Database Darkly: Why do we care about protistan biodiversity in the deep sea?

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Introduction

What is a protist?

- *Protist* is a generalized term for single-celled microbial eukaryotes. Protists are essential for ecosystem functions around the planet, with hundreds to thousands of organisms making up a community.
- The domain Eukarya contains all organisms that have a nucleus. This domain comprises a wide range of organisms, including all animals, plants, fungi, and protists.

Why do we care about protistan diversity?

- Protists play critical roles in marine ecosystems as primary producers, consumers, decomposers, and trophic links.
- Protistan biomass constitutes a large portion of the living carbon in marine ecosystems. Their rapid metabolic rates underscore their importance in elemental cycling and energy transfer in the ocean.
- Understanding the diversity of marine protists is essential for accurate assessments of global biodiversity.
- Major evolutionary transitions, such as the foundations of multicellularity, occurred within protist lineages.

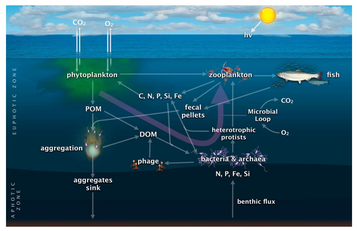

Figure 1: A common depiction of marine microbial food webs. From Worden et al. (2015).

The Eukaryotic Tree of Life

- Represents the eukaryotic biodiversity on earth, underscoring how all life relates back to a common ancestor.
- Historically, relationships were determined based on morphological traits. However, microscopy cannot adequately observe the smallest protists (picoeukaryotes). Furthermore, organisms may appear morphologically similar yet unrelated.
- Modern molecular tools such as metabarcoding and meta'omics allow access to genetic information.
- These tools are especially helpful since many marine protists are uncultivable, making it nearly impossible to observe morphology and behavior.
- Nonetheless, there are still challenges in constructing the tree as genomic sequencing alone cannot fully reveal the underlying complexity of protistan physiology.

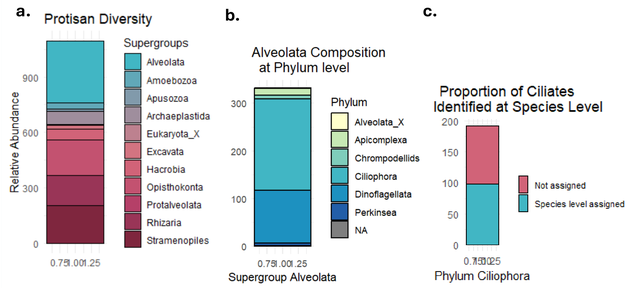

Figure 2: Relative abundance of **(a.)** protist supergroups, **(b.)** phyla within alveolata, and **(c.)** ciliates identified at the species level. The data from these plots was obtained from Database Darkly, illustrating the diversity at the supergroup and phylum levels. The third plot highlights the challenges in identifying protists at the species level.

Eukarya

In the history of life, we trace a profound transition from a world dominated by prokaryotes to one enriched with complex eukaryotic life forms. This evolutionary event underscores the deep interconnections between various forms of life.

By documenting species from hydrothermal vents, Database Darkly helps us understand the ecological roles of ancient protists, providing a crucial link between early eukaryotic life and modern biodiversity.

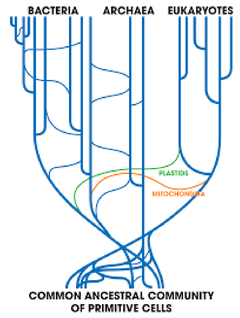

Figure 3: 2005 tree of life showing horizontal gene transfers between branches

Parasitic Protists and their Photosynthetic past

Apicomplexans are parasitic protists that contain an organelle that was once believed to be able to undergo photosynthesis, the apicoplast. While it no longer has the signature green hue and ability to photosynthesize, it is necessary for the parasite's survival.

However, the discovery of *chromera velia*, a photosynthetic protist, connected the relict organelle of the apicomplexans to their past. This organism had a photosynthetic plastid while also having the UGA-Trp codon, which has only been found in apicomplexans. Additionally, the shared *psbA* gene indicates the missing link between apicomplexans and dinoflagellates

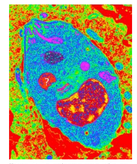

Figure 4: An apicomplexan with an apicoplast, McFadden , G.I.

Figure 5: *chromera velia*, Miroslav Oborník

Regarding Geothermal and Hydrothermal Protists

Protistan communities consist of a wide variety of organisms. In extreme environments, one way to predict this variability is by pH and/or temperature. As pH decreases, microbial species diversity often follows. In geothermal springs, the Alveolata supergroup is found most consistently across springs and is often the most abundant.

Eukaryotes have adapted to survive in these environments because they altered their internal processes during the genetic transfer of proteins, allowing them to keep their internal pH stable.

Additionally, the anaerobic *ciliate Trimyema minutum thermophilium* has been found at high-temperature springs and is also associated with shallow sea hydrothermal vents.

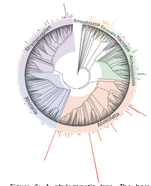

Figure 6: A phylogenetic tree. The bars indicate relative protist abundance, and each color represents taxanomic groups. From Oliverio et al. (2018).

Deep Sea Fungi

Research on the diversity and ecological role of deep-sea fungi was relatively rare until the early 2000s. What has been discovered in the last few decades suggests potential for biotechnical and biomedical applications.

The extreme environment of the deep sea requires organisms to adapt physiologically. Deep-sea fungi regulate and modify gene expression to accommodate the low-temperature, high-pressure environment. These alterations yield specialized proteins and secondary metabolites with industrial and medical applications.

Expanding our knowledge on deep-sea fungi would not be possible without scientific collaboration, including the use of databases such as Database Darkly.

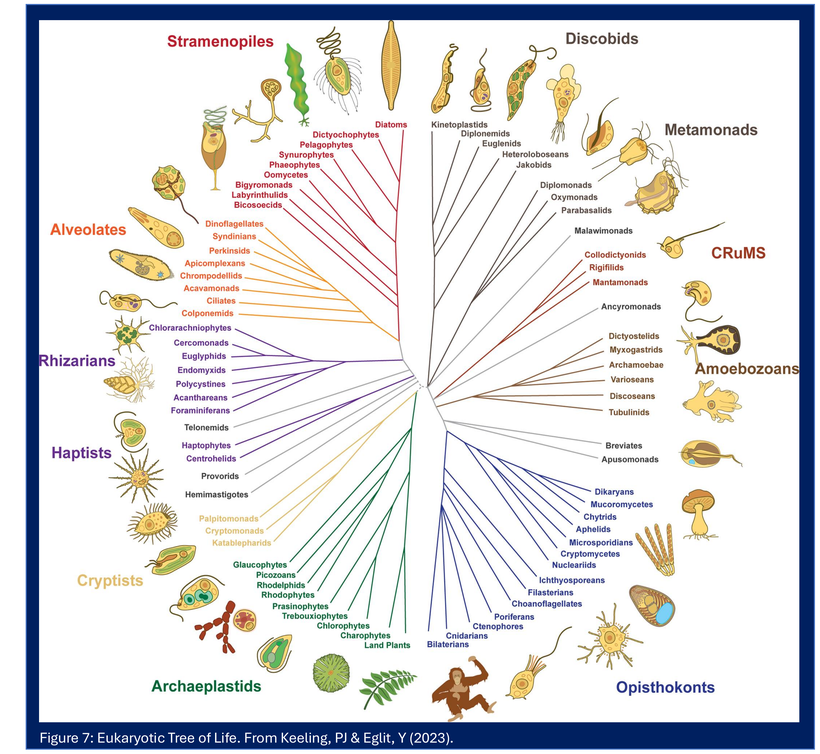

Figure 7: Eukaryotic Tree of Life. From Keeling, PJ & Eglit, Y (2023).

Methods

- The goal of this project was to create a database that compiled information from a deep-sea hydrothermal vent molecular survey (Hu et al. 2023) with existing databases.
- Several databases were used to cross-reference any unknown entries that may be listed under different taxonomic names.
- Protistan taxonomic naming structure is notoriously challenging to document and often changes with new genetic surveys. Therefore, we worked to include other names species may have been known by in the past
- The **PR2 (Protist Ribosomal Reference) database** is a collection of three 18S rRNA databases that aim to provide annotated sequences from domain to species. It currently contains over 220,000 sequences focused on protists but also contains metazoa, fungi, and plant sequences.
- The **WoRMS (World Register of Marine Species) database** provides a comprehensive list of marine organisms and their names. This database was used as a reference for any other name that an organism could go by, which then would widen our research parameters.

Lab website

Database Darkly website

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