

Eukaryogenesis

WEEK 11

AIKYA SONI

Schedule

3:05 – 3:30	Jigsaw
3:30 – 4:00	Lecture
4:00 – 5:00	TED Talk Planning/Break when needed
5:00 – 5:30	TED Talks!

Jigsaw

- Split into pairs
 - Sagan (Split into intro/part 1 and part 2/3)
 - Gray
 - Poole and Gribaldo
- Summarize main points/takeaways, report back to group



Lynn Margulis, 1938 - 2011

[Video](#)

Awesome scientist (#WomenInSTEM!)

Graduated from UChicago at **19**

Master's from UChicago, MS from University of Wisconsin, PhD from UC-Berkeley

Taught at Brandeis University, Boston

University, and University of Massachusetts at Amherst

- Distinguished Professor of Botany at Amherst

Many awards and accolades, including National Medal of Science in 1999

Married to Carl Sagan, Thomas Margulis -- "it's not humanly possible to be a good wife, a good mother and a first-class scientist. No one can do it—something has to go."



(from [Wikipedia](#))

Awards and recognitions [\[edit \]](#)

- Elected Fellow of the [American Association for the Advancement of Science](#) in 1975.^[21]
- [Guggenheim Fellowship](#) in 1978.^[23]
- Elected to the [National Academy of Sciences](#) in 1983.
- Guest Hagey Lecturer, University of Waterloo, 1985^[50]
- Miescher-Ishida Prize in 1986.^[23]
- 1989, conferred the [Commandeur de l'Ordre des Palmes Académiques de France](#).^[21]
- Has her papers permanently archived in the [Library of Congress, Washington, DC](#).
- 1992, recipient of Chancellor's Medal for Distinguished Faculty of the University of Massachusetts at Amherst.^[22]
- 1995, elected Fellow of the [World Academy of Art and Science](#).^{[51][52]}
- 1997, elected to the [Russian Academy of Natural Sciences](#).^{[3][51]}
- 1998, recipient of the Distinguished Service Award of the [American Institute of Biological Sciences](#).^[22]
- 1998, elected Fellow of the [American Academy of Arts and Sciences](#).^[53]
- 1999, recipient of the [William Procter Prize for Scientific Achievement](#).
- 1999, recipient of the [National Medal of Science](#), awarded by President William J. Clinton.
- 2002–05, Alexander von Humboldt Prize.
- 2005, elected President of Sigma Xi, The Scientific Research Society.^[51]
- Profiled in *Visionaries: The 20th Century's 100 Most Important Inspirational Leaders*, published in 2007.
- Founded Sciencewriters Books in 2006 with her son Dorion.^[54]
- Was one of thirteen recipients in 2008 of the [Darwin-Wallace Medal](#), heretofore bestowed every 50 years, by the [Linnean Society of London](#).
- 2009, speaker at the Biological Evolution Facts and Theories Conference, held at the [Pontifical Gregorian University, Rome](#) aimed at promoting dialogue between [evolutionary biology](#) and [Christianity](#).
- 2010, inductee into the Leonardo da Vinci Society of Thinking^[55] at the [University of Advancing Technology](#) in Tempe, Arizona.
- 2010, NASA Public Service Award for Astrobiology.^[23]
- 2012, [Lynn Margulis Symposium: Celebrating a Life in Science](#)[↗], University of Massachusetts, Amherst, March 23–25, 2012
- Honorary doctorate from 15 universities.^[51]

Endosymbiotic Theory

Symbiotic view of eukaryotic cell evolution (aka eukaryogenesis)

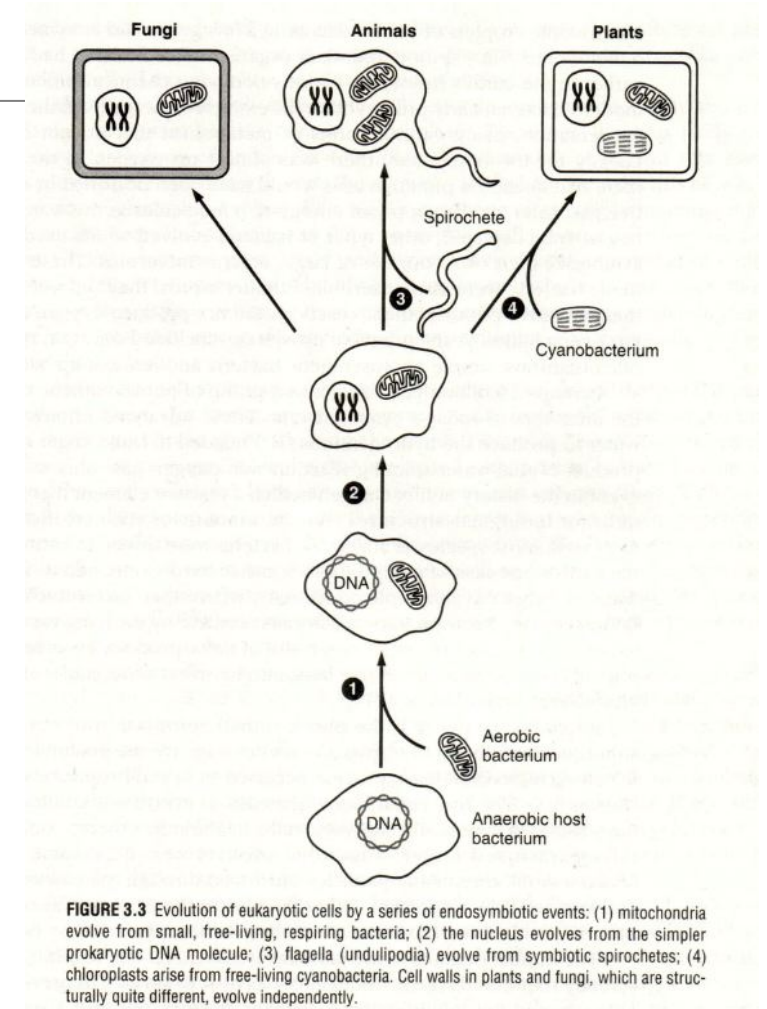


Endosymbiotic Theory

Symbiotic view of eukaryotic cell evolution (aka eukaryogenesis)

Margulis' original theory

- mitochondria, plastids, flagella all from free-living prokaryotes
- Only the first 2 supported in later studies



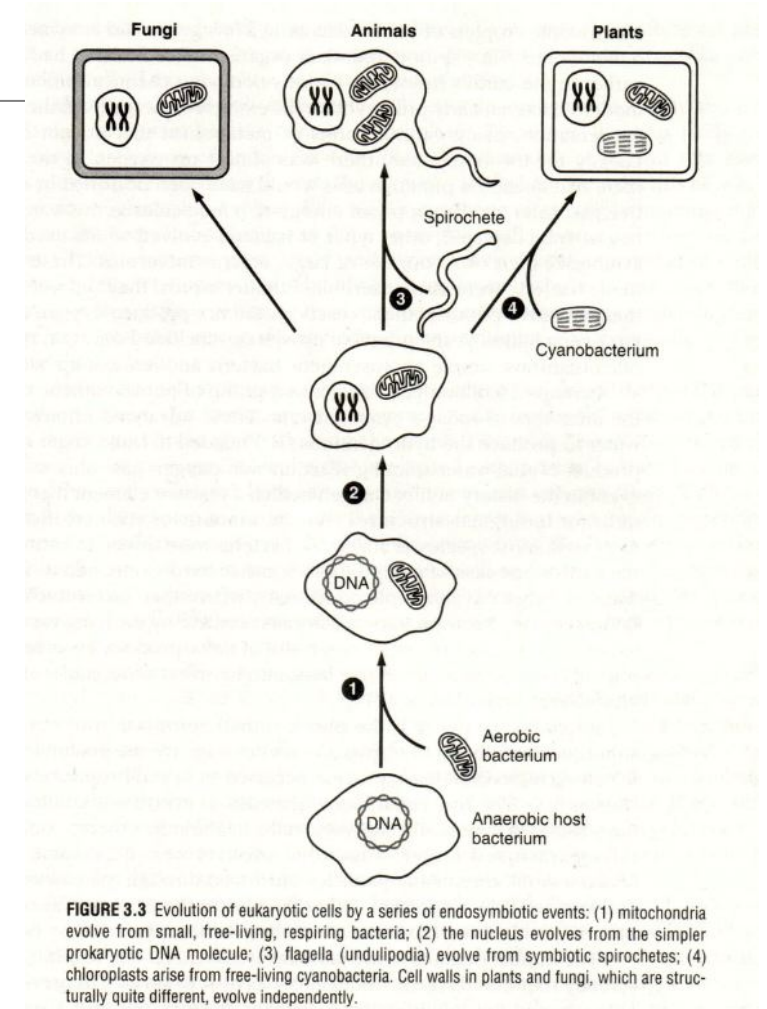
Endosymbiotic Theory

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Serial endosymbiosis?



Endosymbiotic Theory

Short Video

Evidence for Endosymbiosis

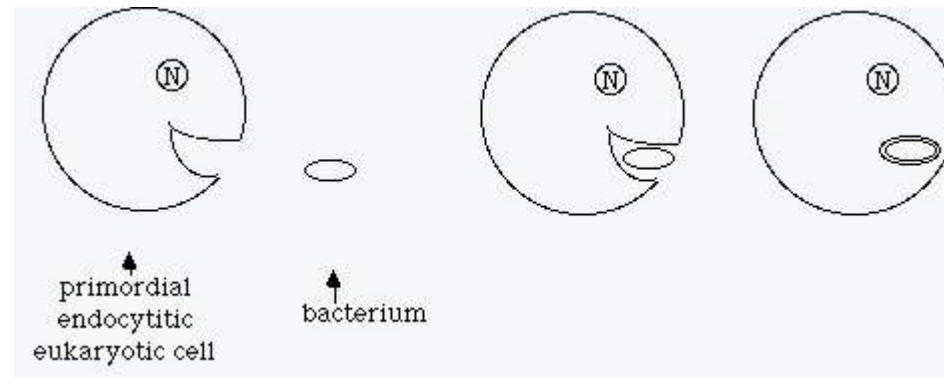
Gray and Doolittle, 1982 - mitochondria from alpha-Proteobacteria

Gray, 1992 - plastids from Cyanobacteria

Gray, 2012 - one partner in symbiosis was a bacterial cell

Muller et al., 2012 - mitochondrial acquisition ubiquitous in modern eukaryote biology;
traces back to ancient endosymbiont

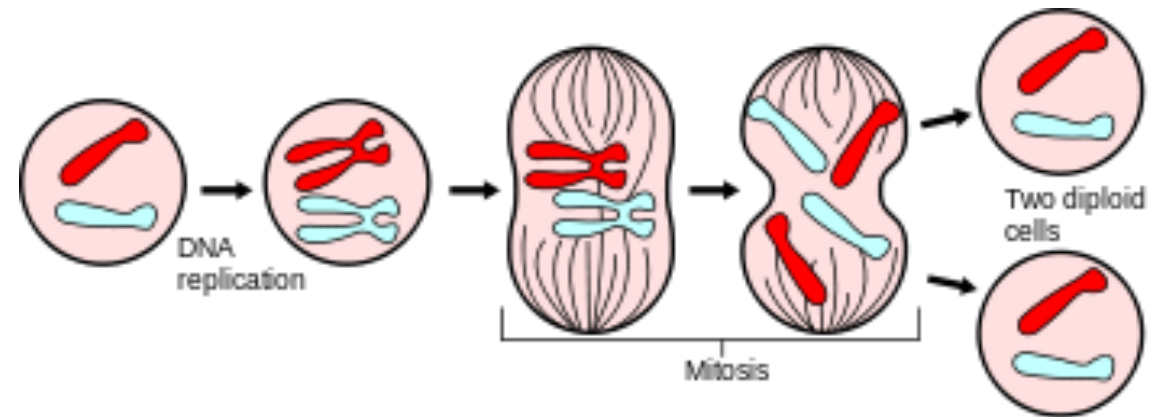
...and more!



Endosymbiotic Theory

Definition of “eukaryote”?

- Margulis: classical mitosis, higher, subcellular organelles, membrane-bound nuclei, “many other features in common”



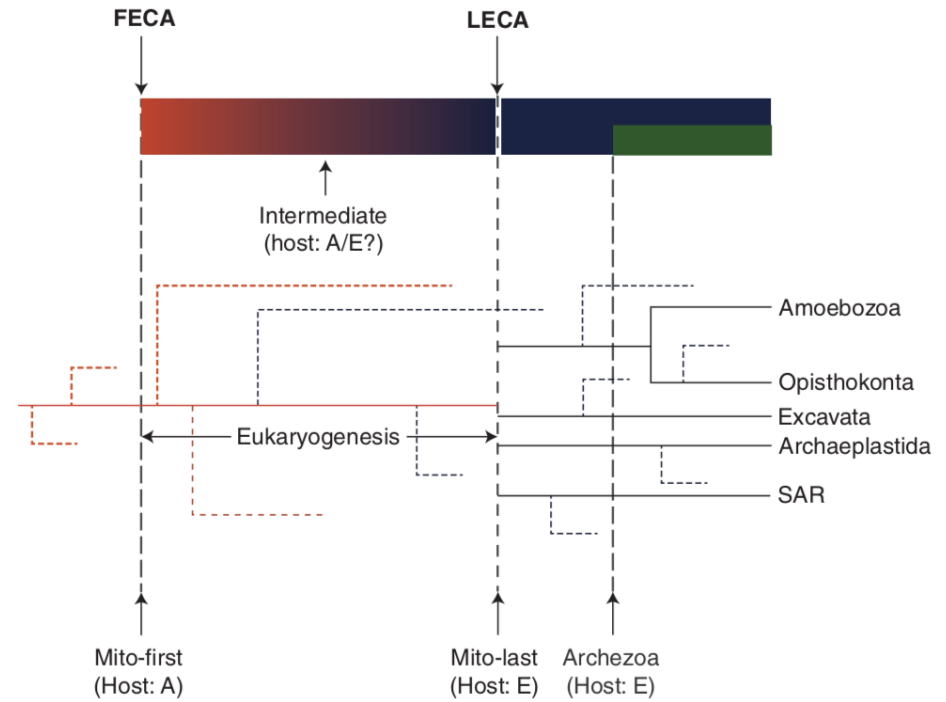
Poole and Gribaldo

Timing

Poole and Gribaldo

Timing

- early mito- vs. late mito-
- not right before LECA (Amiri et al., 2003)



Poole and Gribaldo (2014) Cold Spring Harb Perspect Biol 6:1-12

Poole and Gribaldo

Timing

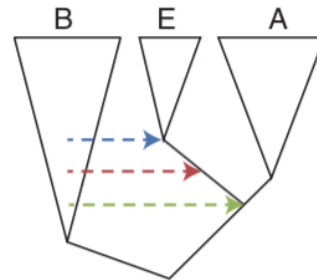
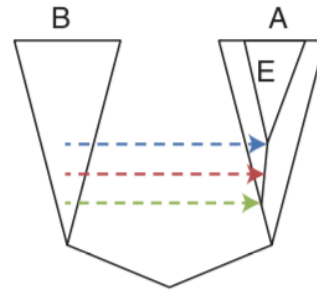
Nature of host

Poole and Gribaldo

Timing

Nature of host

- bacterial? archaeal?
- agreement that it was closest to modern archaea than any bacteria



Mito-first	Intermediate	Mito-last
Yes	Yes	Yes
Yes (if host is a basal archaeal lineage)	Yes	Yes

Poole and Gribaldo (2014) Cold Spring
Harb Perspect Biol 6:1-12

Poole and Gribaldo

Timing

Nature of host

Mechanism of acquisition

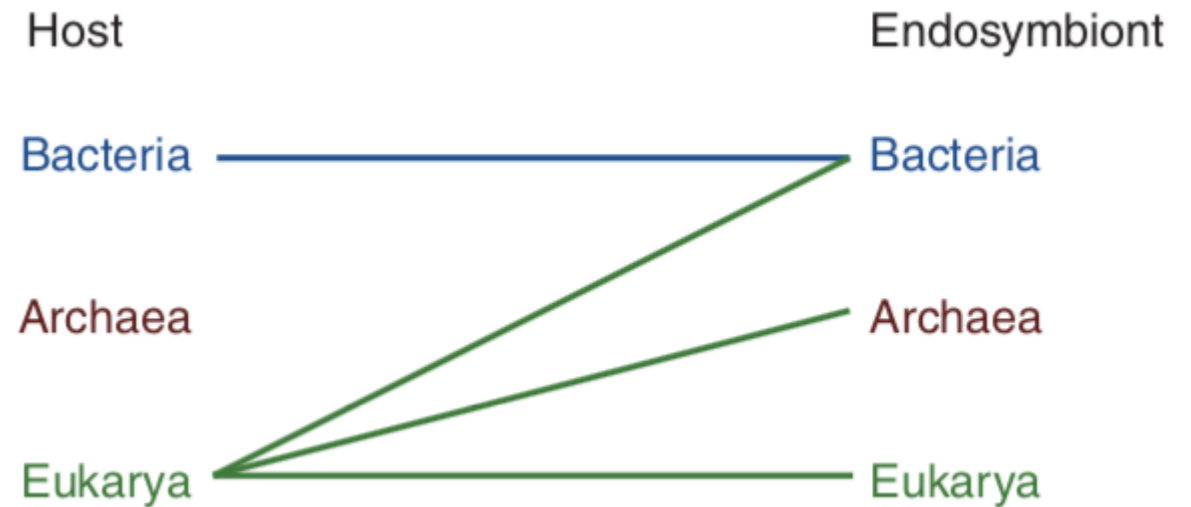
Poole and Gribaldo

Timing

Nature of host

Mechanism of acquisition

- bacteriovory
- syntrophy
- phagocytosis



Poole and Gribaldo (2014) Cold Spring
Harb Perspect Biol 6:1-12

Poole and Gribaldo

Timing

Nature of host

Mechanism of acquisition

- bacteriovory
- syntrophy
- phagocytosis

Bacteriovory - bacterial host/bacterial endosymbiont

bacterial predator invade periplasm

Gram-negative host (and sometimes cytoplasm)

only a failed predatory event would result in endosymbiosis

- both parasite and host survive, co-evolve

Poole and Gribaldo

Timing

Nature of host

Mechanism of acquisition

- bacteriovoxy
- syntrophy
- phagocytosis

Syntrophy - between archaea and bacteria
biochemical interaction, no
endosymbiosis
more likely a factor in an endosymbiotic
interaction than a stand-alone
mechanism (i.e. phagocytosis)
Membrane bending: unsure, but might
have to do with protein interactions

No contemporary examples of a bacterial
endosymbiont in an archaeal host

Poole and Gribaldo

Timing

Nature of host

Mechanism of acquisition

- bacteriovoxy
- syntrophy
- phagocytosis

Phagocytosis - most likely candidate -- bacterial endosymbiont with an archaeal host

components of phagocytosis trace back to LECA

compatible with 2D and 3D trees

simplest answer (avoids need for syntrophic-endosymbiosis or failed predatory attempts) -

- Occam's razor

Table 1. Three criteria must be met for a specific mechanism to be able to explain mitochondrial acquisition and endosymbiosis

	Syntrophy	Bacteriovoxy	Phagotrophy
Cross-domain interaction?	Yes	No	Yes
Contemporary examples of cross-domain endosymbiosis?	No	No	Yes
Evidence of coevolution?	Yes	Yes	Yes

Poole and Gribaldo

“Lightning rod” effect

- example: Lynn Margulis’ view on 5 kingdoms

Like many of the good ideas that the logical empiricists had, instrumentalism did not receive the attention it deserves. In part this was because of what I’ll call *the lightning rod effect*. Here’s how you can witness this phenomenon in the comfort of your own home (children should not do this without adult supervision):

Put a good idea next to a bad one. Someone will then refute the bad idea. Then people will think that the good idea as well as the bad one have both been demolished.

You don’t always get the lightning rod effect when you follow these instructions, but it occurs often enough that it deserves a name.

Questions...?

TED Talk Activity

Research assigned topic/issue

Prepare 7-8 minute presentation -- TED talk style:

- Introduce topic
- Use lay terms
- Be engaging (but succinct!)
- Use chalk ted talk - drawings/keywords or visual aides of some sort



TED Topics (as they're related to eukaryogenesis)

Mitochondria

Endosymbiont transition

Viral eukaryogenesis



Questions to consider...

Bibliography

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