
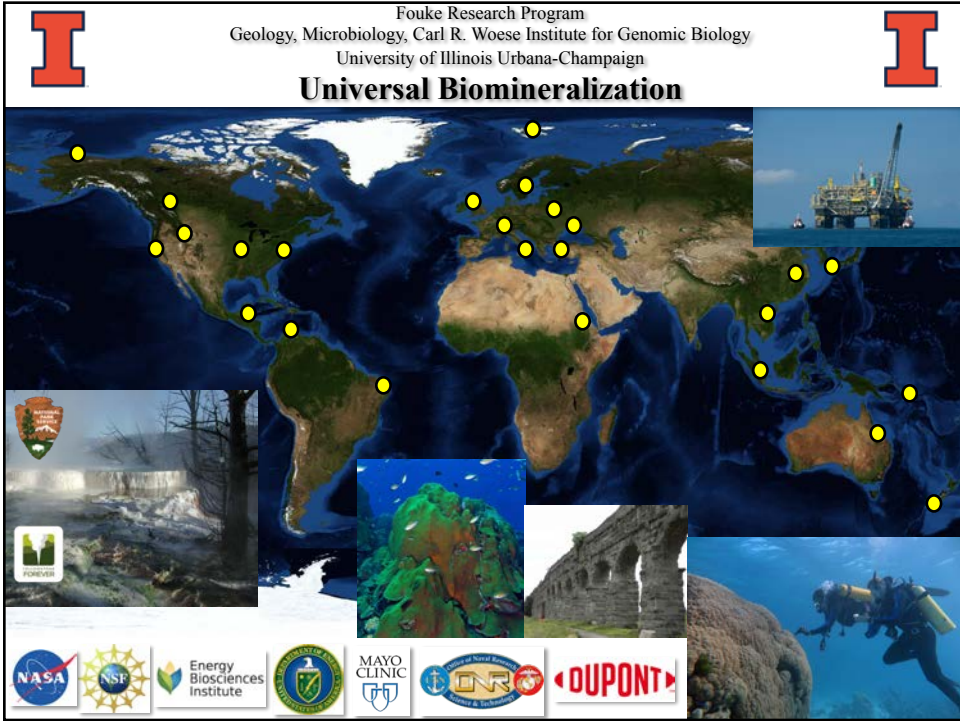




Life Make Rock: 4 Billion Years of Biomineralization

Bruce W. Fouke

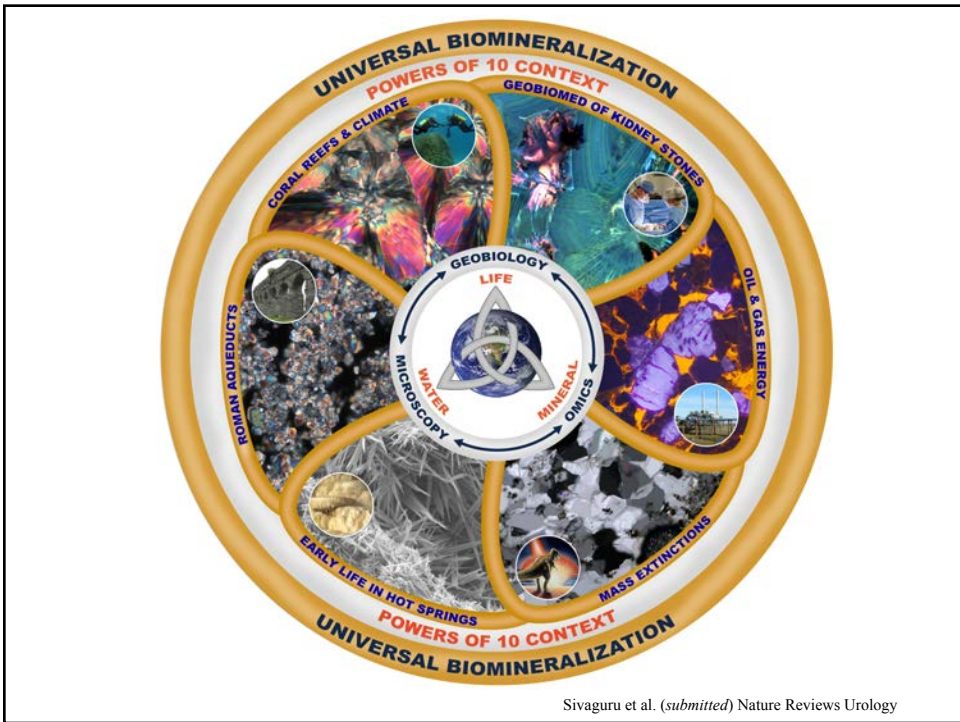
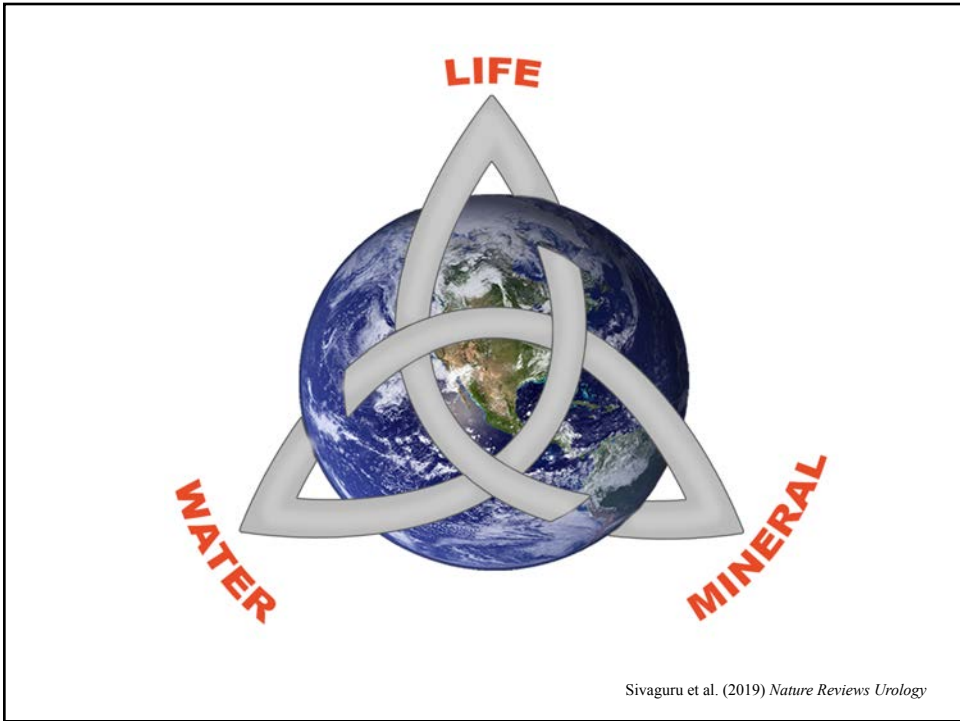
 Director Roy J. Carver Biotechnology Center
Professor of Geology and Microbiology
Carl R. Woese Institute for Genomic Biology

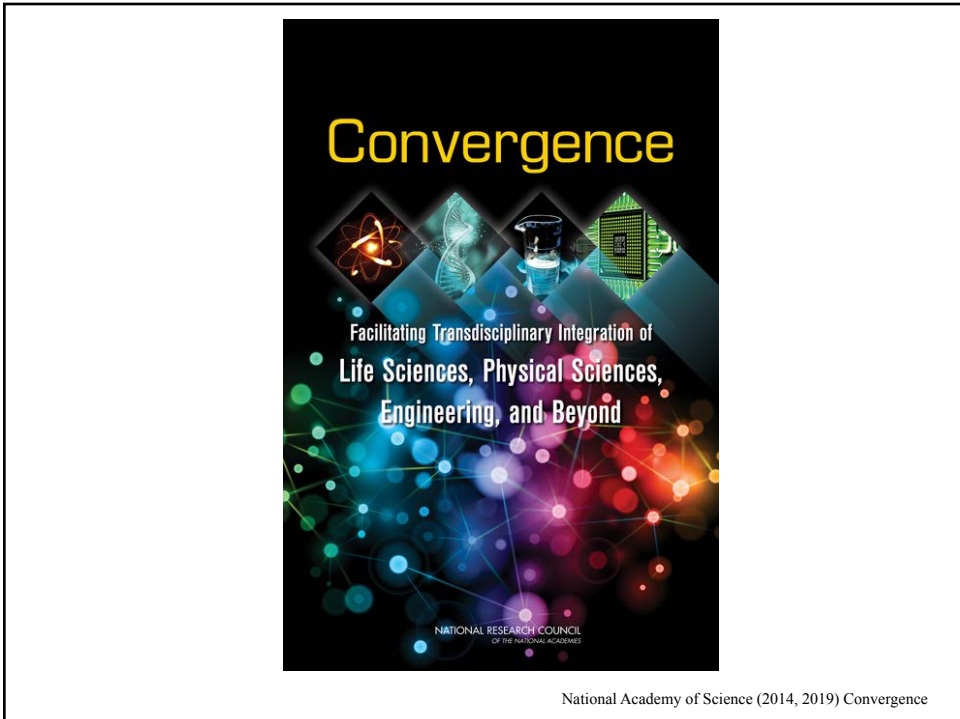


 Fouke Research Program
Geology, Microbiology, Carl R. Woese Institute for Genomic Biology
University of Illinois Urbana-Champaign 

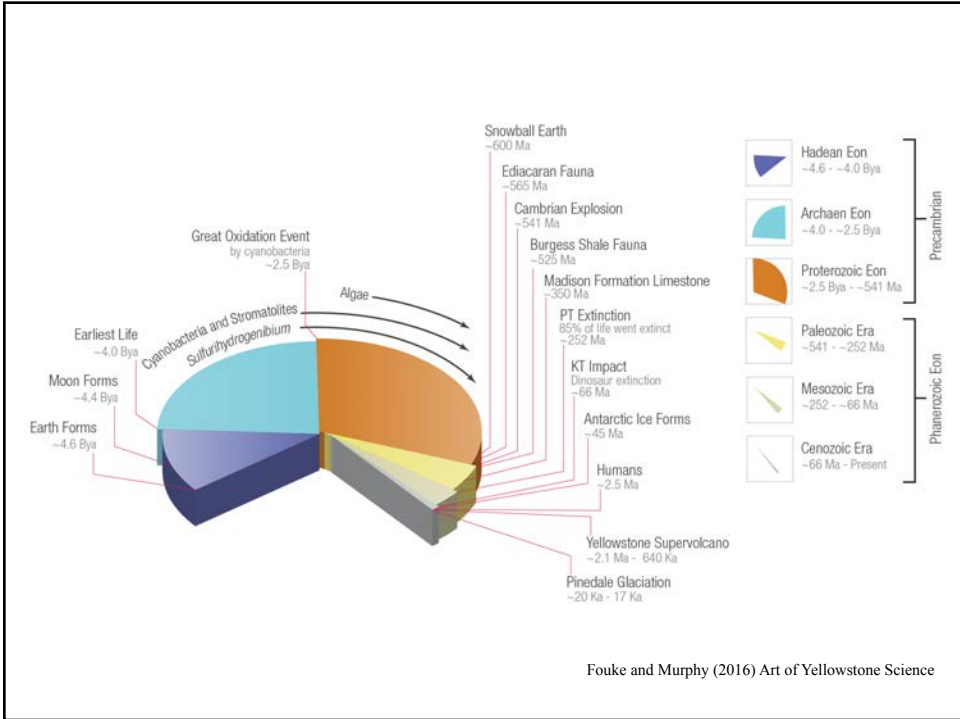
Universal Biomineralization

The slide features a world map with yellow dots indicating research sites across North America, Europe, and Asia. Surrounding the map are several images: an offshore oil rig, a snowy landscape with a 'FOUKE' logo, a colorful microbial mat, a stone archway, and a scuba diver underwater. At the bottom, a row of logos includes NASA, NSF, Energy Biosciences Institute, University of Illinois, Mayo Clinic, Office of Naval Research, and DUPONT.

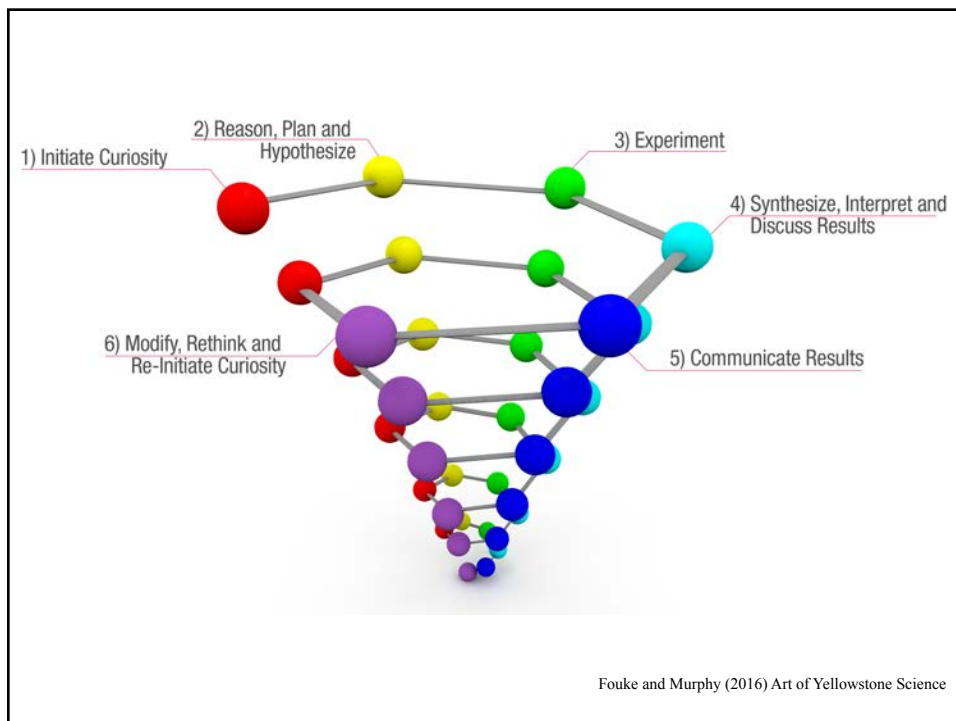
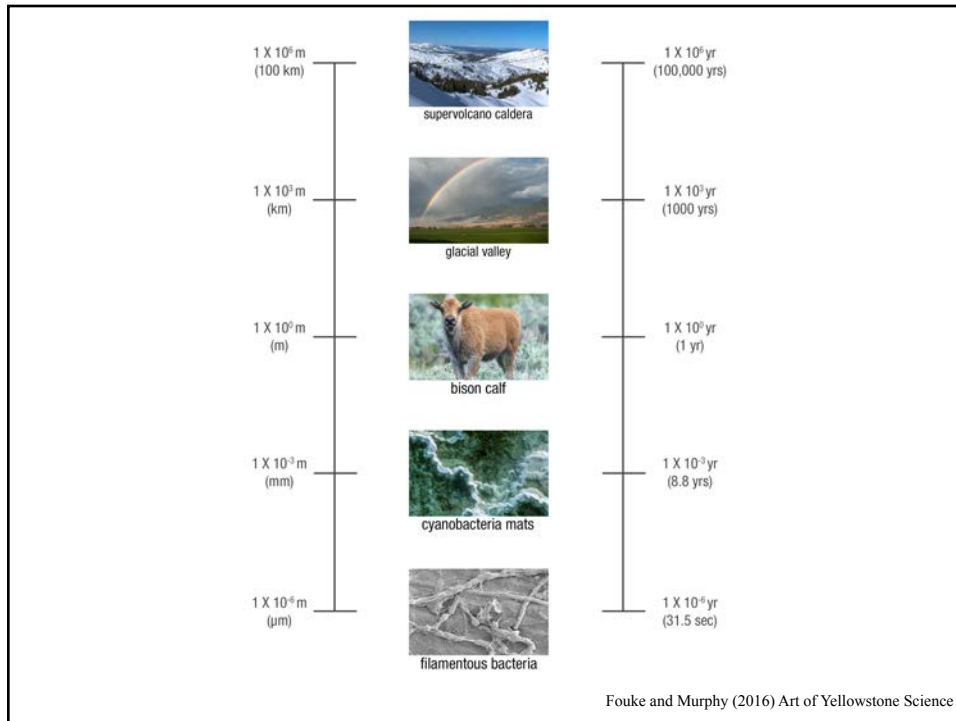


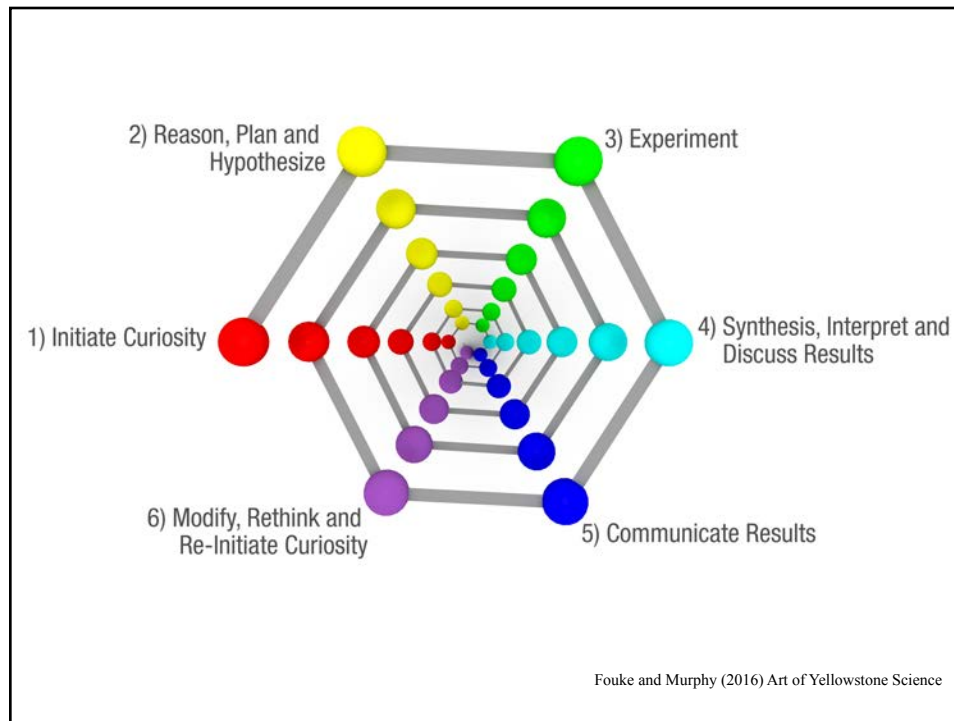


National Academy of Science (2014, 2019) Convergence



Fouke and Murphy (2016) Art of Yellowstone Science

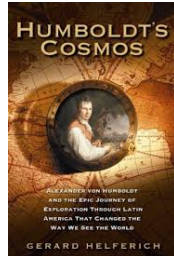




Overview

- **Evolution of the Tree of Life**
- **Professor Carl R. Woese established the first scientific and quantified Tree of Life, and in the process a New Biology for the 21st Century**
- **Expansion of Microbial Diversity and the Ever Evolving Tree of Life.**

Alexander von Humboldt 1768 -1865
 Renowned German explorer, artist and scientist,
 responsible for the grand modern synthesis
 of the sciences and biogeography

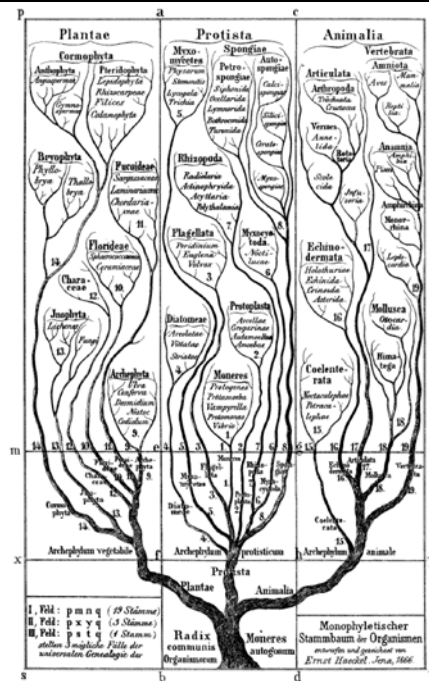
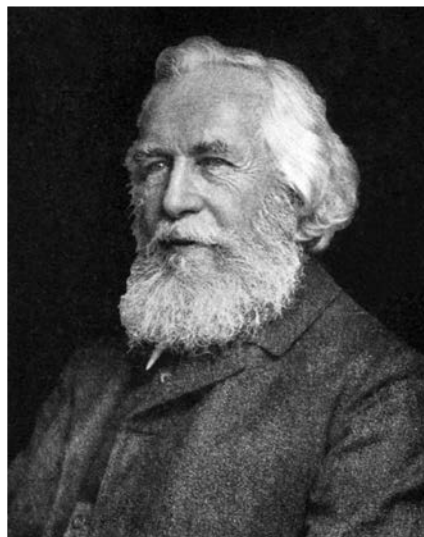


Wolfe, A. (2016) *The Invention of Nature*

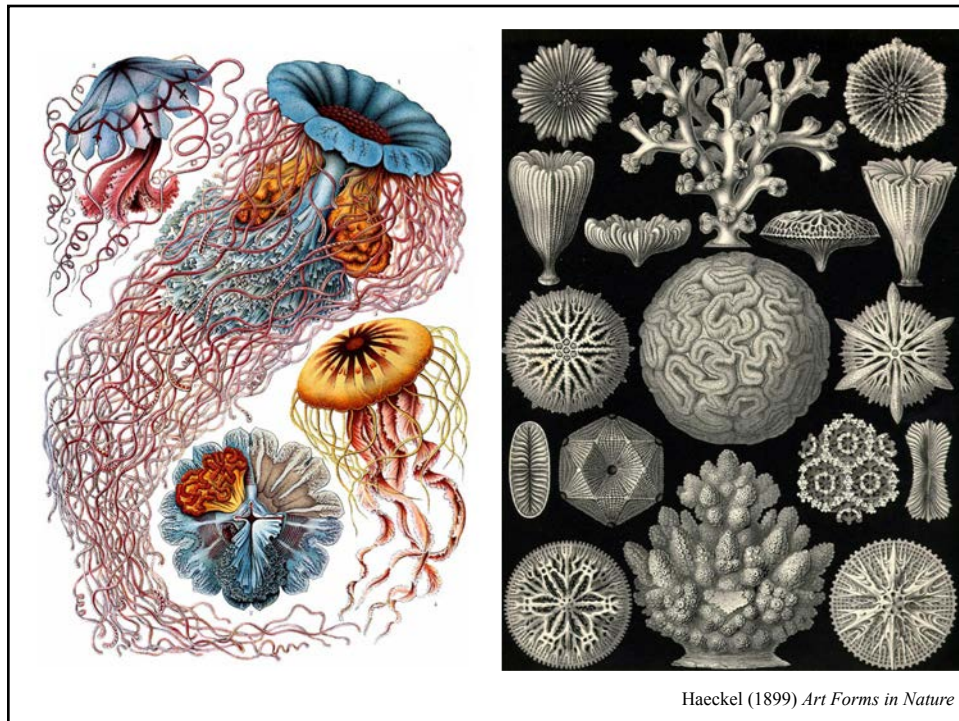
<https://www.humboldt-foundation.de/web/home.html>

Ernst Haeckel 1834-1919

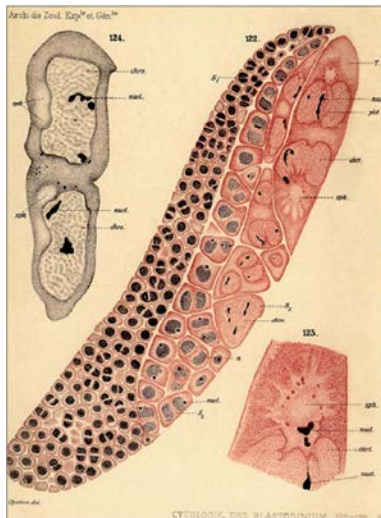
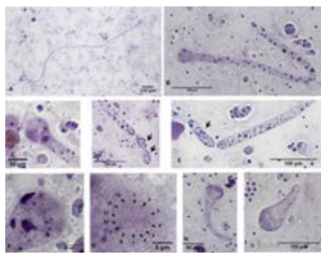
German artist and scientist, coined the phrase
 “ontogeny recapitulates phylogeny”
 First to add microbes (*Monera*) to Tree of Life



<https://ucmp.berkeley.edu/history/haeckel.html>



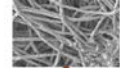
Edouard Chatton 1883-1947
 French biologist who proposed that all of life could be organized into two great “Empires”
 Distinguished between “Prokaryotes” and “Eukaryotes”



Eukaryotes



Prokaryotes

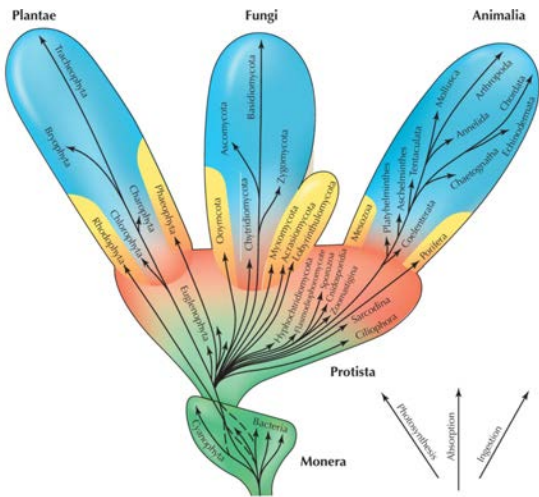


Origin of Life

https://en.wikipedia.org/wiki/%C3%89douard_Chatton

Fouke and Murphy (2016) *Art of Yellowstone Science*

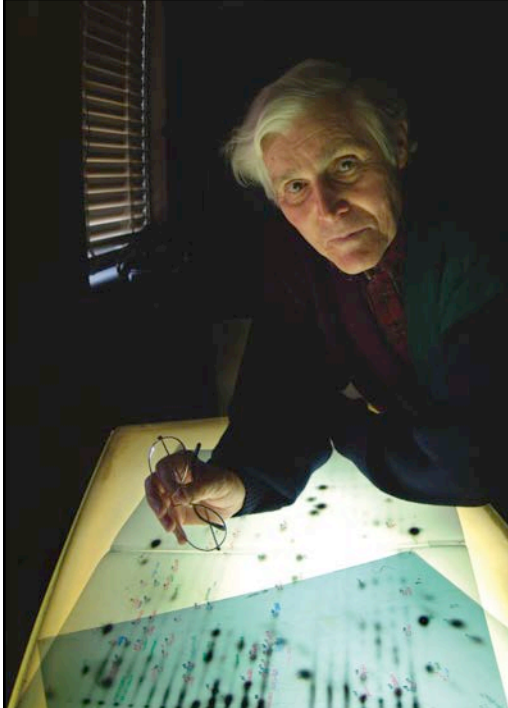
Robert H. Whitaker 1920-1980
 Completed his Ph.D. at the University of Illinois
 Urbana-Champaign and professor at Cornell University
 Established the Five Kingdom Tree of Life based on
 community ecosystem biochemistry and ecology



Whitaker (1969); Barton et al. (2007)

Bruce W. Fouke, Coursera *Emergence of Life*
 Lecture 2.1. The Scientific Inquiry of Carl R. Woese





Carl R. Woese 1928-2012

American microbiologist and biophysicist at the University of Illinois Urbana-Champaign

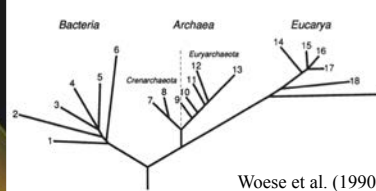
Established Three Domains of Life "Bacteria", "Archaea" and "Eucarya" using 16S rRNA gene sequence molecular phylogeny

Evolution: Woese and Fox Proc. Natl. Acad. Sci. USA 74 (1977) 56


Table 1. Association coefficients (C_{ij}) between representative members of the three primary kingdoms

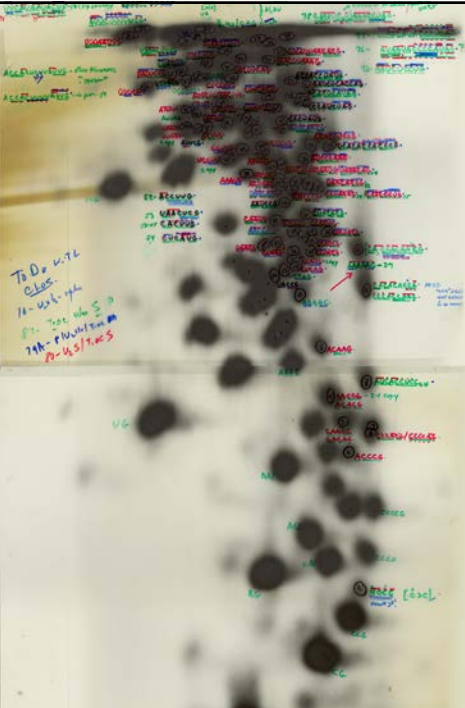
	1	2	3	4	5	6	7	8	9	10	11	12	13
1. <i>Zootherisma americana</i> , 18S	—	0.29	0.33	0.05	0.06	0.09	0.11	0.09	0.11	0.11	0.08	0.08	0.08
2. <i>Leptothorax</i> , 18S	0.29	—	0.36	0.10	0.08	0.10	0.09	0.11	0.10	0.10	0.13	0.07	0.07
3. <i>L. cell</i> , 18S	0.33	0.36	—	0.06	0.06	0.07	0.09	0.06	0.10	0.10	0.09	0.07	0.07
4. <i>Chlorobacter</i> , 16S	0.06	0.10	0.06	—	0.24	0.10	0.08	0.06	0.23	0.11	0.10	0.07	0.12
5. <i>Chlorobacter</i> , 16S	0.06	0.10	0.06	0.24	—	0.22	0.22	0.19	0.23	0.06	0.09	0.06	0.09
6. <i>Bacillus</i> 16S	0.08	0.06	0.07	0.22	0.22	—	0.34	0.26	0.20	0.11	0.13	0.06	0.12
7. <i>Corynebacterium</i> , 16S	0.09	0.10	0.07	0.20	0.22	0.34	—	0.22	0.21	0.12	0.12	0.09	0.10
8. <i>Aphanizomenon</i> 16S	0.11	0.09	0.09	0.20	0.20	0.26	0.22	—	0.31	0.11	0.11	0.10	0.10
9. <i>Chlamydomonas</i> (16S)	0.08	0.11	0.06	0.21	0.19	0.21	0.21	0.31	—	0.14	0.12	0.10	0.12
10. <i>Methanobacterium</i> 16S	0.11	0.10	0.10	0.11	0.06	0.11	0.12	0.11	0.14	—	0.51	0.25	0.30
11. <i>Methanobacterium</i> 16S	0.11	0.10	0.10	0.11	0.06	0.11	0.12	0.11	0.14	0.51	—	0.25	0.24
12. <i>Methanobacterium</i> sp., <i>Carotino</i> 16S	0.08	0.13	0.09	0.07	0.06	0.06	0.06	0.10	0.10	0.25	0.25	—	0.32
13. <i>Methanospirillum</i>	0.08	0.07	0.07	0.13	0.09	0.12	0.10	0.10	0.12	0.30	0.25	0.32	—

Woese and Fox (1977)

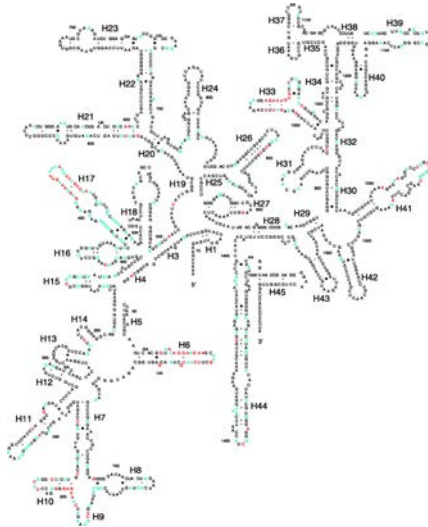


Woese et al. (1990)





New Frontier Roadmaps



Structure of the 16S rRNA Gene Sequence
Applied and Environmental Microbiology (2019)

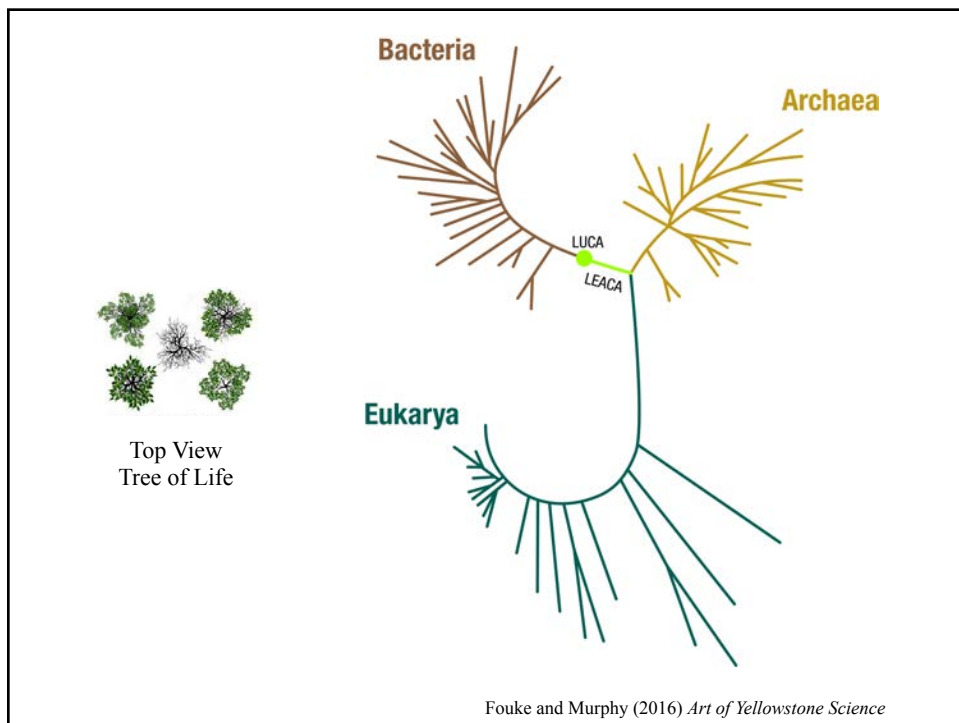
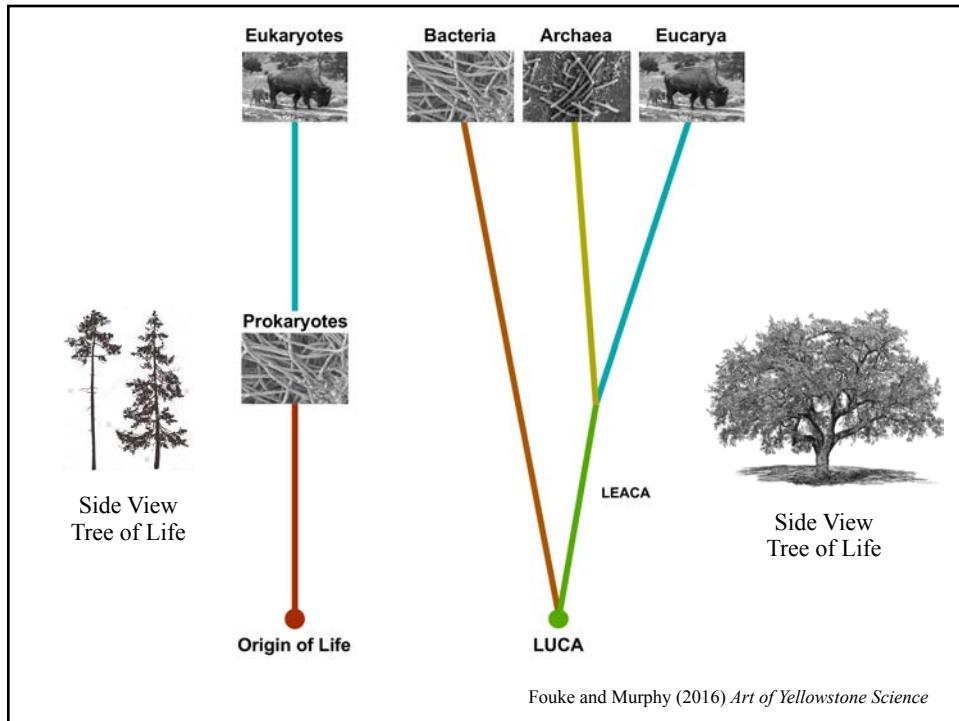


Stiles (1837) map in Washington Irving's *The Rocky Mountains: Scenes, Incidents and Adventures in the Far West*

Fouke and Murphy (2016) *Art of Yellowstone Science*

Contributions of Carl R. Woese

- Chemical Nature of the Genetic Code
- Prebiotic RNA World; Nature of the Pre-Cellular World
- Phylogenetic-Comparative RNA Structure Analysis
- rRNA Sequence-Based Tree of Life
- Discovery of Archaea
- Rejuvenation of microbial ecology because of the newly envisioned Tree of Life



Bruce W. Fouke, Coursera *Emergence of Life*
Lecture 2.4. How Did Life Emerge

