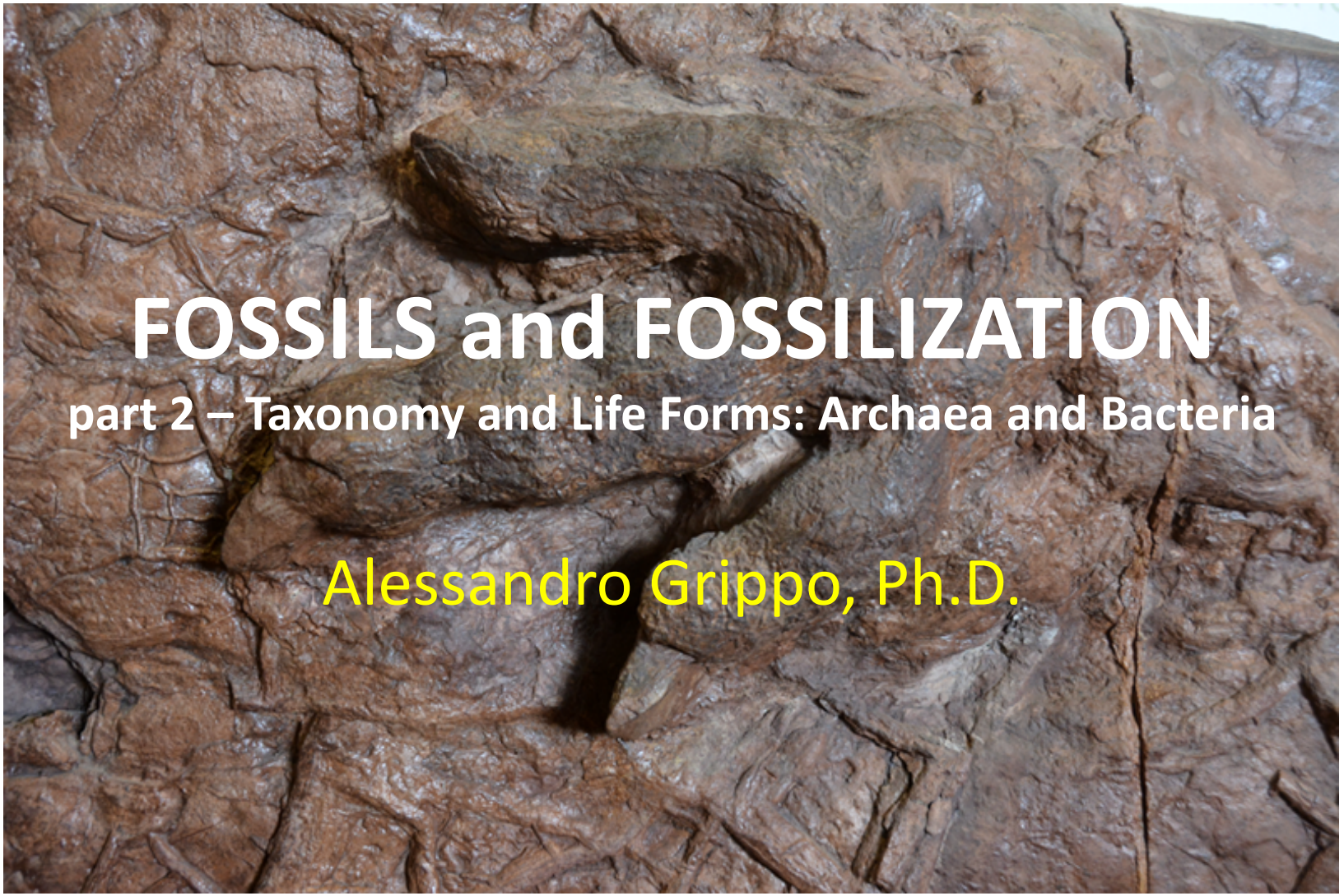

FOSSILS and FOSSILIZATION

part 2 – Taxonomy and Life Forms: Archaea and Bacteria

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Dinosaur footprint, St George Discovery Center, St George, Utah

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Taxonomic Groups

- Taxonomy
  - The study of the composition of, and relationship between different groups of organisms
  - In other words, taxonomy deals with what belongs to a group (or taxon) and how taxonomic groups are related to each other

- Taxonomic groups, or **taxa**
  - All life forms belong to different categories, or taxonomic groups, based on their characteristics

Life on Earth is divided in three Domains

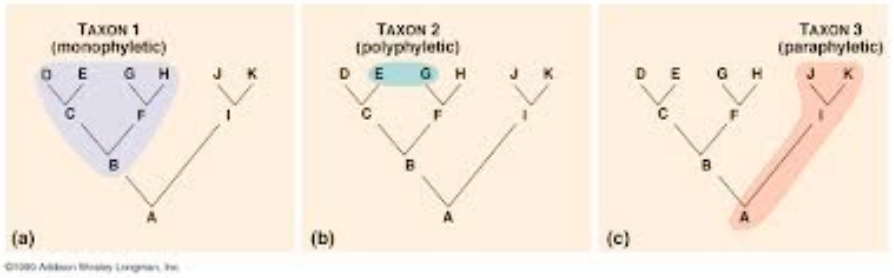
- **Archaea**
  - Prokaryotes
- **Bacteria**
  - Prokaryotes
- **Eukarya**
  - Eukaryotes

- All life forms are formed by cells containing DNA
- Prokaryotic cells lack internal organization
- Eukaryotic cells present internal structuring

Taxa vs. Clades

- Domains are divided in smaller groupings, or clades

- What is the difference between a taxon and a clade?
  - A taxon is any group of species
  - A clade is a monophyletic taxon, that is a taxon that contains only all descendants of a common shared ancestor and the common ancestor



Only Taxon 1 is a Clade

Taxonomy

- All Prokaryotes (Archaea and Bacteria) are unicellular
- Some Eukaryotes are unicellular, others are (like us) pluricellular

- All taxa are organized in a hierarchy, from Domain to Species

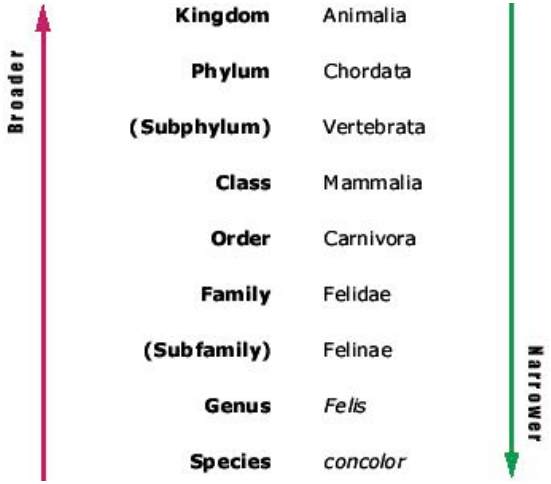
Taxonomic Hierarchy

- The Domain is the highest-rank taxon (or taxonomic group)
  - Within a Domain is the Kingdom
  - Within a Kingdom is the Phylum, and so on:
  - Within a Phylum is the Class, followed by the Order, the Family, the Genus and, last, the Species.

- A Species is a group of individuals that can interbreed

An example of Taxonomic Hierarchy

- These are all the taxonomic groups a mountain lion would belong to:



- Names of Taxa are capitalized, except for Species
- Genus and Species are italicized
- The name of the species is always associated with that of the genus
  - *Felis concolor*
  - *Homo sapiens*

the Tree of Life

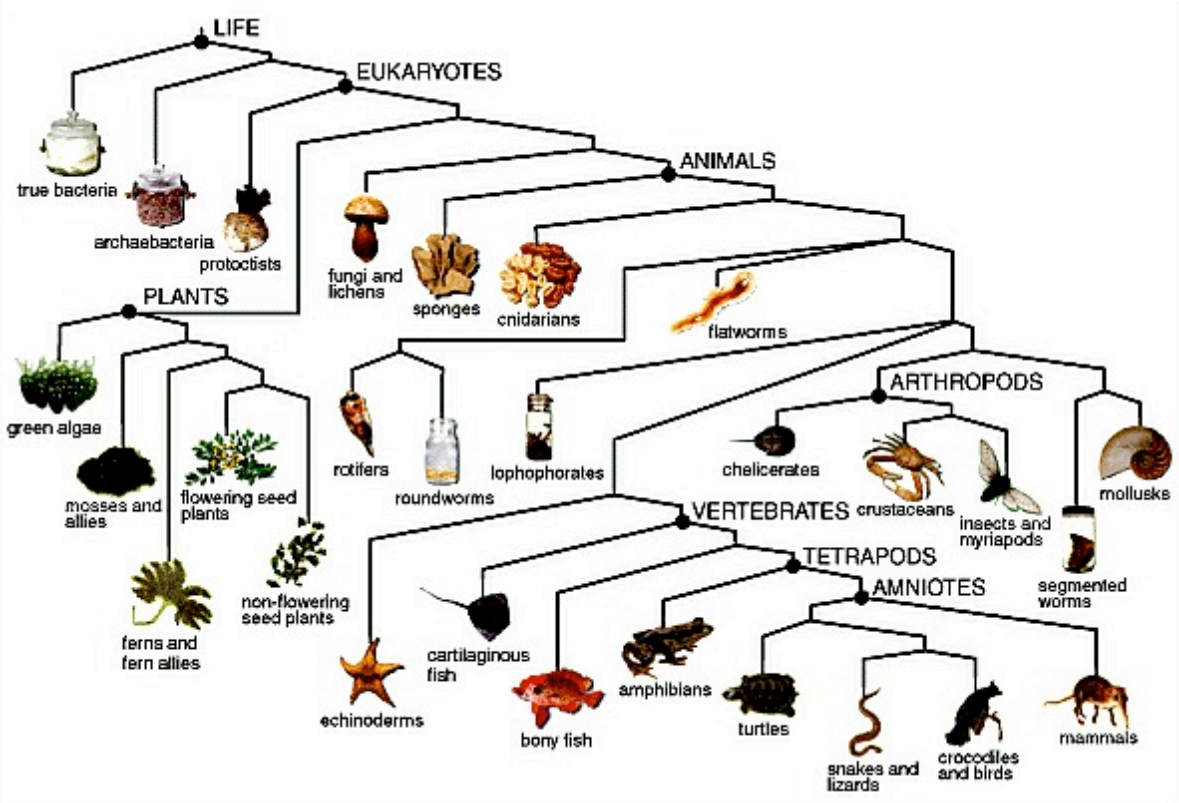
- evidence form morphology, biochemistry and gene sequencing strongly suggests that

  ALL EARTH ORGANISMS ARE GENETICALLY RELATED

- The genealogical relationships between all living things can be represented by the **Tree of Life**

- The Tree of Life represents the **Phylogeny** of organisms (that is, the history of their lineage as they change through time)

the Tree of Life



Domains Archaea and Bacteria

- Collectively known as “bacteria”
- Prokaryotes
- Unicellular
- Mostly very small in size
  - between 500 nm and 2µm
  - 1000 nm = 1µm; 1000 µm = 1 mm; 1000 mm = 1 m

“bacteria” (Archaea and Bacteria)

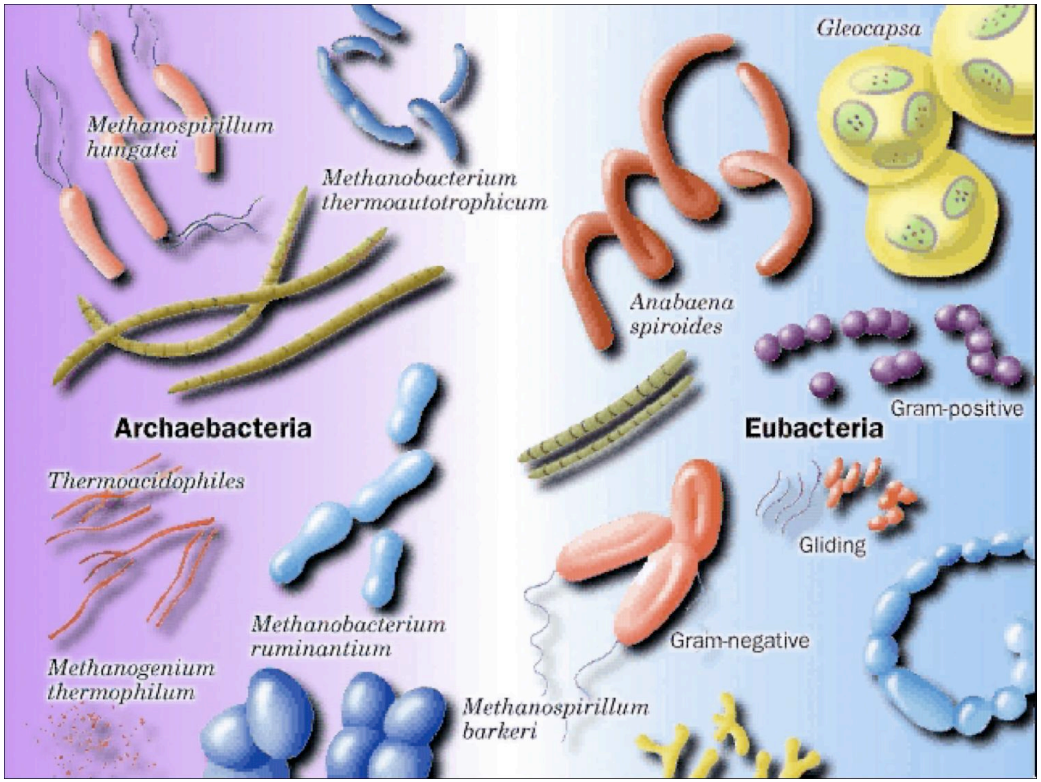
- being so small, bacteria have no physical space within their cells to host a more organized structure, typical of Eukaryotes

- Simplicity of bacterial cell favors basic life processes and functions

- Easier for bacteria to thrive in “extreme” environments (precluded to us eukaryotes)

Archaea and Bacteria

- Archaea (or Archaebacteria) can survive in extreme environments
- Bacteria (or Eubacteria, “True” bacteria) are present almost everywhere, including our body



Archaea: Life in Extreme Environments

- Extreme conditions prevailed on Earth at the very beginning of its existence
- Precambrian life is virtually only bacterial (eukaryotes show up very late during the Proterozoic)
- Not many fossils left: study of signatures left in rocks by bacteria

Archaea: Life in Extreme Environments

- Bacteria establish the broadest limits for life
- Bacteria can survive in conditions we would otherwise define as “impossible”

Archaea: Life in Extreme Environments

- Temperature
  - hot hydrothermal vents (mid-ocean ridges)
  - hot spots (hot pools at Yellowstone National Park)
  - polar ice (and ice in general)
- Pressure
  - interstellar space
  - deep ocean trenches
  - a few kilometers underground

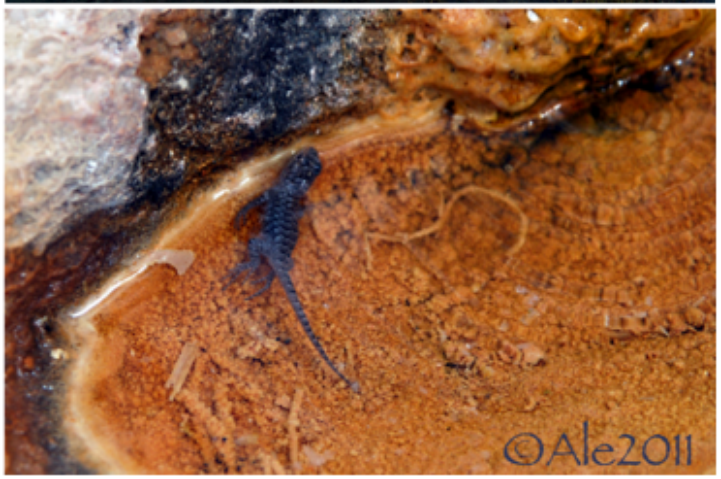
Archaea: Life in Extreme Environments

- Water chemistry
  - acidic waters
  - alkaline waters
- Extreme desiccation
  - water basins with high salinity
  - dry environments, including salt pans like in Death Valley
- Radioactivity
  - some bacteria would survive sterilizing amounts of radiation
  - bacteria found within the water core of nuclear reactors

Extreme Environments:
four examples from our own California

Alkaline waters: Mono Lake

Salt waters to salt deposits: Death Valley



Hot Springs water: Bridgeport

Ice and cold waters: Convict Lake

Bacteria

- Bacteria include:
  - decomposers
  - photosynthesizers
  - agents of disease
  - polluters

Bacteria: cyanobacteria

- Photosynthetic bacteria
  - sometimes called blue algae because they make photosynthesis (but they are not algae!)
- Left an important fossil record (since the Precambrian) in stromatolites
- Some stromatolites are dated to more than 3 billion years ago
- Can be spherical or filamentous (threadlike)

spherical cyanobacteria

filamentous cyanobacteria

- *Nostoc*
  - These Cyanobacteria live in clusters within a gelatinous sphere, usually attached to a surface. The individual Cyanobacteria are the small, filamentous cells inside that form long strands. Some of the cells are larger.

- *Anabaena*
  - Planktonic, solitary

from Cyanobacteria to Stromatolites

- Some filamentous cyanobacteria float as greenish scum on lake, streams, or ocean waters

- Others form “algal” mats on the seafloor that can trap sediment to produce distinctive 3-D structures (stromatolites)

Modern Stromatolites from Shark Bay, Australia

Stromatolites

in four "simple" steps

① **Accretionary organosedimentary structures**

the structure build up (accretes), and forms a structure through interaction of biological and physical processes

② **commonly thin-layered, megascopic, and calcareous**

made of thin, stacked laminae, visible to the naked eye, partially composed of calcium carbonate minerals

③ **produced by the activity of mat-building communities of mucilage-secreting microorganisms**

microscopic organisms living together generate mats, or layers by secreting sticky gelatin-like slime

④ **mainly filamentous photoautotrophic prokaryotes such as cyanobacteria**

most organisms are developing threads (and not spheres), are photosynthetic, are Bacteria and Archaea, and most of the times are cyanobacteria

Fossil Stromatolites

from Glacier National Park, Montana

Fossils
and
Fossilization

end of part 2