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SHORT COMMUNICATION

ON THE CLASSIFICATION OF THE GENERA *Labyrinthula, Schizochytrium* AND *Thraustochytrium* (Labyrinthulids AND Thraustochytrids)

Øjvind Moestrup

Biological Institute, University of Copenhagen, Universitetsparken 4,
DK- 2100 Copenhagen, Denmark

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Corresponding author email: moestrup@bio.ku.dk

Species of the genera *Labyrinthula*, *Schizochytrium*, *Thraustochytrium* and related organisms have recently attracted attention in biotechnology, and here is a short note on how to classify these rather special organisms.

The labyrinthulids and thraustochytrids belong to the heterokonts, a large group of very diverse organisms, from microscopic unicells to metre-long brown algae. The heterokonts comprise species that were formerly classified as algae, fungi and/or protozoa.

Many heterokonts are autotrophic and contain chloroplasts, and such organisms are often classified as algae (golden algae, brown algae). Labyrinthulids and thraustochytrids, however, are heterotrophic and lack chloroplasts. They were until recently known as Labyrinthulomycetes or Labyrinthulea , indeed the new classification of Adl et al. (2019) uses the first of these names. It is an unfortunate name as it gives the misleading impression that they are fungi. Honigberg et al. (1964) and others considered them protozoa.

Are heterokonts algae, protozoa or fungi? And, more specifically, what are labyrinthulids and thraustochytrids?

The heterokonts are thought to be a very old group (probably precambrian), and this may account for their huge morphological diversity. In the WORMS list (World Register of Marine Species) heterokonts are classified as the Infrakingdom Heterokonta . They are considered to be a natural (monophyletic) group. Motile cells of heterokont organisms are typically biflagellate, with an anteriorly directed hairy flagellum which pulls the cell forward when swimming (a 'tractellum'), and draws a water current with food towards the cell in sessile species or stages. The second flagellum is typically smooth. The term stramenopile was created by Patterson (1989) as a name for heterokonts and related organisms with a different type of flagellation, but stramenopile is sometimes used as a synonym of heterokont.

The groups Heterokonta and the related group Apicomplexa , together sometimes known as Chromalveolata, have been thought to be primarily autotrophic. In other words, the ancestors of the group had chloroplasts, postulated to be of red algal origin. One might therefore consider the heterokonts to be algae, many of which later lost their chloroplasts and reverted to heterotrophic nutrition.

Against the hypothesis that the chromalveolates were primarily autotrophs, a theory which is based on molecular evidence, speaks that in the molecular phylogenetic trees, the base of the chromalvelolates is

occupied by purely heterotrophic organisms, not by photosynthetic, chloroplast-containing species. Autotrophic organisms appear higher up in the phylogenetic trees, indicating that chloroplasts were gained later during evolution. If this is correct, then the ancestral heterokonts were heterotrophic.

The labyrinthulids and thraustochytrids are net forming, and the nets are used to catch prey. They form no mycelium and their classification as fungi has therefore always been problematic. In other words, they behave like animals by taking up prey into food vacuoles. Based on their way of feeding they can be classified as protozoa.

Can they also be considered modified algae? Algae are typically photosynthetic, but many species have during evolution lost the ability to photosynthesize. This applies to some red algae and to a few green algae, etc. but phycologists still consider these colourless species to be algae. Even a few higher plants have lost the ability to photosynthesize and have turned to parasitism. However, they are still considered to be higher plants.

If the heterokonts are primarily heterotrophic, they cannot be considered algae which have lost the ability to photosynthesize. They have never had chloroplasts but gained them later by ingesting an alga and retaining its chloroplast as a functional chloroplast. There is no compelling evidence known to me that the ancestors of labyrinthulids and thraustochytids ever had chloroplasts. While the term algae is therefore inappropriate, the terms protists or protozoa are both usable. Like the term ’algae’ these terms go back to the 1800s.

I suggest using the term ‘protists’ for labyrinthulids and thraustochytrids, it is unambiguous. One can also argue for ‘protozoa’, while ‘algae’ is misleading.

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