**Supplementary Information D1**

The taxonomic relationship within each clade were established with an additional literature review search for

* Cnidaria (1–3)
* Unicellular Eukaryotes (4)
* Fungi (5)
* Algae (6)
* Chlorophyta Mamiellophyceae (7)
* Chlamydomonas (8)
* Rhodophyta (9,10) – Bangio (11)
* Rhodophyaceae - (12) (13)
* Haptophyta (14,15).
* Metamonads (16)
* Rhizaria – Cercozoa (17) – Endomyxia (18)
* Alveolata (19)
* Stramenopiles (20)

References

1. Shpirer E, Diamant A, Cartwright P, Huchon D. A genome wide survey reveals multiple nematocyst-specific genes in Myxozoa. BMC Evol Biol. 2018 Dec 12;18(1):138.

2. Layden MJ, Rentzsch F, Röttinger E. The rise of the starlet sea anemone *Nematostella vectensis* as a model system to investigate development and regeneration. WIREs Developmental Biology. 2016 Jul 19;5(4):408–28.

3. Kayal E, Roure B, Philippe H, Collins AG, Lavrov D V. Cnidarian phylogenetic relationships as revealed by mitogenomics. BMC Evol Biol. 2013;13(1):5.

4. Fairclough SR, Chen Z, Kramer E, Zeng Q, Young S, Robertson HM, et al. Premetazoan genome evolution and the regulation of cell differentiation in the choanoflagellate Salpingoeca rosetta. Genome Biol. 2013 Feb 18;14(2):1–15.

5. Naranjo‐Ortiz MA, Gabaldón T. Fungal evolution: diversity, taxonomy and phylogeny of the Fungi. Biological Reviews. 2019 Dec 29;94(6):2101–37.

6. Hirooka S, Itabashi T, Ichinose TM, Onuma R, Fujiwara T, Yamashita S, et al. Life cycle and functional genomics of the unicellular red alga Galdieria for elucidating algal and plant evolution and industrial use. Proceedings of the National Academy of Sciences. 2022 Oct 11;119(41).

7. Piganeau G, Grimsley N, Moreau H. Genome diversity in the smallest marine photosynthetic eukaryotes. Res Microbiol. 2011 Jul;162(6):570–7.

8. Merchant SS, Prochnik SE, Vallon O, Harris EH, Karpowicz SJ, Witman GB, et al. The Chlamydomonas Genome Reveals the Evolution of Key Animal and Plant Functions. Science (1979). 2007 Oct 12;318(5848):245–50.

9. Yang EC, Kim KM, Kim SY, Lee J, Boo GH, Lee JH, et al. Highly Conserved Mitochondrial Genomes among Multicellular Red Algae of the Florideophyceae. Genome Biol Evol. 2015 Aug;7(8):2394–406.

10. Brawley SH, Blouin NA, Ficko-Blean E, Wheeler GL, Lohr M, Goodson H V., et al. Insights into the red algae and eukaryotic evolution from the genome of *Porphyra umbilicalis* (Bangiophyceae, Rhodophyta). Proceedings of the National Academy of Sciences. 2017 Aug 17;114(31).

11. Jain K, Krause K, Grewe F, Nelson GF, Weber APM, Christensen AC, et al. Extreme Features of the Galdieria sulphuraria Organellar Genomes: A Consequence of Polyextremophily? Genome Biol Evol. 2015 Jan;7(1):367–80.

12. Chen H, Chu JSC, Chen J, Luo Q, Wang H, Lu R, et al. Insights into the Ancient Adaptation to Intertidal Environments by Red Algae Based on a Genomic and Multiomics Investigation of *Neoporphyra haitanensis*. Mol Biol Evol. 2022 Jan 7;39(1).

13. Yang EC, Scott J, West JA, Orlova E, Gauthier D, Küpper FC, et al. New taxa of the Porphyridiophyceae (Rhodophyta): *Timspurckia oligopyrenoides* gen. et sp. nov. and *Erythrolobus madagascarensis* sp. nov. Phycologia. 2010 Nov 23;49(6):604–16.

14. Andruleit H, Young JR. Kataspinifera baumannii: A new genus and species of deep photic coccolithophores resembling the non-calcifying haptophyte Chrysochromulina. J Micropalaeontol. 2010 Dec 1;29(2):135–47.

15. Lin Y, Chung C, Gong G, Chiang K. Diversity and abundance of haptophytes in the East China Sea. Aquatic Microbial Ecology. 2014 Jun 12;72(3):227–40.

16. Karnkowska A, Treitli SC, Brzoň O, Novák L, Vacek V, Soukal P, et al. The Oxymonad Genome Displays Canonical Eukaryotic Complexity in the Absence of a Mitochondrion. Mol Biol Evol. 2019 Oct 1;36(10):2292–312.

17. Hirakawa Y, Howe A, James ER, Keeling PJ. Morphological Diversity between Culture Strains of a Chlorarachniophyte, Lotharella globosa. PLoS One. 2011 Aug 15;6(8):e23193.

18. Stjelja S, Fogelqvist J, Tellgren-Roth C, Dixelius C. The architecture of the Plasmodiophora brassicae nuclear and mitochondrial genomes. Sci Rep. 2019 Oct 31;9(1):15753.

19. Sakamoto H, Lin XX, Bai YD, Chen XF, Zhang ZZ, Honjo Y, et al. Development of a novel electroporation method for the oyster parasite Perkinsus marinus. Sci Rep. 2022 Nov 21;12(1):19996.

20. Jacob AS, Andersen LO, Bitar PP, Richards VP, Shah S, Stanhope MJ, et al. *Blastocystis* Mitochondrial Genomes Appear to Show Multiple Independent Gains and Losses of Start and Stop Codons. Genome Biol Evol. 2016 Nov;8(11):3340–50.

**Supplementary Information D2**

List of UnirProt Identifiers included in the initial phylogenetic analysis

DANRE,HUMAN,CHICK,ANOCA,XENLA,LATCH,CALMI,PETMA,BRAFL,CIOIN,STRPU,SACKO,HELRO,DROME,LIMPO,SCHMA,HYDVU,NEMVE,ANTEL,ACRMI,AMPQE,APLCA

In addition,

ARATH: *Arabidopsis thaliana*

YEAST: *Saccharomyces cerevisiae*

**Supplementary Information D3**

Renamed entries

Entries renamed to Git3

- L8HLR0\_ACACF

- A0A2P6N124\_9EUKA

- F1A2E5\_DICPU

- A0A1X7UQJ0\_AMPQE

- H3B6G6\_LATCH

- GP157\_HUMAN

- A0A4W3GN33\_CALMI

- R7ULM5\_CAPTE

- A0A1X7URB2\_AMPQE

- A0DKL9\_PARTE

- W7X9L3\_TETTS

- A0D9W5\_PARTE

- L8H869\_ACACF

- L8HF38\_ACACF

- A0A0L0DIQ1\_THETB

- A0A0L0SXM6\_ALLM3

- A0A0L0DY10\_THETB

- CRLF\_DICDI

- A7RV25\_NEMVE

Entries renamed to cAMP

- CRLC\_DICDI

- A7S541\_NEMVE

- A0A1X7VI69\_AMPQE

- CRLG\_DICDI

- F1A0N4\_DICPU

- A0A5J4YHZ4\_PORPP

- M2X2Z8\_GALSU

- A0A162PLB8\_9CRUS

- L8GKI9\_ACACF

Enties renamed to Frizzled

- A0A0L0SZS7\_ALLM3

- A0A0L0SPS2\_ALLM3

Entries renamed for cAMP-PIPK

- A0A0D2WMD5\_CAPO3

- A0A833WNI1\_PHYIN

- A9UUR7\_MONBE

- A0A833WGZ5\_PHYIN

- A0A0L0DRJ2\_THETB

- A0A2P6NGK7\_9EUKA

- A0A2P6NIK2\_9EUKA

Entries renamed to Git3-PIPK

- A0A833RTJ3\_PHYIN

- L8GPK2\_ACACF

- Q86D86\_DICDI

- F0ZZ14\_DICPU