Winogradsky columns

Environmental Microbiology

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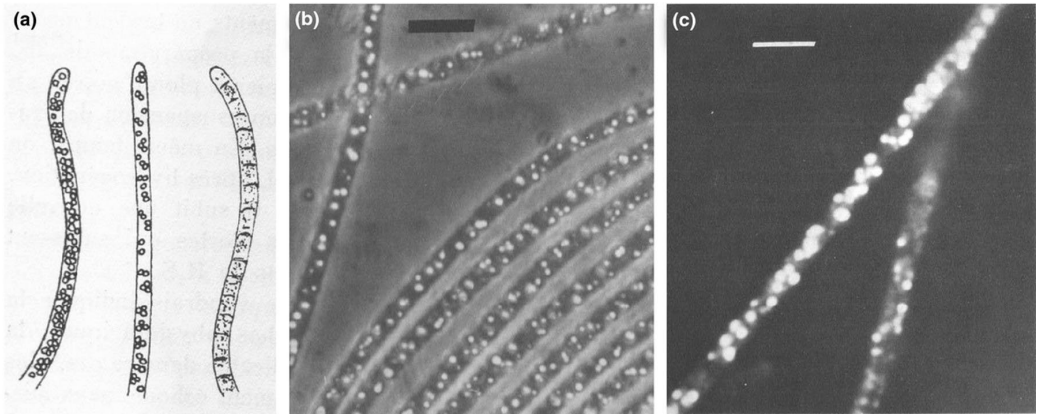
Sergei Winogradsky – First Microbial Ecologist I

Серге́й Никола́евич Виногра́дский (1856 – 1953).

- Discovered chemolithotrophy and later, more specifically, chemolitoautorophy.
  - Chemolithotrophy is the gain of energy through the oxidation of reduced inorganic compounds, such as H_2S by sulphur reducing bacteria (SOB).
  - Chemolithoautotrophy is the gain of energy through the oxidation of reduced inorganic compounds, which also act as C source.

- Established the first microbial naming conventions based on physiological characteristics.



(a) Winogradsky's drawing of sulfur granules in *Beggiatoa* (Winogradsky,). (b) *Beggiatoa* with sulfur granules by phase contrast. (c) Dark field. Bars: 10 µm (Strohl & Larkin,). https://doi.org/10.1111/j.1574-6976.2011.00299.x

Sergei Winogradsky – First Microbial Ecologist II

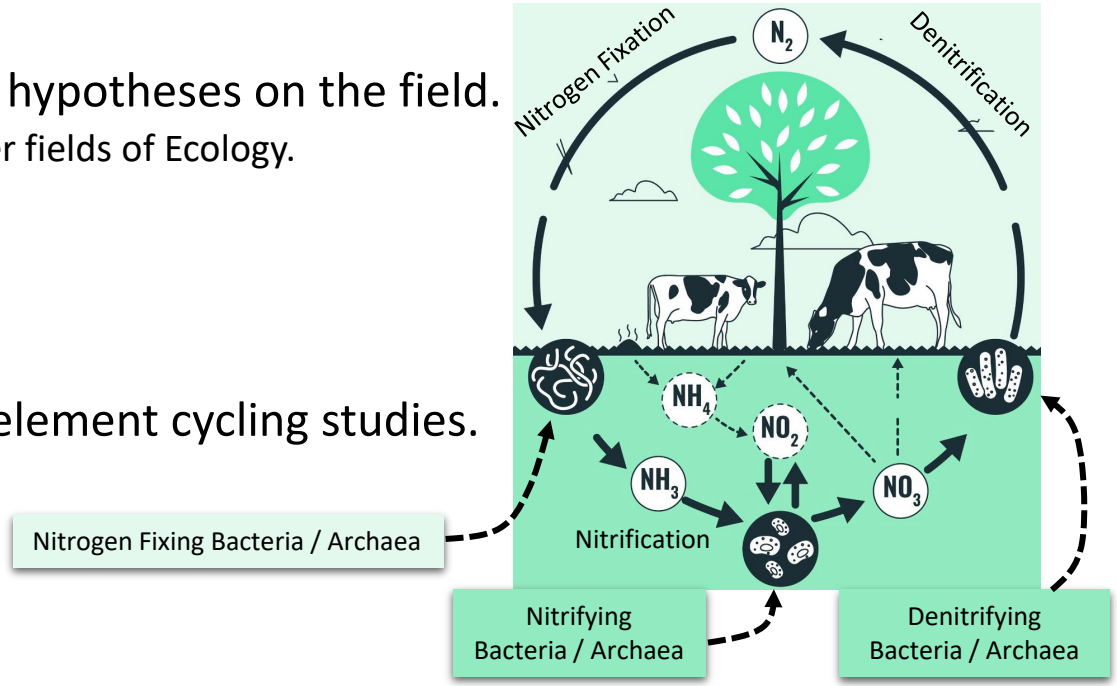
- Discovered nitrification (parallel to Robert Warington).
  - (oxidation of ammonia to nitrite and finally nitrate, Ammonia oxidising bacteria AOB)
  - Co-invented the method of enrichment cultures during his nitrification studies (parallel to Martinus Beijerinck).

- Proved biological nitrogen fixation and isolated the first free-living nitrogen fixing bacteria.
  - *Clostridium pasteurianum.* Capable of transforming atmospheric N_2 into NH_3 which is then released into the soil.

- Pioneered the field of Microbial Ecology and postulated the first hypotheses on the field.
  - His methodical and scientific approach also brought an evolution to all other fields of Ecology.

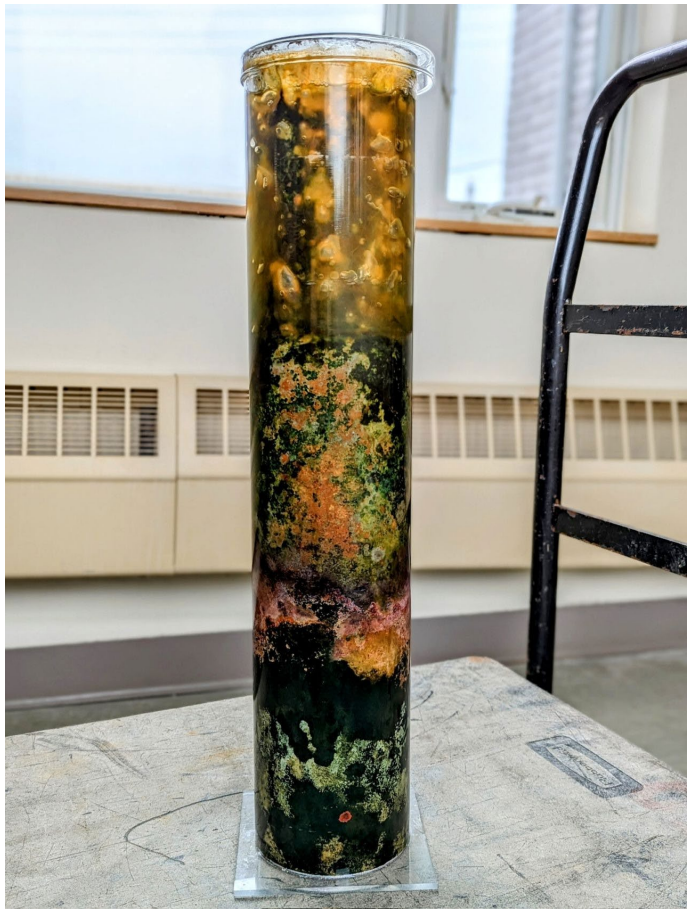
- Massively developed the field of Soil Microbiology.

- Described Sulphur and Nitrogen cycles and preceeded all other element cycling studies.
  - Provided unequivocal evidence of the role of microbes in those cycles.



Winogradsky columns I

- Ecosystem in a bottle.
- First used during the late XIX century.
- Used to study the world of microorganisms in environmental nutrient cycling.
- Can be used as enrichment cultures for microorganisms with metabolisms of interest (such as sulphur reducing).



Joe Vallino, MBL Ecosystems Center

Winogradsky Column: Microbial Ecology in a Bottle

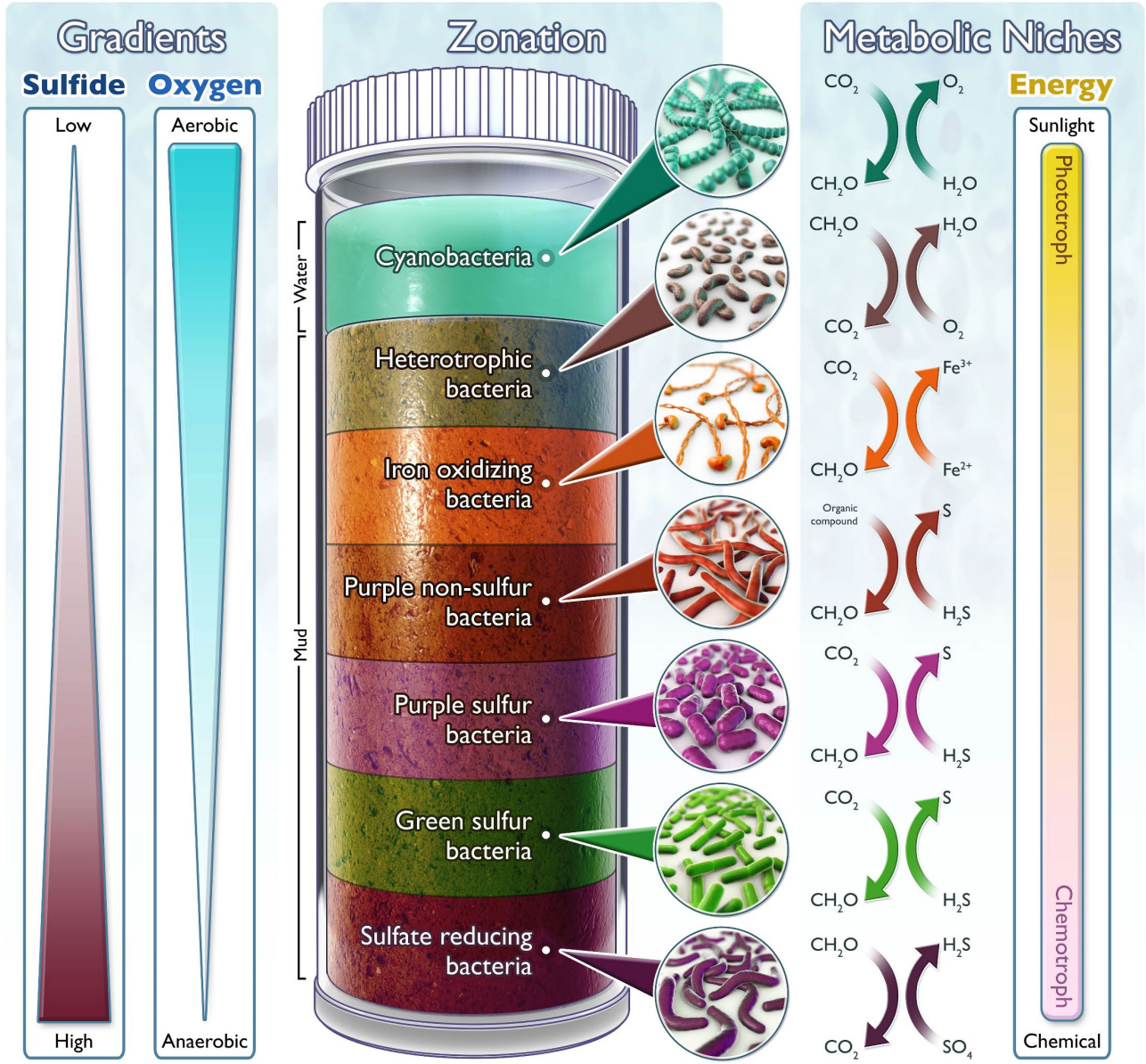
Sergei N. Winogradsky
1856 – 1953

Sergei N. Winogradsky was one of the first microbiologists to study the organisms found in complex biofilm communities. One of the strategies he used to isolate organisms from nature was a miniature model of a pond cross section that is now called a Winogradsky column. It is a simple device for constructing a stratified ecosystem and provides a visual example of various modes of metabolism and zonation in the microbial world. It is a classic demonstration of the metabolic diversity of prokaryotes.

HHMI

H. Olins

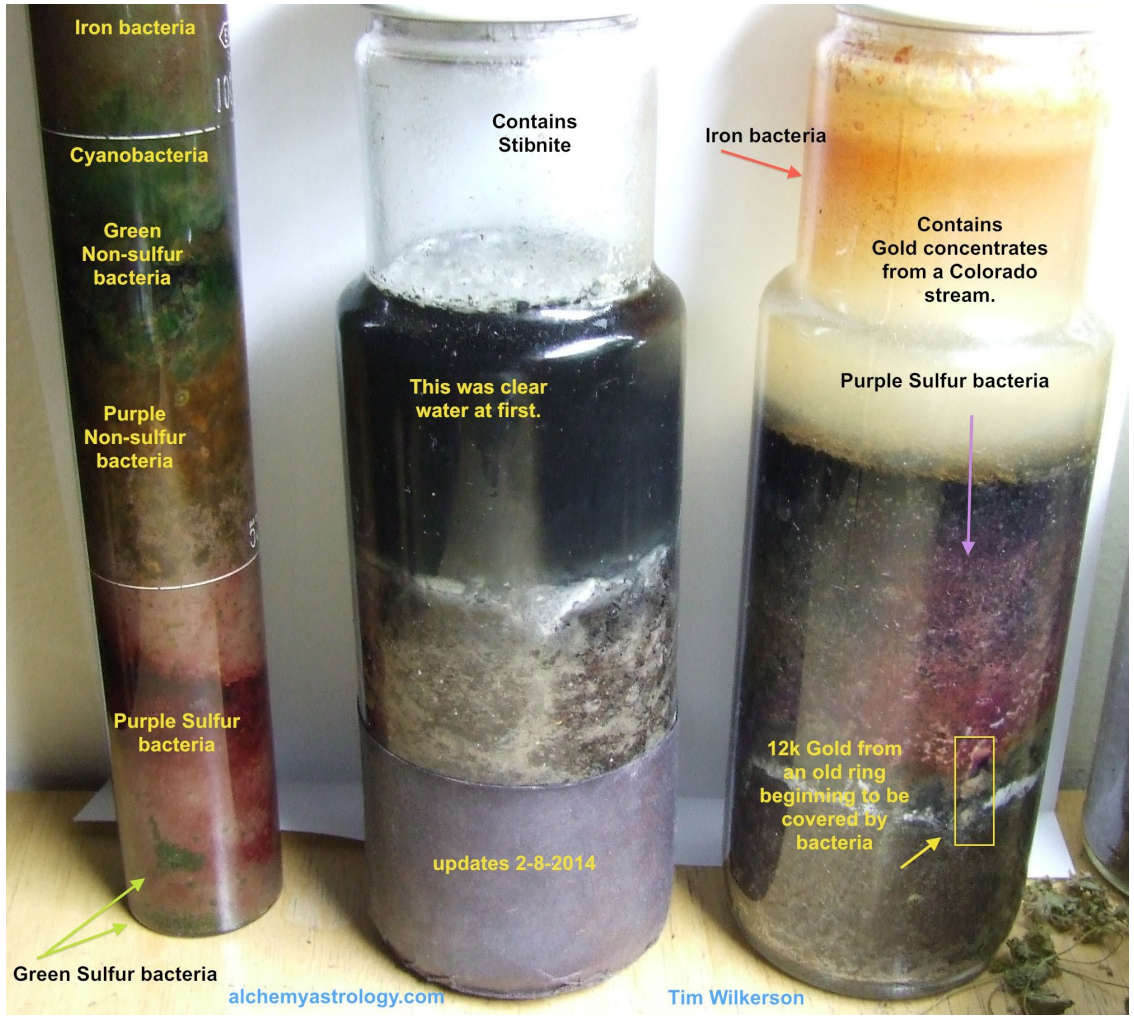
A soil or sediment sample is collected from nearly any source and amended with a variety of compounds such as carbon, sulfur, iron, and/or calcium. The mixture is added to a clear container and topped with water; the container is lightly capped to prevent evaporation. The column is incubated for weeks to months in well-lit conditions, thereby establishing gradients of oxygen, nutrients, and light. Different microbial taxa are adapted to different niches within these overlapping gradients, creating a stratified ecosystem defined by metabolic potential.



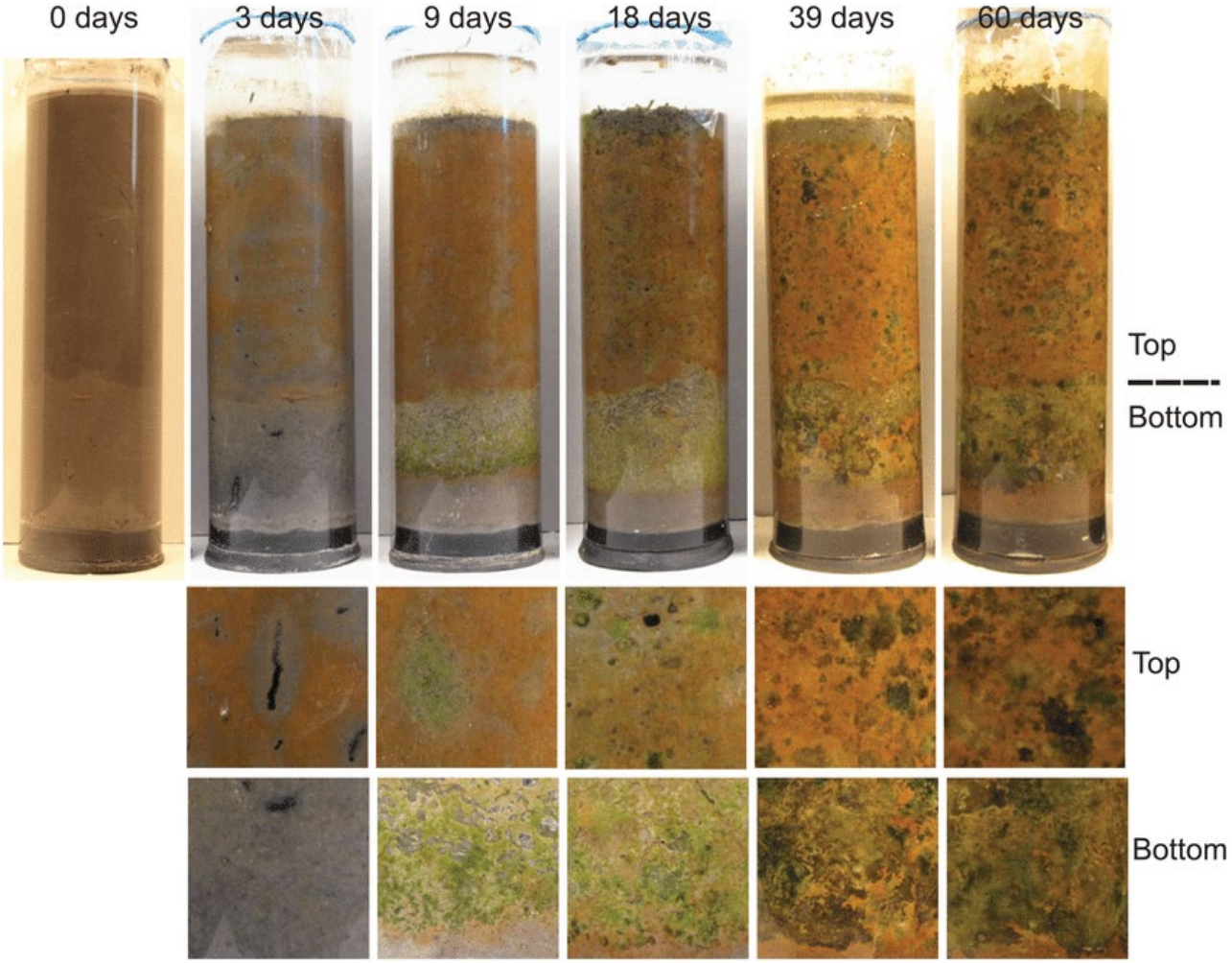
All life on Earth can be categorized according to an organism's carbon and energy source. Energy can be obtained from light reactions (phototroph) or chemical oxidations (chemotroph), and carbon for cellular synthesis can be obtained from carbon dioxide (autotroph) or from preformed organic compounds (heterotroph). These categories combined form the four basic life strategies and can be found among the bacteria within a single Winogradsky column: photoautotrophy, photoheterotrophy, chemoautotrophy, and chemoheterotrophy. Depending on conditions, Winogradsky columns can enrich for many different types of bacteria. The illustration above lists some common examples.

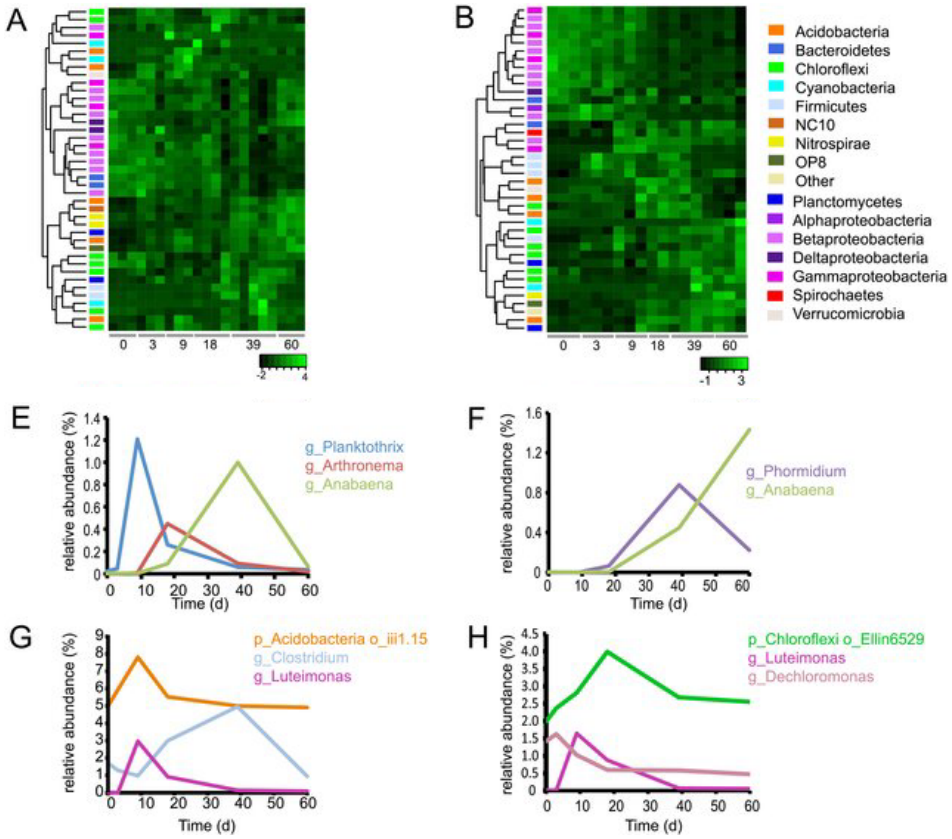
Winogradsky columns II

- Column structure, highly stratified, provides many microenvironments for bacteria, archaea and algae.
- The column is exposed to light which acts as the main energy source
  - Other energy sources will develop as chemoautotrophy is not uncommon.
- Each strata is often dependent on the others.
- Each Winogradsky column is unique. Its community will change and develop based on the initial conditions but also other ones such as light received and temperature during the incubation period.



Winogradsky columns III





Time dependent changes in relative abundance of genera in Winogradsky columns. Abundant genera in the **A)** top layer and **B)** bottom layer are shown. Each row represents a unique genus and the colored bar on the left represents the phylum to which it belongs. Selected taxa that showed rare-to-prevalent dynamics as determined using CRT analysis: **E)** Cyanobacteria, top layer; **F)** Cyanobacteria, bottom layer; **G)** other taxa, top layer; **H)** other taxa, bottom layer. Esteban D. J. *et al.,* 2015. 10.1371/journal.pone.0134588