

# Symbiogenesis

Perry Marshall

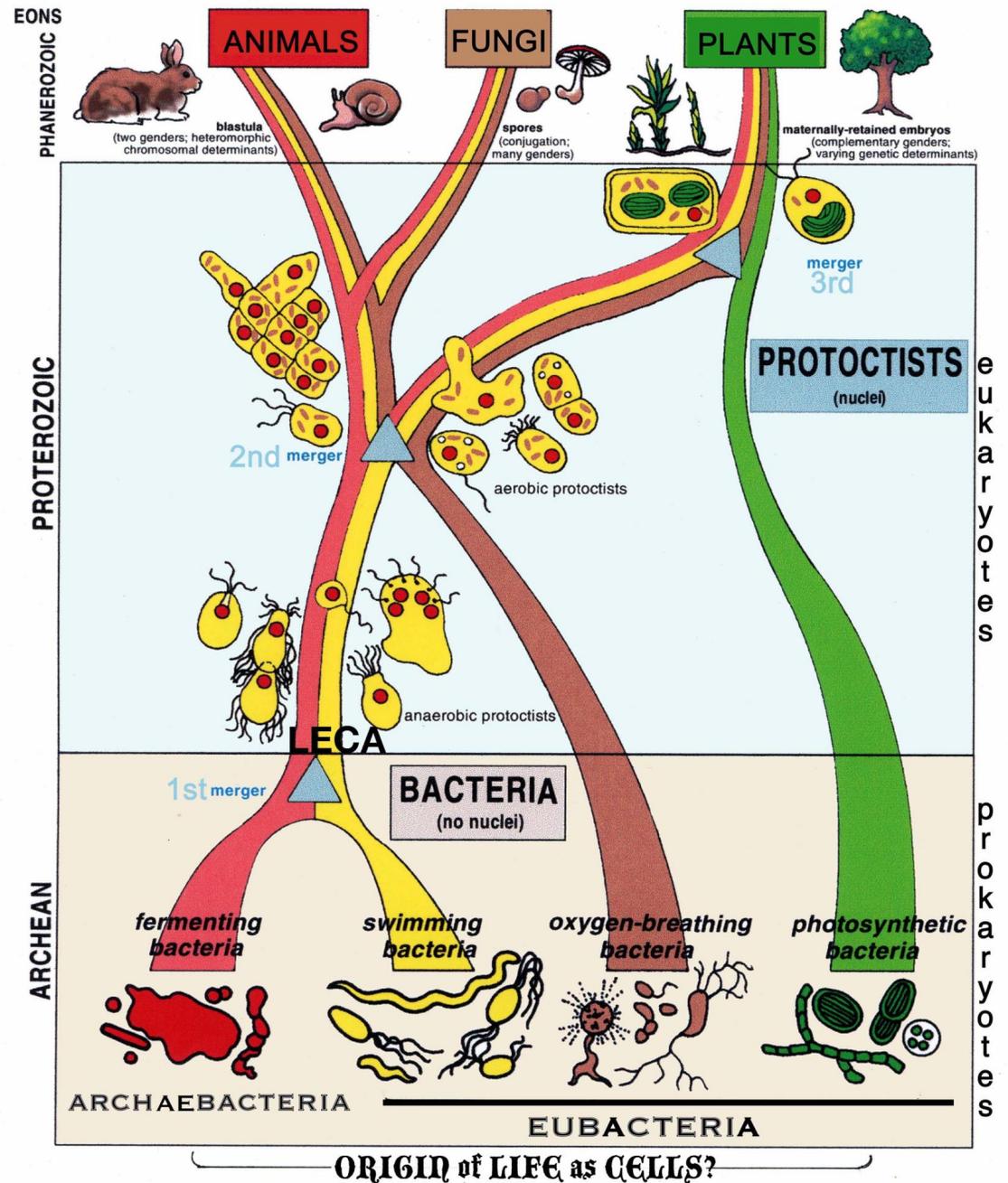
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# Symbiogenesis

- Symbiogenesis is when two different organisms merge to become a single new organism
- A major branch within the theory of evolution
- Initially formulated by Russian biologists in the 1920's
- In 1967 Lynn Margulis (U. Mass Amherst) said that microorganisms had a major role in the process of evolution through the process called endosymbiosis
- Her theory was ridiculed at first but has now gained wide acceptance.

# Endosymbiogenesis is

- A possible interconnected tree of life for the evolution of plants, animals and fungi from bacteria





# Process of symbiogenesis

- The merger of two different organisms results in the formation of a new organism
- This process occurs by exchanging DNA
- The DNA determines the functioning of different parts of the body. Merging of genes as a result of changing environmental needs led to the synthesis of a new organism

# Process (Cont'd)

- One of the simplest modes of symbiogenesis is the ingestion of one organism by the “host organism”
- The ingested organism could in some cases live exclusively on nutrients present in the host organism
- Subsequently, both these organisms reproduce independently while the ingested organism is still present in the host. Some genes are exchanged.
- The cells and/or organisms help each other thrive in altered conditions



# Some Examples of Symbiogenesis

Archaeobacteria + Eubacteria = Archaeotist

Archaeotist + Paracoccus = Protozoa

Protozoan + Cyanobacteria = Alga

The following form embryos:

Protozoan + Burkholderia = Fungus

Alga + Yeast = Plant

Protozoan + Eubacterium = Animal

(ref: "Acquiring Genomes" by Margulis & Sagan)

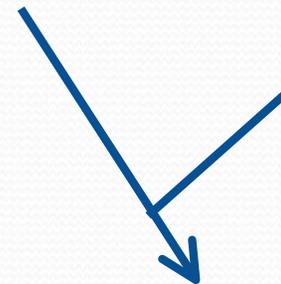
# Elysia viridis (sea slug)

- Algae-eating ancestors of the modern day sea slug fed on the seaweed codium
- Chloroplast cells of the seaweed which convert sunlight to nutrients (photosynthesis) in the algae were ingested and integrated into the digestive system
- The sea slug never eats during its adult life and obtains carbohydrate-rich molecules from sunlight

Algae-eating  
ancestors of  
Elysia viridis



Chloroplast  
cells of the  
sea weed  
Codium



Elysia viridis

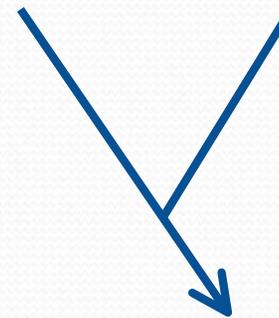
# Lichen

- Formed by the fusion of fusion of algal and fungal genes
- The formation of lichens has helped it survive in environments where neither fungi nor algae could survive alone



Fungi

Green  
Algae

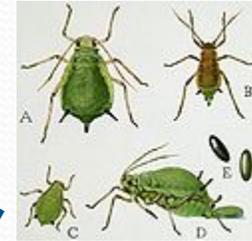


Lichens

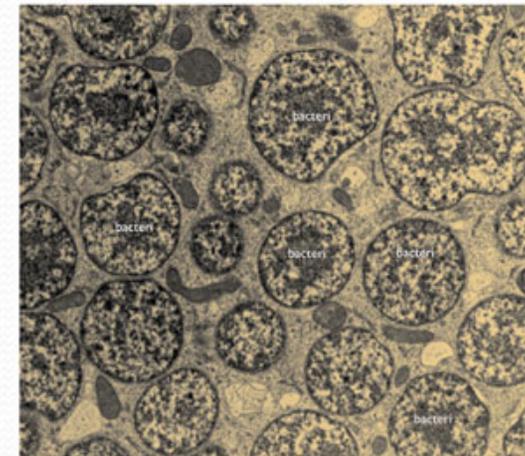
# Buchnera aphidicola

- Buchanera, a type of bacteria found in aphids (plant lice) were once free living organisms
- During the process of evolution these merged with the aphids and are located in specialized cells called bacteriocytes
- The bacteria provide the aphids with amino acids while the aphids feed on plants to provide carbohydrates to the bacteria

Enterobacteriaceae



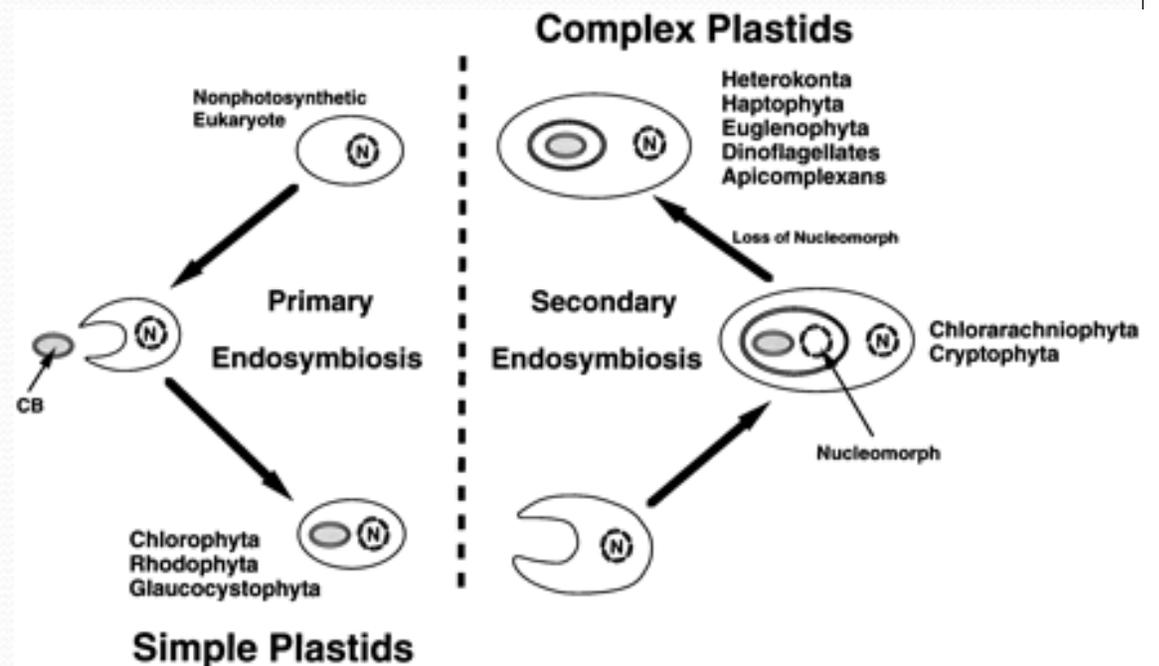
aphids



**Buchanera** (image from:  
[http://images.blogstream.com/i/userImages/83/83141\\_34660.jpg](http://images.blogstream.com/i/userImages/83/83141_34660.jpg))

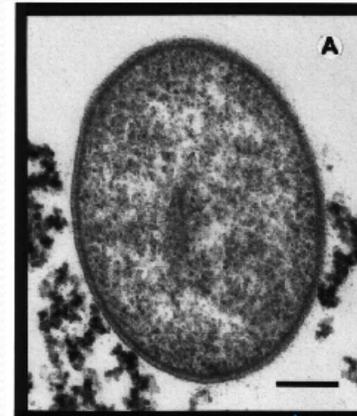
# Glaucocystophytes (algae)

- Glaucocystophytes are algae believed to have evolved through symbiogenesis
- Glaucocystophytes emerged through endosymbiosys between a non-photosynthetic eukaryote and cyanobacterium
- This organism obtains the chloroplast cells from the cyanobacteria which is essential for photosynthesis



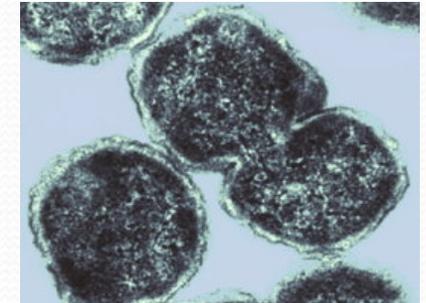
# Protozoa

- Have features of the suggesting endosymbiogenesis of eukaryotes and bacteria
- Archae are among the oldest life forms
- Can survive under extreme conditions
- Their merger with the bacterium called paracoccus resulted in the formation of the protozoa



Archae protist

Image from:  
<http://web.mit.edu/12.000/www/m2005/a2/finalwebsite/environment/bio/index.shtml>



Paracoccus

image from:  
<http://microbewiki.kenyon.edu/images/0/09/P31.jpg>



Protozoa

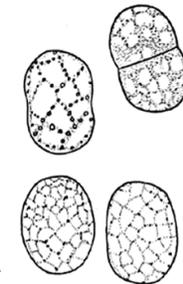
# Alga (photosynthetic eukaryote)

- Endosymbiosis between the protozoan and the synechococcus resulted in the evolution of alga which has photosynthetic abilities
- Symbiogenesis between protozoa and bacteria



Protozoan

Synechococcus



A

A after Prescott (1951)

B © J. Oyadomari, see [http://www.bio.mtu.edu/~jkoyadom/algae\\_webpage/HOME.htm](http://www.bio.mtu.edu/~jkoyadom/algae_webpage/HOME.htm)



B

Synechococcus



Alga

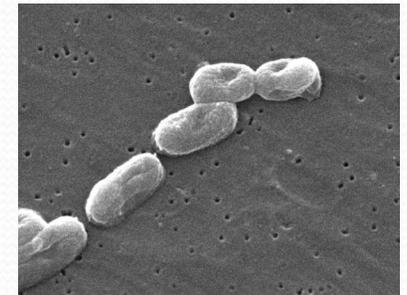
Source: <http://staff.jccc.net/pdecell/photosyn/alg3.jpg>

# Fungus (basidiomyocyte)

- Fungus (basidiomyocyte) was formed by a merger between protozoa and a proteobacteria known as Burkholderia



Protozoan



Burkholderia

Source:  
[http://web.mst.edu/~microbio/BIO221\\_2000/Burkholderia\\_cepacia.html](http://web.mst.edu/~microbio/BIO221_2000/Burkholderia_cepacia.html)

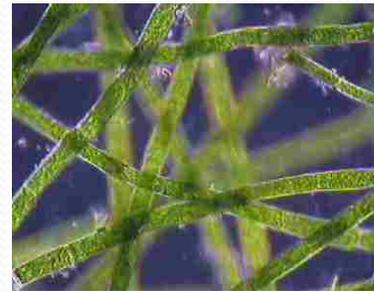


Basidiomyocyte

Source:<http://pollen.utulsa.edu/Spores/Basidiomycetes.html>

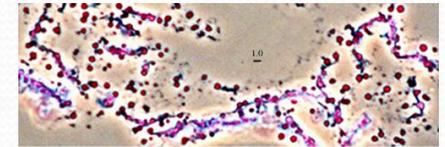
# Plant (bryophyte or tracheophyte)

- The symbiosis between the algae and yeast is theorized to be the first embryo forming stage in the evolution process
- This relation gave rise to the bryophyte or tracheophyte



Alga

Source:  
<http://staff.jccc.net/pdecell/photosyn/alga3.jpg>



Mycosome

Source:<http://www.atsatt.com/mycosomes/LM/Resources/myco100.jpeg>



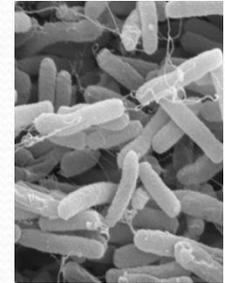
Bryophyte

# Animal (parazoan, mesozoan or metazoan)

- The formation of animals has been suggested to have been a symbiogenetic relationship between the protozoan and carbonate precipitating eubactrium or other similar species
- The sponge is an animal that belongs to the parazoa subkingdom



Protozoan



Eubactrium



Parazoa

# Summary

- Endosymbiosis proposes that some of the basic structures of the cells of different organisms combine to become one
- The new organism retains the functions of both ancestors
- The organism adapts as a single unit to the new environment
- Symbiogenesis helped in the formation of present day animals and plants which would not have survived if they did not cohabitate

# Symbiogenesis in Business



# Symbiogenesis in Language

## The word “Alchemy”

ORIGIN [Middle English alkamie , from Old French alquemie , from Medieval Latin alchymia , from Arabic al-kīmiyā' : al- , the + kīmiyā' , chemistry (from Late Greek khēmeia, khumeia , perhaps from Greek Khēmia , Egypt ).]

# Symbiogenesis in Advertising

## Uncertainty Restores Glitter to an Old Refuge, Gold

By NELSON D. SCHWARTZ  
Published: June 12, 2010

It is the resurgent passion of the doomsday crowd, a bet that everything will go wrong. No matter what has you worried, they say, the answer is gold.

### Related

Times Topic: [Gold](#)

Inflation, [deflation](#), government borrowing or the plunging euro — you name it — the specter of these concerns has set off a dash to gold, driving the precious metal to new highs and illustrating how fears of economic turmoil have moved from the fringe to the mainstream.

And gold bugs, often dismissed as crackpots who hoard gold bars in the basement, are finally having their day.

“I just think you’re in a world where a lot of chickens are coming home to roost,” said John Hathaway, manager of the Tocqueville Gold fund. “Gold is an escape hatch.”

The most visible new gold enthusiasts range from the Fox News commentator [Glenn Beck](#) on the right to the financier [George Soros](#) on the left, with even some sober-minded Wall Street types developing a case of gold fever. While their language may differ, they share a

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# Symbiogenesis in Software



# The Dick and Jane Version of Evolution

Symbiogenesis is not mentioned even once in Dawkins' "Greatest Show on Earth" - or any of the other major popular books on evolution

# A more complete theory of evolution combines symbiogenesis with:

- Horizontal Gene Transfer
- Epigenetics
- Natural Genetic Engineering (Transposition & Gene Reorganization)
- Genome Doubling
- Golden Ratio Checksum Matrix
- The “Swiss Army Knife”



# **An Entirely Different Understanding of Evolution**