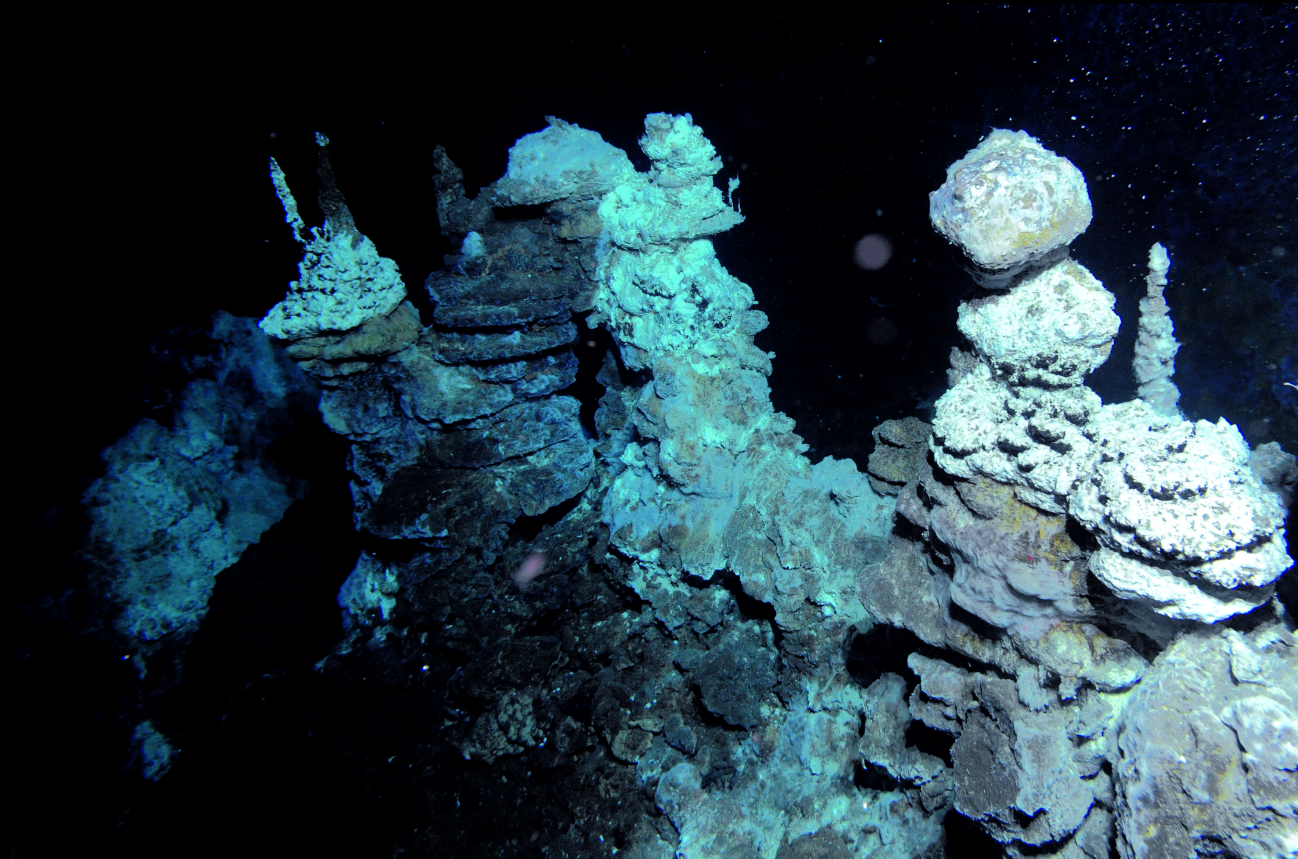
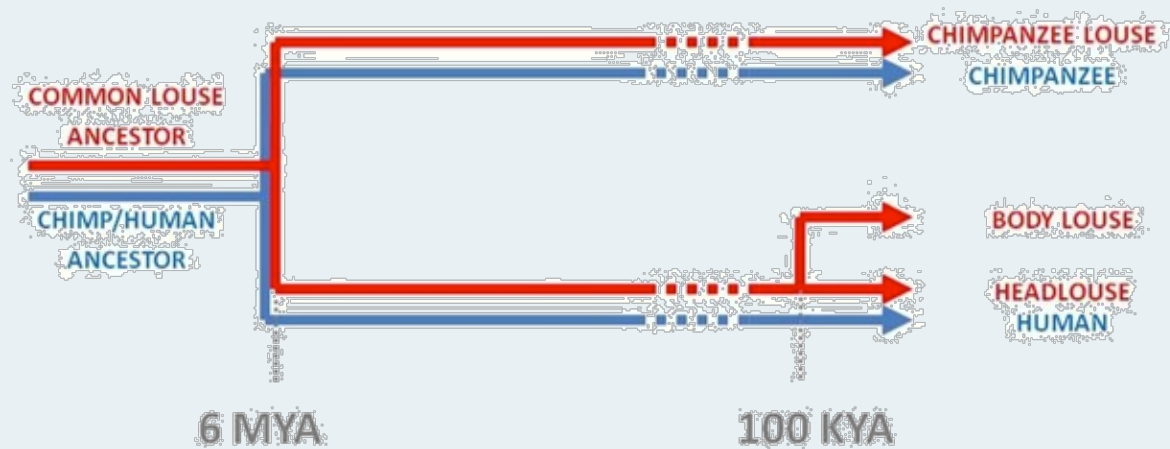


Molecular Archaeology: Using genomes to reconstruct two billion years of cellular life

Mukund Thattai
ICTS@10, January 2018
thattai@ncbs.res.in



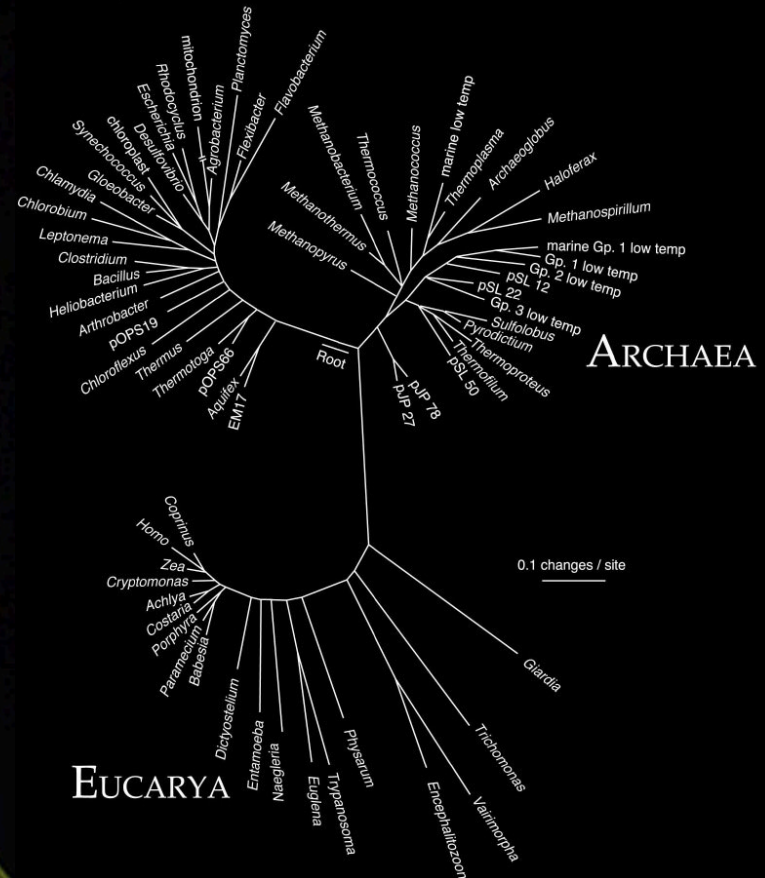
Molecular archaeology: Using DNA/RNA/proteins as probes to reconstruct historical events



Here's what we know
about the origins of eukaryotes
so far...

Carl Woese's "Archaea"

BACTERIA



ARCHAEA

EUCARYA

Tree: Norman Pace
Photo: IGB

Lynn Margulis's
mitochondrial endosymbiont
hypothesis



J. Theoret. Biol. (1967) **14**, 225–274

On the Origin of Mitosing Cells

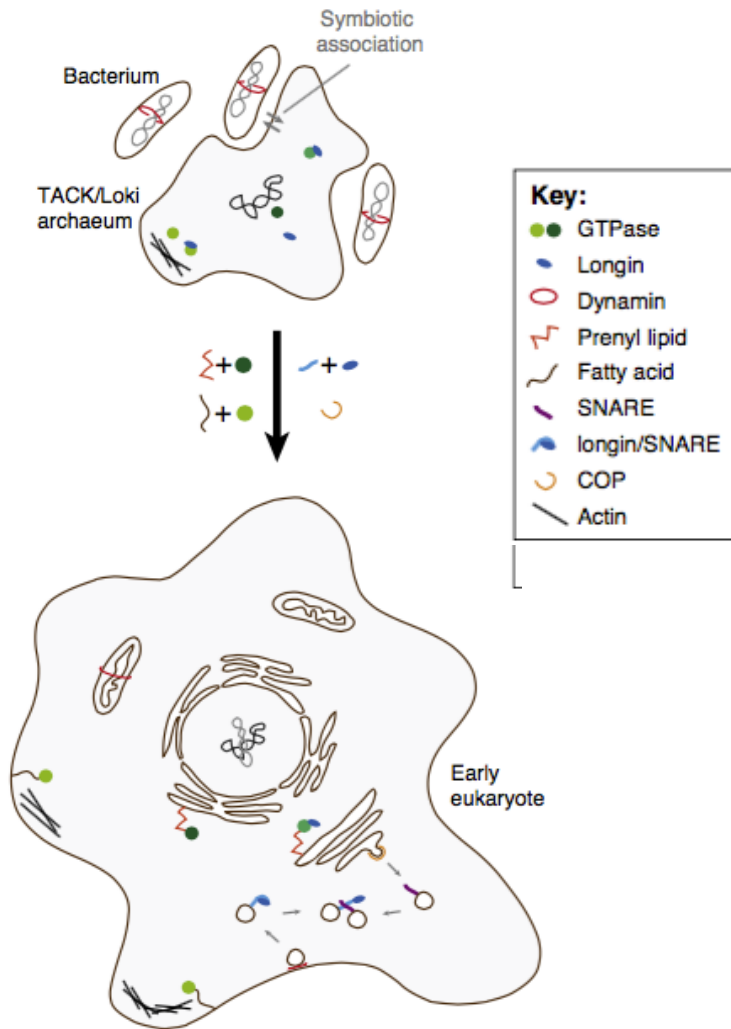
LYNN SAGAN

*Department of Biology, Boston University
Boston, Massachusetts, U.S.A.*

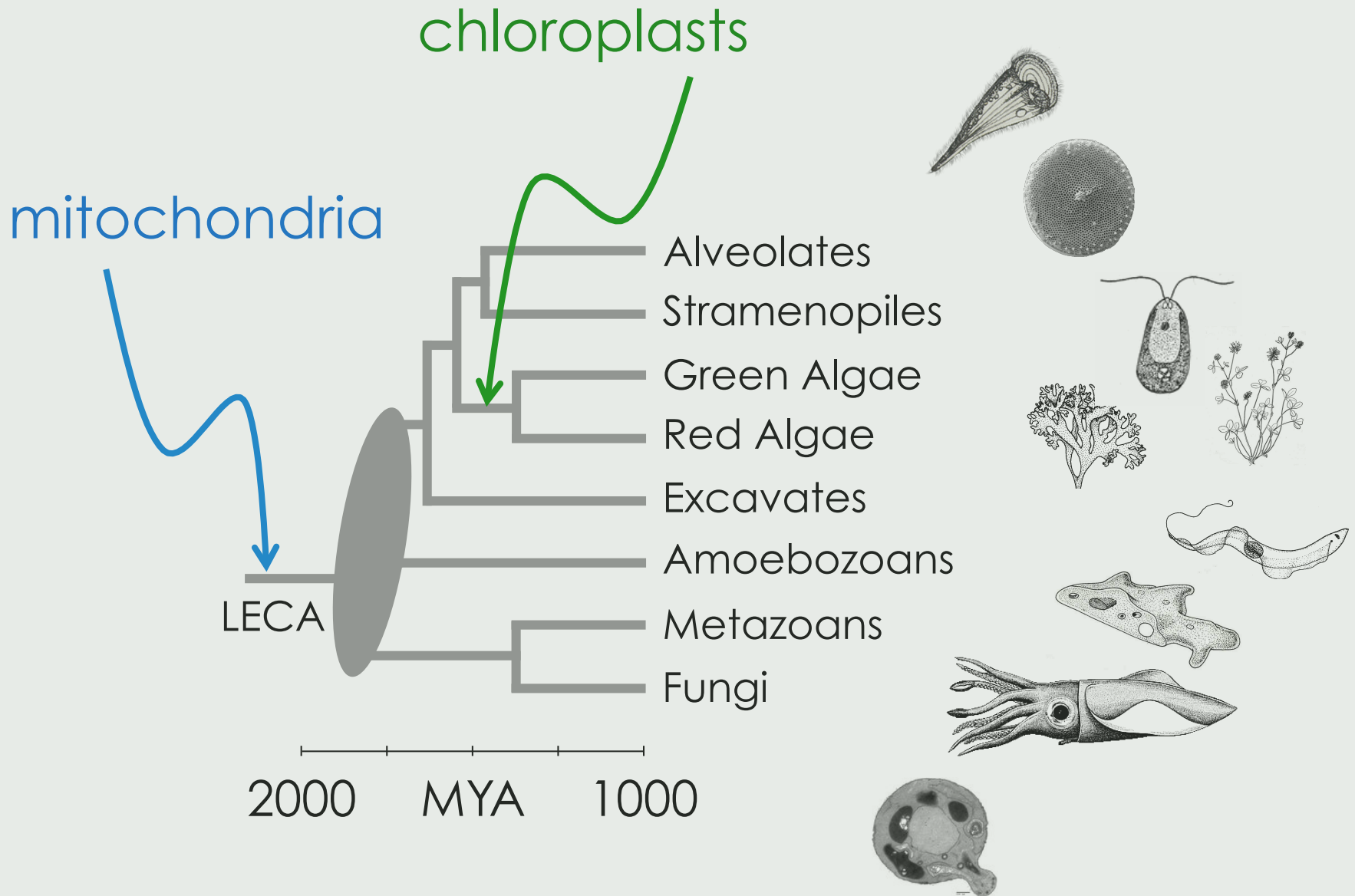
(Received 8 June 1966)

A theory of the origin of eukaryotic cells (“higher” cells which divide by classical mitosis) is presented. By hypothesis, three fundamental organelles: the mitochondria, the photosynthetic plastids and the (9+2) basal bodies of flagella were themselves once free-living (prokaryotic) cells. The evolu-

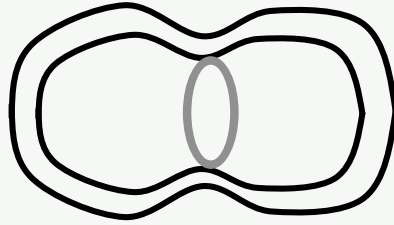
Eukaryotes = Archaea + Bacteria



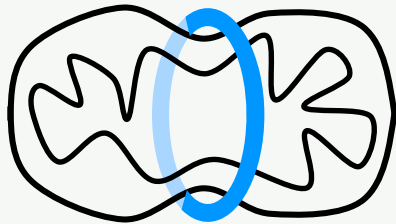
	Bacteria	<i>Lokiarchaeum</i>	Eukaryotes
Small GTPases	—	Present	Present
CAAX domains	—	—	Present
Prenyltransferases	—	—	Present
Fatty acid transferases	—	—	Present
GDI/GDF/REP/accessory	—	—	Present
Longin/Roadblock	Present	Present	Present
SNARE	—	—	Present
Coat proteins	—	—	Present
Dynamins	Present	—	Present
Actin/actin-like proteins	Present	Present	Present



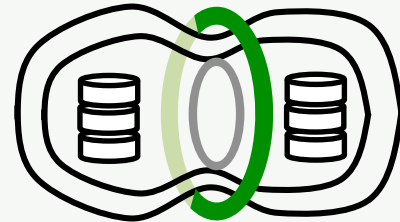
Eukaryote endosymbiont division is coordinated by dynamin



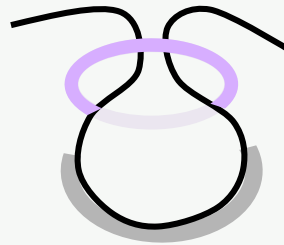
Bacteria:
FtsZ



Mitochondria:
Dynamin + ?



Chloroplasts:
Dynamin + FtsZ

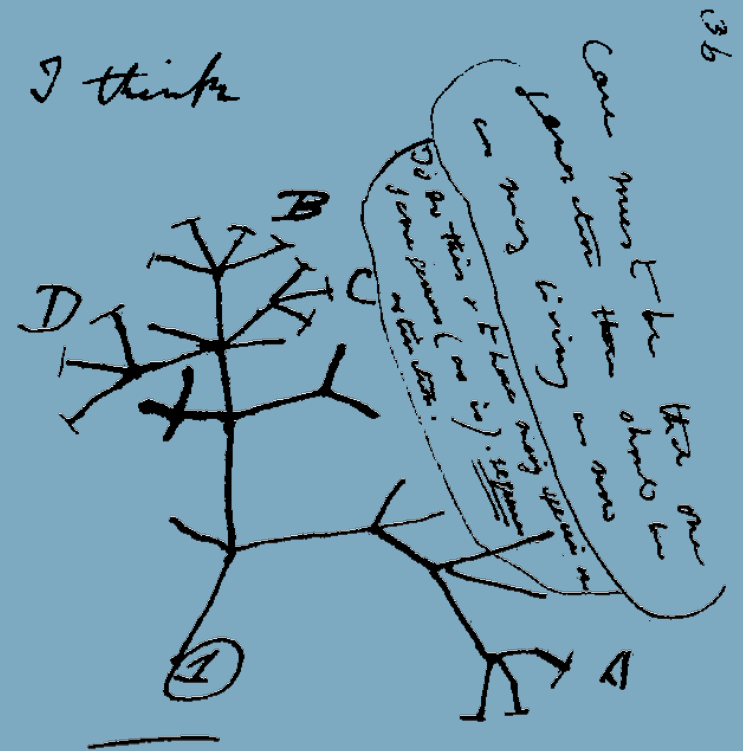


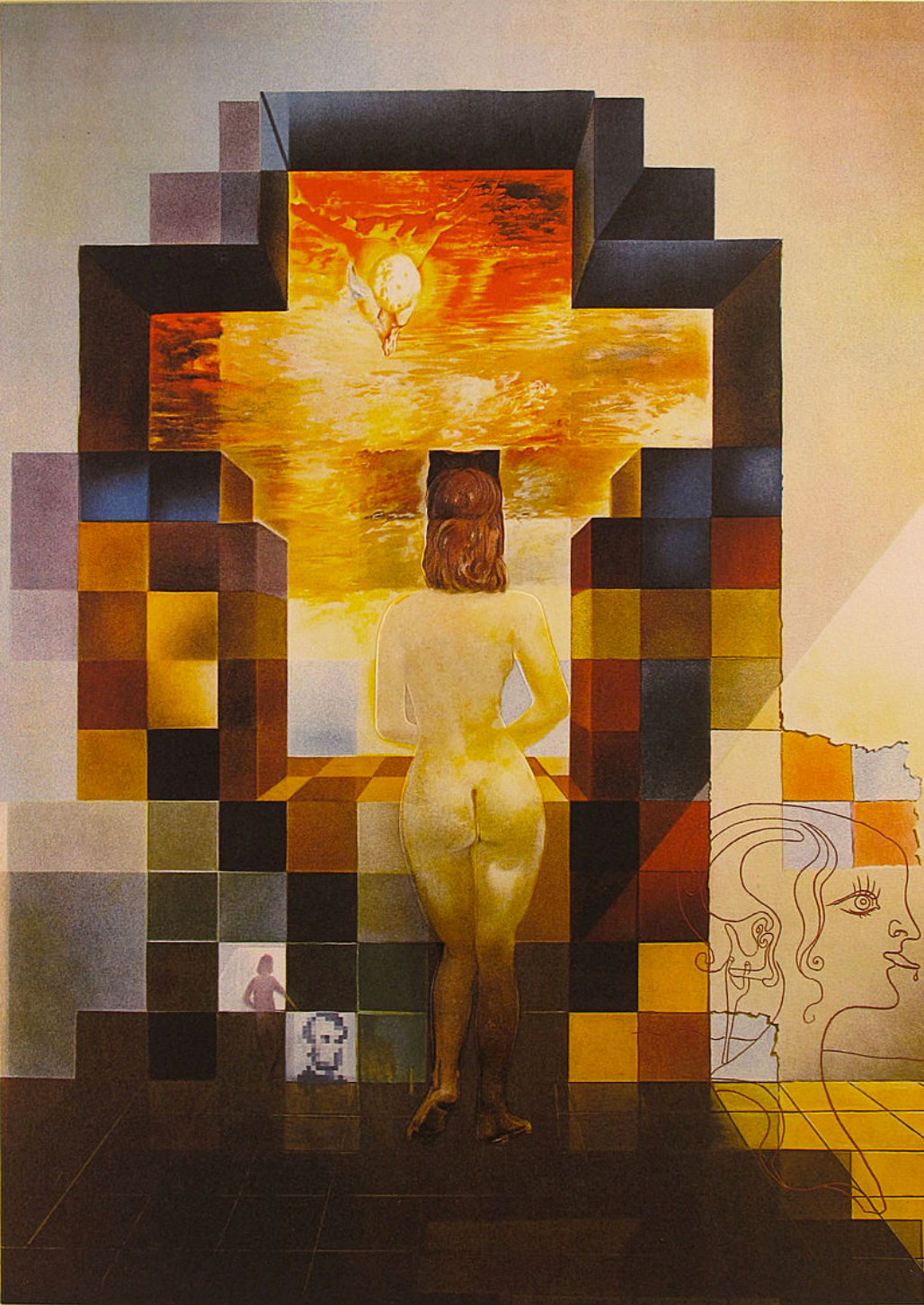
Vesicle scission:
Dynamin + Clathrin

What did the early
mitochondrial division apparatus
look like?

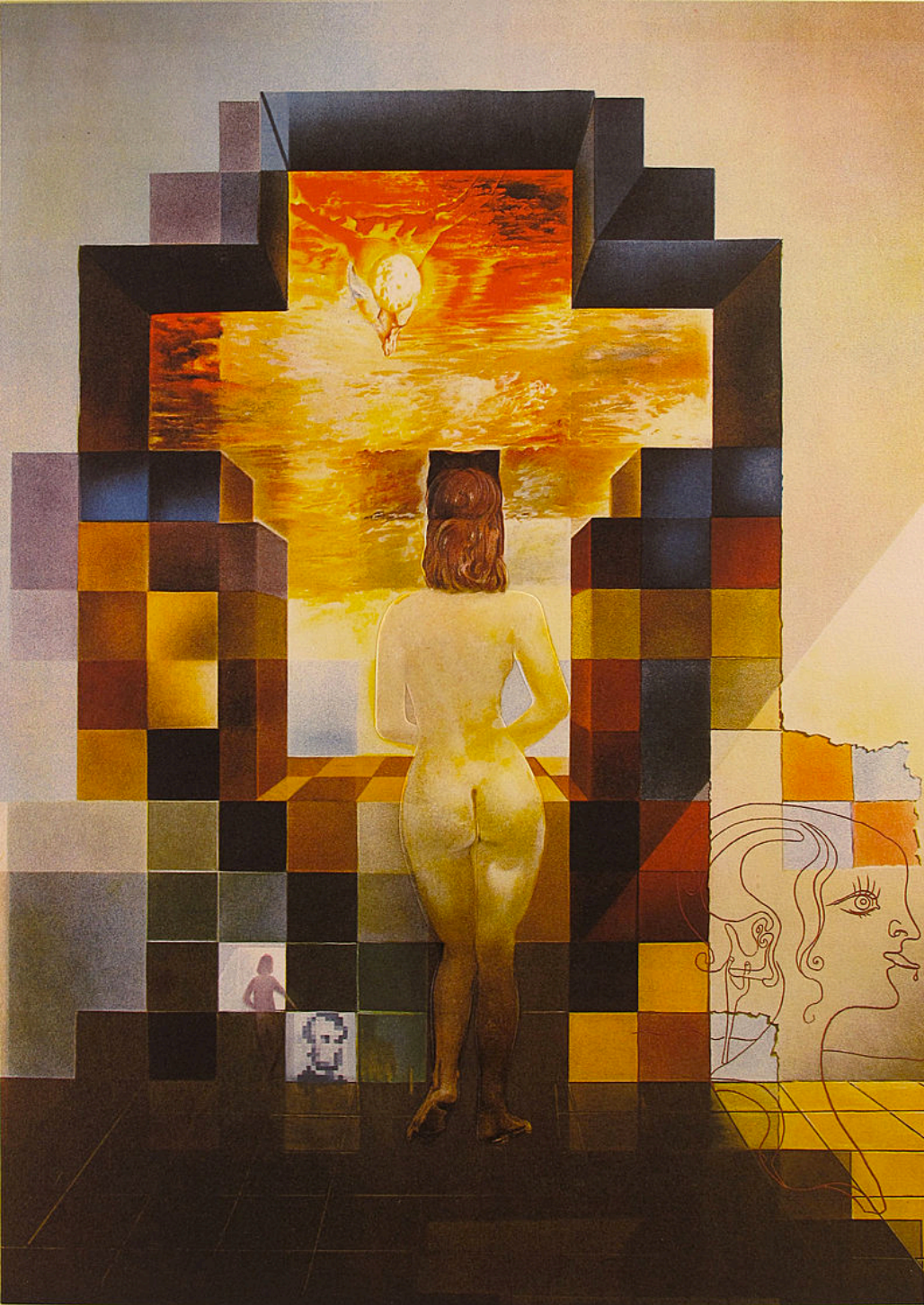
What would Darwin do?

On the Origin of Species



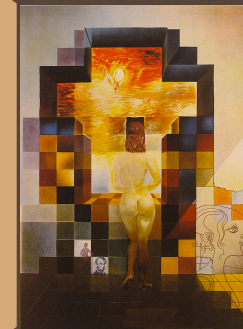


To look billions of years
into the past ...



To look billions of years
into the past ...

we might have to
squint a bit

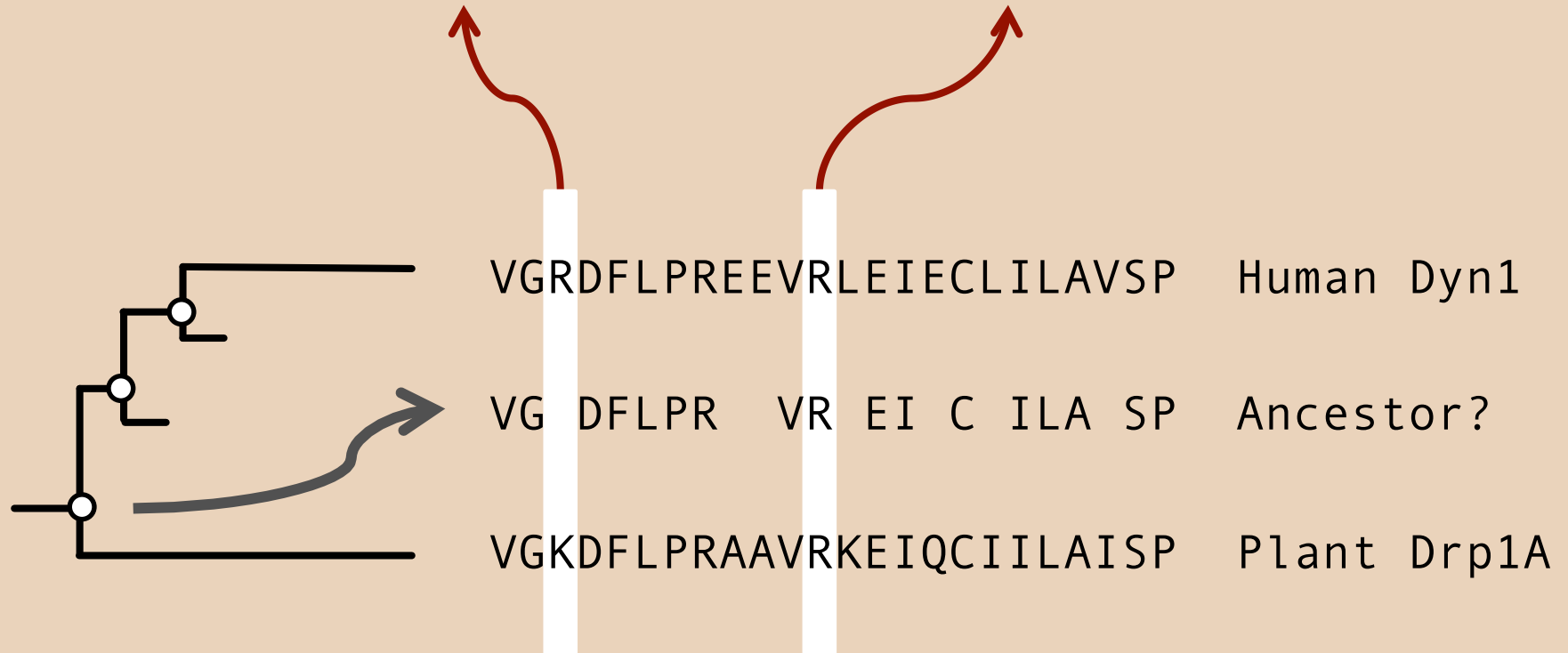


Lincoln in Dalivision, Salvador Dalí

Real amino acid sequences

Unknown?

Convergence?

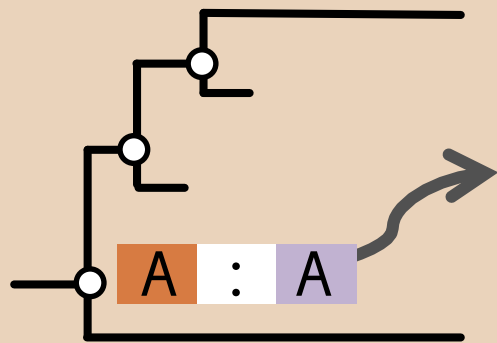


2000 MYA 0

Coarse-grained sequences

"fake amino acids"

A A A : : : : :



VGRDFLPREEVRLEIECLILAVSP

Human Dyn1

VG DFLPR VR EI C ILA SP

Ancestor?

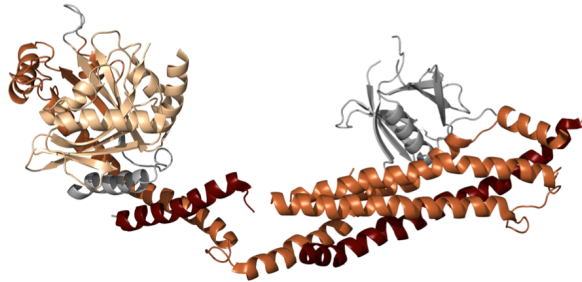
VGKDFLPRAAVRKEIQCIILAISP

Plant Drp1A

2000 MYA 0

A V A : : : : :

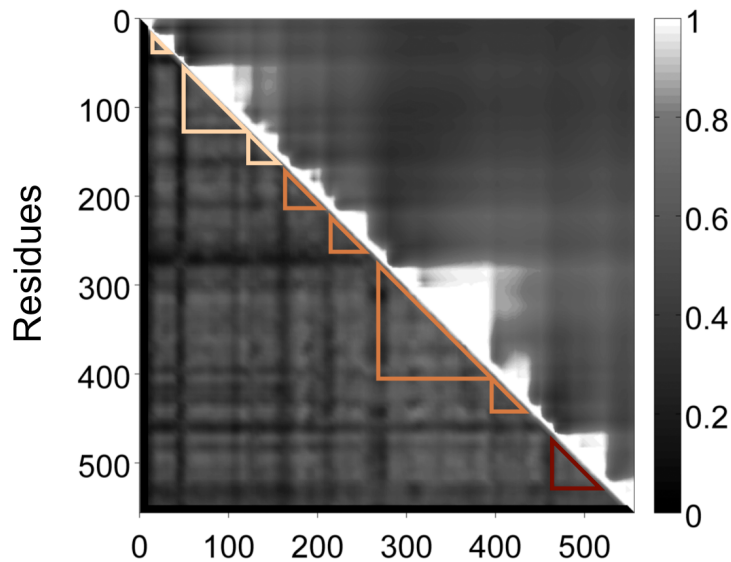
Dynamin in Dalivision



N (GTPase) M (Middle) GED

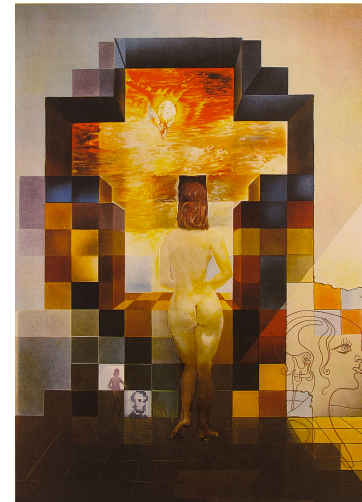


1 2 3 4 5 6 7 8



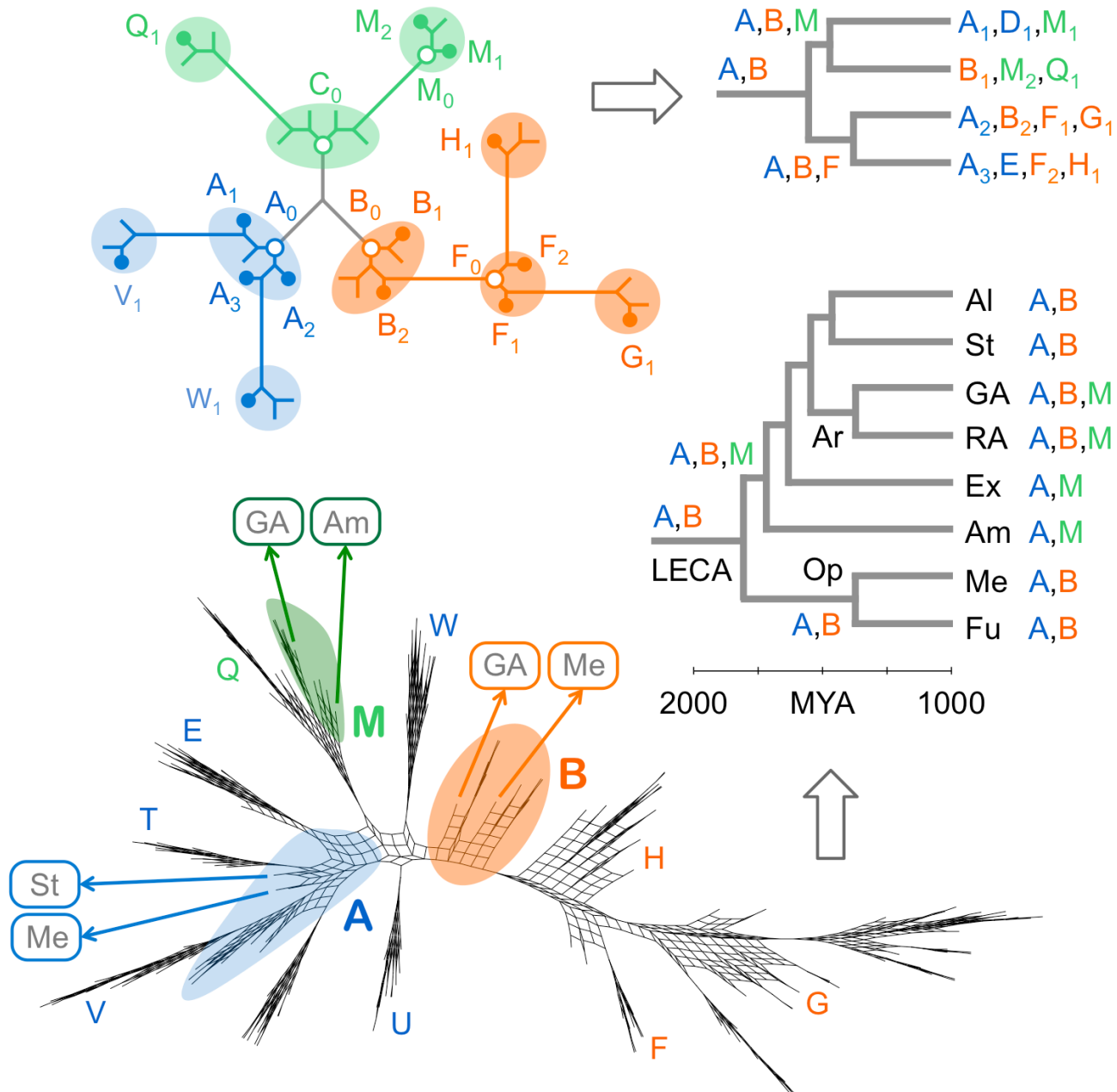
A V A A : X Y Z

8-letter
protein "signature"
of fake amino acids



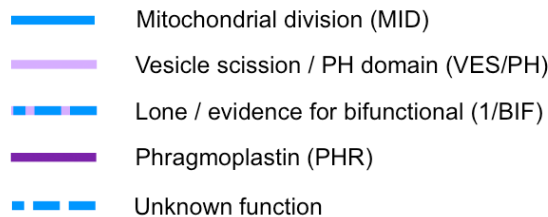
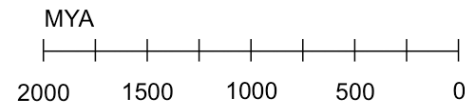
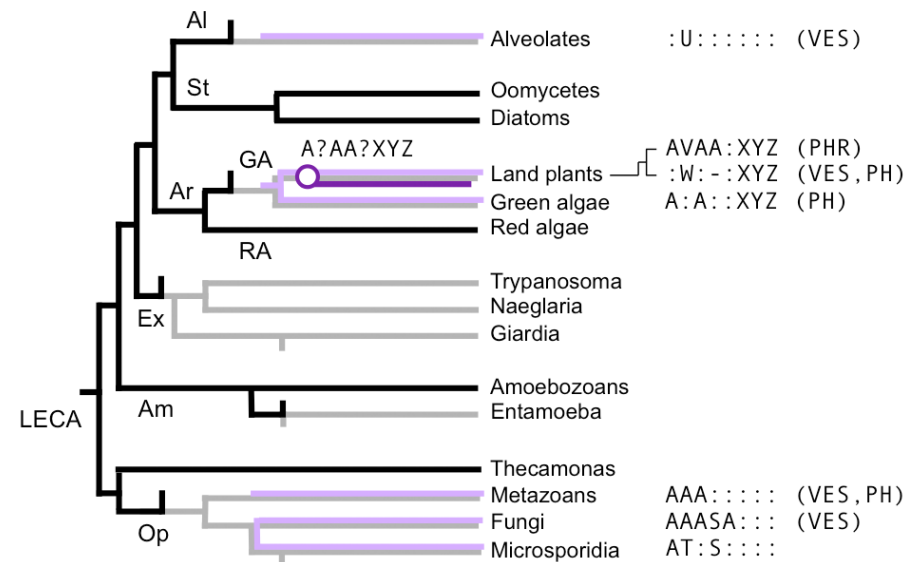
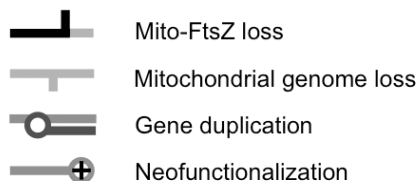
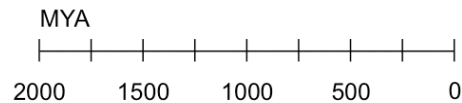
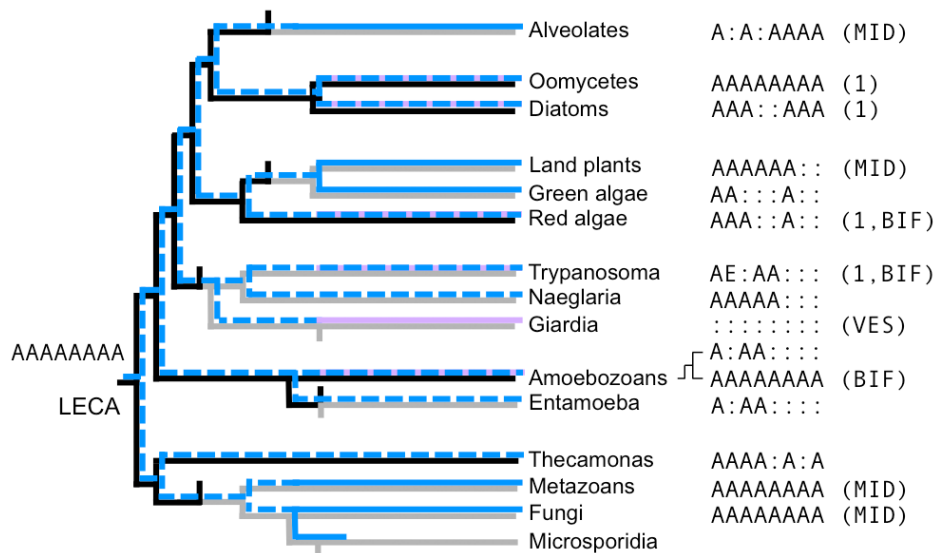
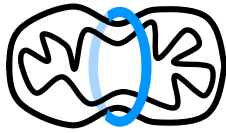
protein tree

species tree

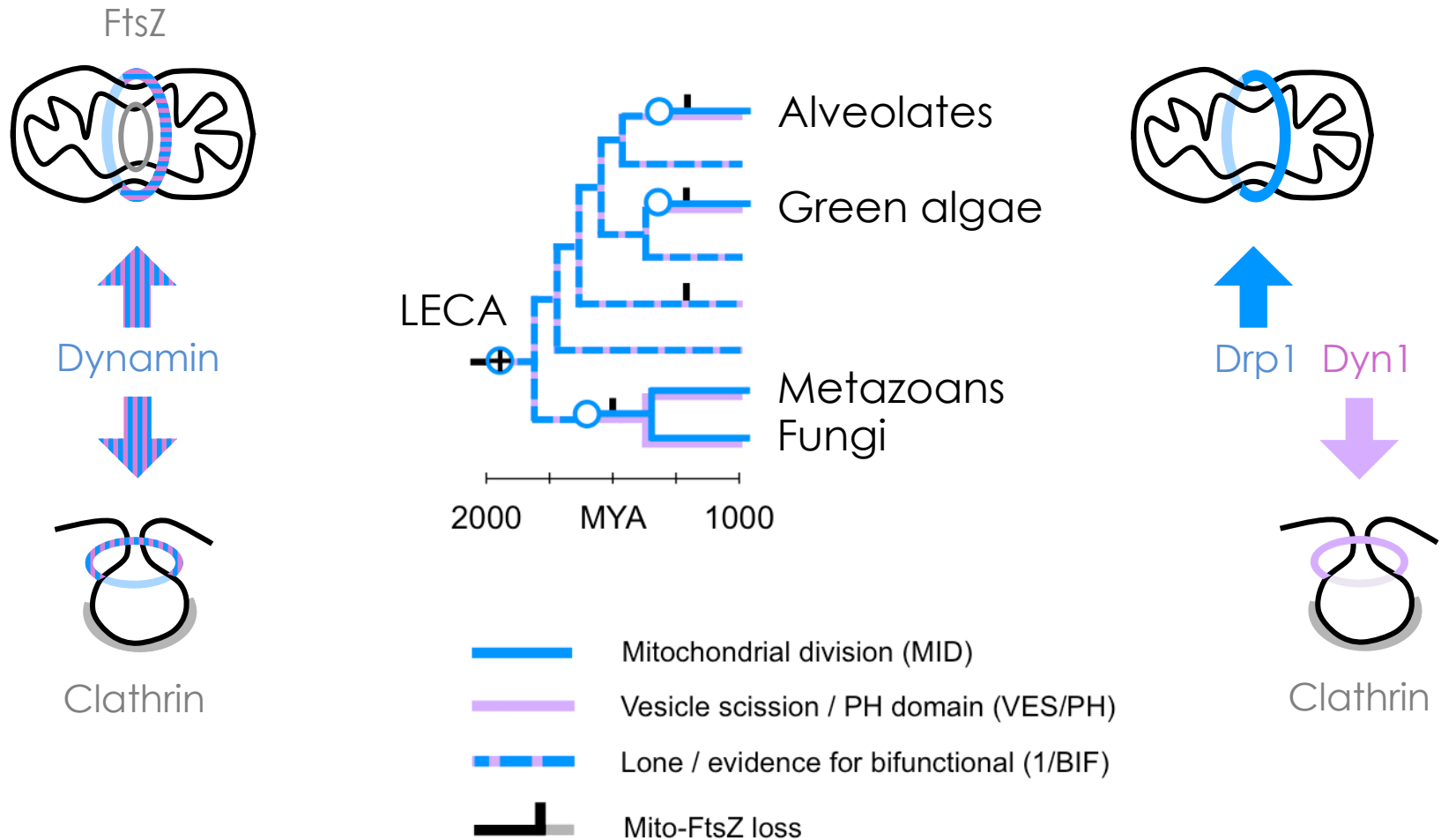


Living fossils
allow us to reconstruct
ancient mitochondria

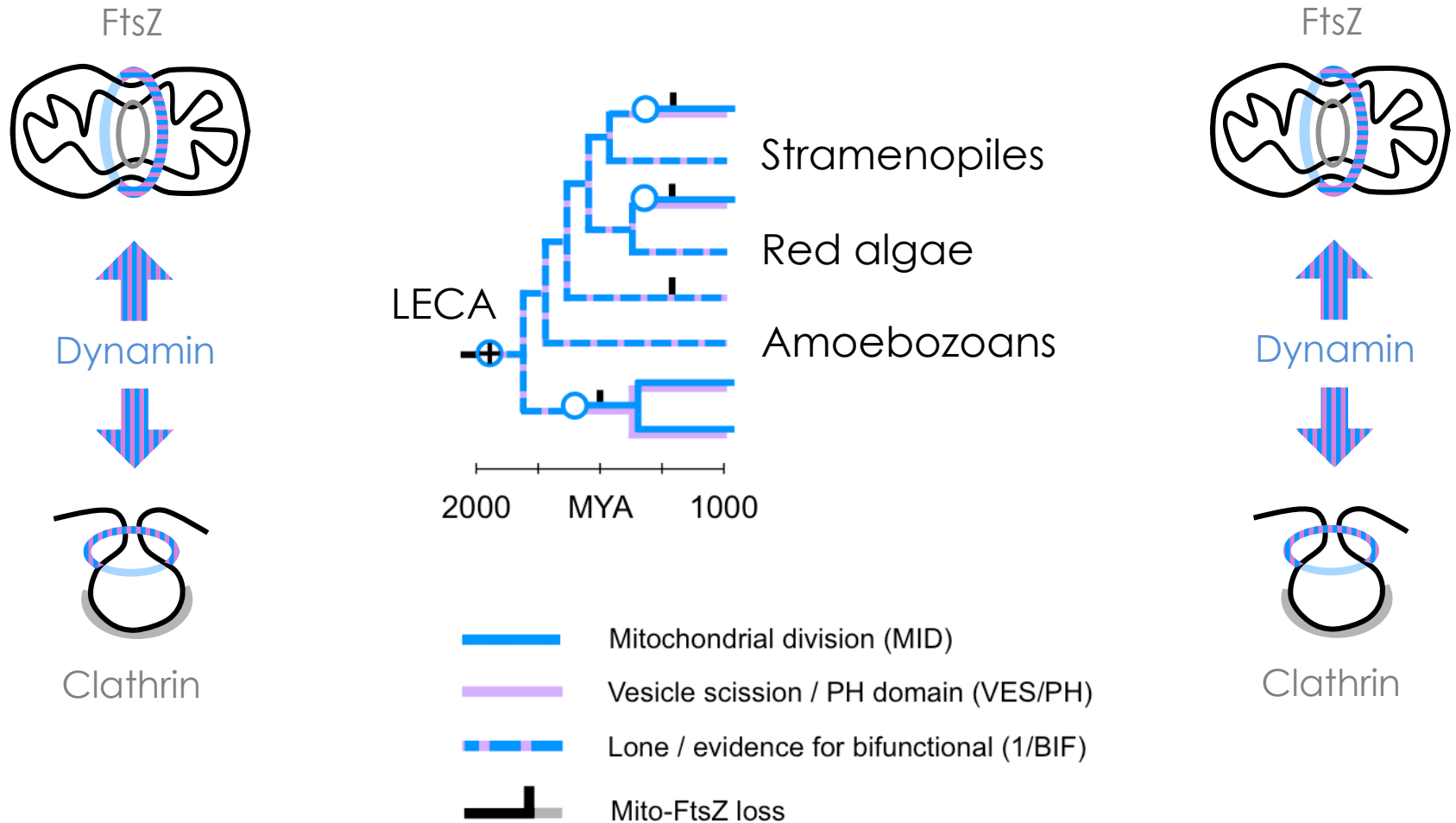
Dynamin evolution across 1.8 billion years



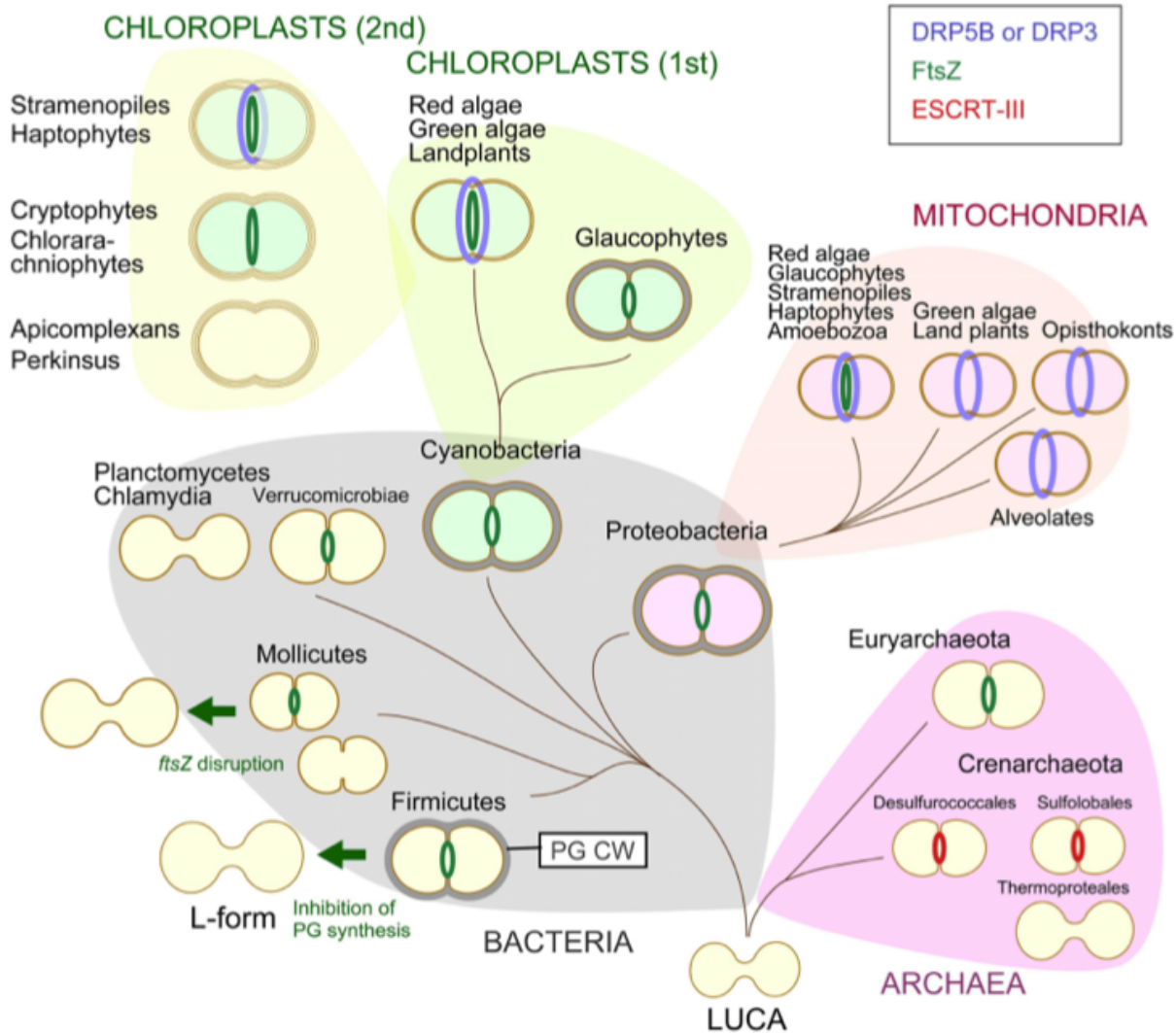
Two types of eukaryotes survive today



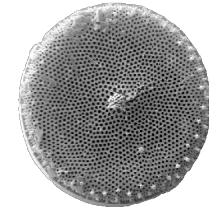
Two types of eukaryotes survive today



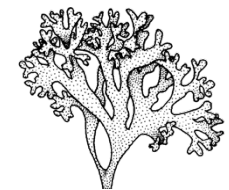
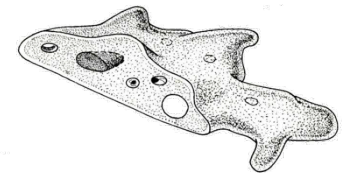
Living fossils preserve ancient mechanisms



Stramenopiles



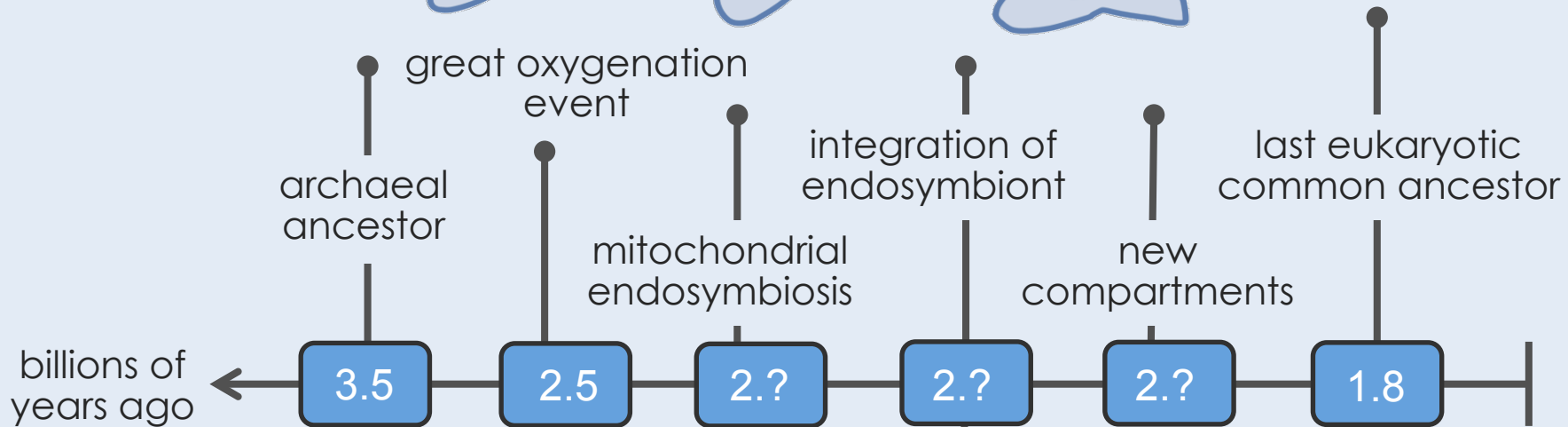
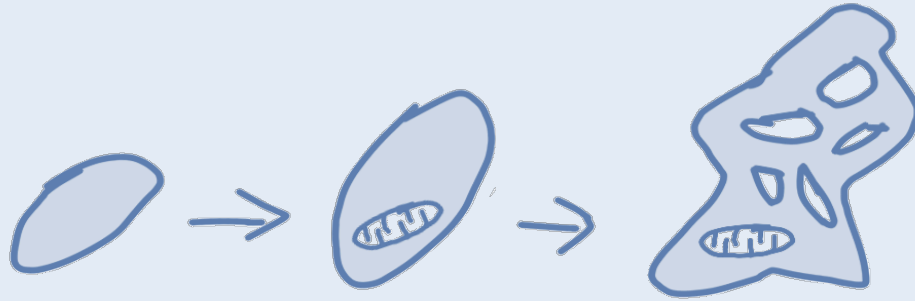
Amoebozoans



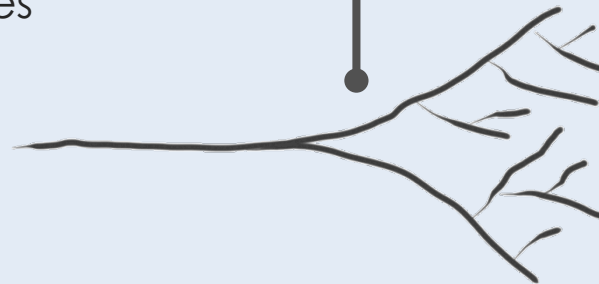
Red algae

Many phases of eukaryote evolution

Phenotype



Information





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Ramadas & Thattai, Biophys J 2013
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Anjali Jaiman, Shruti Malviya, Sachit Daniel

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