Manipal Journal of Medical Sciences

Volume 6 | Issue 1 Article 2

6-30-2021

Fungi: Are they plants or animals?

Himanshu YN
Kasturba Manipal College, Manipal, himanshuan007@gmail.com

Sufyan Ibrahim
Kasturba Medical College, Manipal, sufyan.ibrahim2@gmail.com

Revathi P. Shenoy Dr
Kasturba Medical College, Manipal, revathi.shenoy@manipal.edu

Experience

Fungi: Are they plants or animals?

Himanshu Y N*, Sufyan Ibrahim, Revathi P Shenoy

Email: himanshuan007@gmail.com

Abstract

The status of fungi in the phylogenetic setup still continues to be an intriguing question in biological sciences. Having long been considered as close relatives of plants, over the years, their resemblance towards animals has been brought into the greater limelight. While the vast diversity of the group demands a separate kingdom, evolution biology coaxes us to trace back their ancestry and establish similarities between different kingdoms and as newer pieces of evidence emerge up, the question as to whether fungi are plants or animals, remains contentious.

Key words: Fungi; Plants; Animals; Phylogeny; Genetics; Biology.

Introduction

Fungi are a hyper-diverse group of eukaryotic organisms, whose phylogeny has remained a controversial issue all these years because of lack of solid fossil evidence, the divergence of lineages[1], the resemblance of features with more than one kingdom (discussed further) and difficult genomic sampling and genomic/morphological reduction owing to a parasitic lifestyle.[1] More than five decades have passed since they have been given a distinctive identity as a kingdom, but the answer to a simple question of 'What are fungi?' remains a 'dark matter' till today. While none of the fungi has shown any objection to them being called a plant or an animal, over the decades, inquisitive human minds have strived to establish the 'roots' of fungal origin. We herein try to present as to why we think fungi are related more to animals than they are to plants using evidence from existing literature.

Himanshu Y N[1], Sufyan Ibrahim[2], Revathi P Shenoy[3]

[1] *Final Year MBBS Student, Kasturba Medical College, MAHE, Manipal, Karnataka, India.*

[2] *Intern, MBBS, Kasturba Medical College, MAHE, Manipal, Karnataka, India*

[3] *Associate Professor, Department of Biochemistry, Kasturba Medical College, MAHE, Manipal, Karnataka, India*

*Corresponding Author

Manuscript received: 9 February 2021
Revision accepted: 18 June 2021

The earlier considerations

A controversial issue in phylogenetic relationships is the Fungi. Up until the first half of the 20th century, based on primitive observations like lack of locomotion, growth in soil, and presence of a rigid cell wall – all of which were contrary to the then existing notion about animals, fungi were safely considered as plants. When Robert Whittaker put forth the five-kingdom classifications in 1969, taking into consideration the cellular organization, mode of nutrition, and mode of reproduction, it was recognized that fungi are largely a separate category.[2] But, ever since evolution biologists came into the picture, there have been several attempts to explore the theory of common ancestry and thus establish the relationship between fungi and the other major eukaryotic groups.

Basic arguments

Several levels of evidence exist to consider fungi as being more closely related to animals. Basic pieces of evidence like lack of chloroplasts to perform photosynthetic processes and hence lack of autotrophic mode of nutrition (which characterize plants), presence of chitin in the cell wall (chitin being the component of the exoskeleton in lower animals versus cellulose present in plant cell walls), storage of reserve food materials in the form of glycogen (like animals) exist to prove the same. Other morphological, ultrastructural,

How to cite this article: Himanshu YN, Ibrahim S, P Shenoy R. Fungi: Are they plants or animals?. *MJMS*. 2021; 6(1): 3-5

Published by Impressions@MAHE, 2021

and biochemical similarities like the presence of flagellated zoospore stages (motile sperms of animals and spores of Chytridiomycetes with a single flagellum being posteriorly directed); well-developed mitochondria with the flattened plate-like cristae – with reduced gene content, UGA codon in them encoding tryptophan – also support the same. However, evolution biologists have shown that such traits cannot be used at the level of inter-kingdom comparisons considering the lack of universal applicability and their presence in other lineages like protists.[3-8] Nevertheless, through these pieces of evidence, no similarities have been found to link fungi with plants.

Molecular evidence

Research in the field of fungal phylogenetics has advanced in the past few decades owing to advances in DNA technology. Genomic and proteomic evidence in biology promise what sub-atomic particles in physics are expected to do – establishing the origin. Woese has rightly pointed out that "sequence information is innately more informative of evolutionary relationships than phenotypic information".[9]

The first concrete evidence pertinent to our discussion came with the analysis of small subunit ribosomal RNA in 1993, which built upon the foundation of eukaryotic supergroup 'Opisthokonta', linking fungi and animal lineages.[10] In 1994, several other 'conserved' protein sequence analyses including alpha tubulin, beta tubulin, actin, heat shock protein-70 showed evidence to support animal-fungi clade ((A, F), P) by maximal likelihood method of analysis; the plant-fungi clade was true only for the large subunit of RNA polymerase II and was regarded to be unlikely to be the true topology.[11,12]

Since then, there have been confounding proofs about the same – concatenated multigene analysis, single gene analysis, amino acid sequencing.[13-16] Although the 2004 gene analysis involving multimeric beta thymosin gene, a molecular character considered unique to opisthokonts, has been shown only in a single fungus certain molecular signatures like insertion of a 12 amino acid sequence in the elongation factor 1 alpha has been universally applicable to animals and fungi and even their possibly common protists.[12, 17] Future phylogenetic research is aimed at finding more such universally applicable molecular signatures that would further solidify the existing evidence.

Therapeutic considerations

Closer to a plant or an animal, human beings have been exploring therapeutic benefits from fungi since time immemorial – be it penicillins in 1928 or fingolimod in 2011 – fungi have been instrumental in the development of some of the most important drugs in humanity.

In today's world where antibiotic resistance is on the rise and new cancers are discovered every day, the mere fact that humans and fungi are phylogenetically related and could be possibly sharing genetic and protein sequences, opens up new possibilities to look into the unexplored yet related fungal diversity, study disease pathogenesis and develop new and non-toxic therapeutics. Not to mention the potential up-scaling of drug and human protein production.

Secondary metabolites of fungal origin secreted into extracellular medium (extrolites) could be manipulated for human use in various diseases, in order to meet the demands for therapeutic alternatives with enhanced pharmacological properties in order to circumvent the adverse effects of drugs currently in use such as antibiotics or statins.[18]

We could also be looking at widespread drug and vaccine studies on ubiquitously present fungi. All this being said, when the above possibility turns into a reality, we have to be ready to deal with a group of people refusing medicines derived from fungi, just because they are related to animals, making prescription difficult.

Conclusion

In a world of continuing research, what is true today may not be so tomorrow. On the basis of the current literature evidence, we largely support the sisterly relationship between animal and fungal phylogeny.

As new pieces of evidence are gathered, newer insights are dwindled with. Researches have also

reported that perhaps plants and animals could be related to each other more than either of them is to fungi! And whilst evolution biologists continue to solve the major mystery, we would definitely wonder as to how a mushroom could be related to us more than it is related to similar looking salads – The world is indeed a mystery!

References

1. Naranjo-Ortiz MA, Gabaldón T. Fungal evolution: diversity, taxonomy and phylogeny of the Fungi. Biol Rev Camb Philos Soc. 2019 Dec;94(6):2101-2137. doi: 10.1111/brv.12550. PMID: 31659870; PMCID: PMC6899921.
2. Whittaker RH. New concepts of kingdoms of organisms. Science. 1969 Jan 10; 163(3863):150-60.
3. Smith C. The origin of fungi and pseudo-fungi. In: Rayner ADM, Brasier CM, Moore DM, editors. Evolutionary biology of the fungi. Cambridge: Cambridge University Press. 1987. 339–353. (Symp Br Mycol Soc 13).
4. Patterson DJ. The Diversity of Eukaryotes. Am Nat. 1999 Oct; 154(S4): S96-S124. doi: 10.1086/303287. PMID: 10527921.
5. Adl SM, Simpson AG, Lane CE, Lukeš J, Bass D, Bowser SS, Brown MW, Burki F, Dunthorn M, Hampl V, Heiss A. The revised classification of eukaryotes. Journal of eukaryotic microbiology. 2012 Sep; 59(5): 429-514.
6. Adl SM, Bass D, Lane CE, Lukeš J, Schoch CL, Smirnov A, Agatha S, Berney C, Brown MW, Burki F, Cárdenas P. Revisions to the classification, nomenclature, and diversity of eukaryotes. Journal of Eukaryotic Microbiology. 2019 Jan; 66(1):4-119.
7. Gray MW. The endosymbiont hypothesis revisited. Int Rev Cytol. 1992; 141:233-357. doi: 10.1016/s0074-7696(08)62068-9. PMID: 1452433.
8. Cavalier-Smith T. The origin of eukaryotic and archaebacterial cells. Ann N Y Acad Sci. 1987; 503:17-54. doi: 10.1111/j.1749-6632.1987.tb40596.x. PMID: 3113314.
9. Woese CR. Bacterial evolution. Microbial. Rev. 1987. 51 p: 221-27.
10. Wainright PO, Hinkle G, Sogin ML, Stickel SK. Monophyletic origins of the metazoa: an evolutionary link with fungi. Science. 1993 Apr 16; 260(5106):340-2. doi: 10.1126/science.8469985. PMID: 8469985.
11. Nikoh N, Hayase N, Iwabe N, Kuma K, Miyata T. Phylogenetic relationship of the kingdoms Animalia, Plantae, and Fungi, inferred from 23 different protein species. Mol Biol and Evol. 1994 Sept. 11(5). P762-68.
12. Baldauf SL, Palmer JD. Animals and fungi are each other's closest relatives: congruent evidence from multiple proteins. Proc Natl Acad Sci U S A. 1993 Dec 15; 90(24):11558-62. doi: 10.1073/pnas.90.24.11558. PMID: 8265589; PMCID: PMC48023.
13. Baldauf SL, Roger AJ, Wenk-Siefert I, Doolittle WF. A kingdom-level phylogeny of eukaryotes based on combined protein data. Science. 2000 Nov 3; 290(5493):972-7. doi: 10.1126/science.290.5493.972. PMID: 11062127.
14. Lang BF, O'Kelly C, Nerad T, Gray MW, Burger G. The closest unicellular relatives of animals. Curr Biol. 2002 Oct 15; 12(20):1773-8. doi: 10.1016/s0960-9822(02)01187-9. PMID: 12401173.
15. Baldauf SL. A Search for the Origins of Animals and Fungi: Comparing and Combining Molecular Data. Am Nat. 1999 Oct; 154(S4):S178-S188. doi: 10.1086/303292. PMID: 10527926.
16. Inagaki Y, Ford Doolittle W. Evolution of the eukaryotic translation termination system: origins of release factors. Mol Biol Evol. 2000 Jun; 17(6):882-9. doi: 10.1093/oxfordjournals.molbev.a026368. PMID: 10833194.
17. Telford MJ. The multimeric beta-thymosin found in nematodes and arthropods is not a synapomorphy of the Ecdysozoa. Evolution & Development. 2004 Mar-Apr; 6(2):90-94. DOI: 10.1111/j.1525-142x.2004.04013.x.
18. Leitão AL, Enguita FJ. Fungal extrolites as a new source for therapeutic compounds and as building blocks for applications in synthetic biology. Microbiol Res. 2014;169(9-10):652-665. doi:10.1016/j.micres.2014.02.007.