

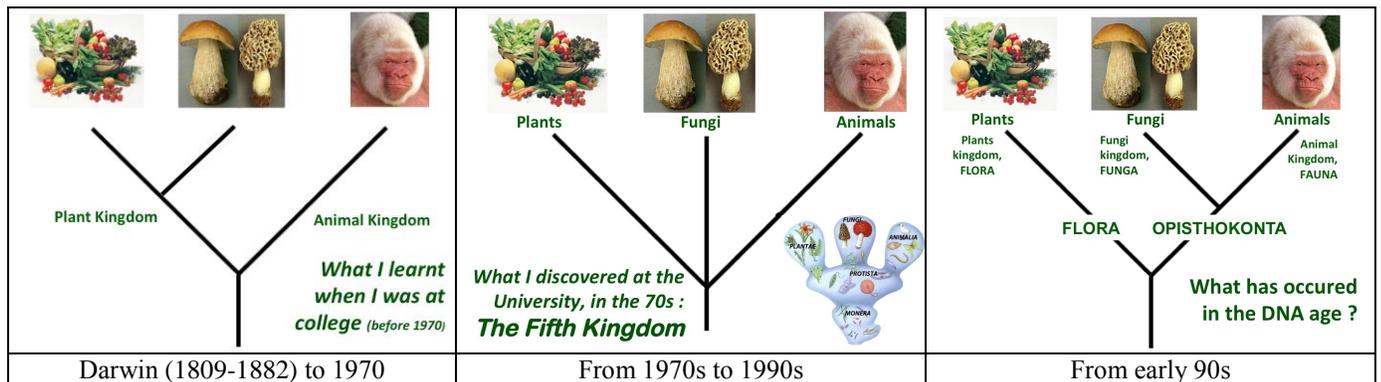
State of the Words of Fungi

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Introduction

The classification of fungi has undergone long and gradual change since Darwin. From 1990s onward, considerable changes occurred. Because of the advances in DNA analysis, fungi have been re-examined and repositioned in the tree of life based on empirical research evidence (see figure 1).

Figure 1: Three major kingdoms in the tree of life (Simplified version)



Note: Figure 1 illustrates the progress in understanding of the relationships between the three major kingdoms of multicellular eukaryotes. Before 1970, fungi were considered to be a part of the plant kingdom because of their similarities to plants such as immobility, rigid cell wall and spores reproduction mode despite Fungi have no chlorophyll, stems, roots, leaves or vessel. The status of fungi was increasingly questioned from 1970 as research evidence emerged and the notion of the fifth kingdom spread¹. Since the early 1990s, the development of DNA sequencing methods has enabled research to confirm that fungi are not plants but closely related to animals².

One of the consequences of these changes has impacts on the vocabulary of mycology in the last thirty years. For example, in the classification of fungi many taxa have changed their names that puzzle many mycologists for two reasons. Firstly, the definition of certain terms have been used for a long time and deeply rooted in mycology. Secondly, some of these terms become obsolete but others have to be clarified while new terms have to be used to replace some others. Thus, though these changes are valued for their scientific clarification of fungi, making changes can be an upheaval or a disruption for some mycologists.

The goals of this paper are to clarify important changes, what have been done and what need to be done in the process of repositioning the Kingdom of Fungi to its current state. A conclusion is drawn for a call for leadership in mycology to advocate mycology as an evidence-based empirical study of fungi and promote the compliance with new rules and standards for naming fungi.

Taxonomy and Terminology

Terms and related definitions exist to describe specific aspects of fungi but they often are changed or to be adjusted over the time of development as new scientific discoveries emerge. Though names of some taxa have been used for centuries, they are to be replaced to comply with writing rule of the new hierarchical rank and commonly accepted standard for consistency with the support of research evidence. Name replacements are valued for applying scientific description of fungi in correspondence to accountability and accuracy. For example, basidiomycetes and

¹ Whittaker, Robert H (1969). "New concepts of kingdoms or organisms. Science, 163: 150-194

² Baldauf SL et al (1993). Animals and fungi are each other's closest relatives: Congruent evidence from multiple proteins. Proc Natl Acad Sci U S A. 90(24):11558-62.

ascomycetes have been replaced by Basidiomycota and Ascomycota. The suffix -mycetes refers to a rank of classes as a rule but those two groups belong to the higher rank of phylum, their suffix is changed to -mycota. In this way, confusion is limited, especially, for students and nonspecialists³.

Some names of taxa that are more than 100 years old have lost their meaning in the phylogenetic classification because of their polyphyletic nature (i.e., members of the group located on different branches in evolution). Note that these taxa names that have become obsolete often retain a descriptive value of morphological groups. It is the case of gasteromycetes, which means these mushrooms producing their spores until maturity inside a closed sporophore. The term retains a practical utility for a morphological group of mushrooms, that is, those species that are grouped solely based on their macroscopic resemblance without evolutionary consideration.

Other terms relating to the biological nature and ways of living of the fungi have been adjusted. For example, saprotroph⁴ is fungi that feed on or get nourishment from decaying organic matter. It replaces saprophyte, which refers to plant. Similarly, for specifying the reproductive structure of fungi, sporophore replaces carpophore and sporocarp. For another example, in Basidiomycota and Ascomycota, basidioma and ascoma are increasingly used to replace basidiocarp and ascocarp. The reason is that the prefix and suffix of carpo- and -carp signify a fruit that is the reproductive organ proper to flowering plants and have nothing to do with fungi.

Apart from taxonomy, the use of two relatively new terms has remarkably made their way into mycology in recent years, particularly in French. These terms are "*fonge*" and "*fongarium*"; they are *funga* and *fungarium* in English. *Funga* denotes the kingdom of Fungi (also known as Mycota). Similarly, *flora* is for plants and *fauna* is for animals. Nevertheless, continental divide occurs in its acceptance. The use of *fonge* has widely spread in Europe and in Québec for almost a decade and so as the term *funga*, particularly in publications such as the internationally renowned mycological book series *Funga Nordica*. In contrast, *funga* is rarely used in English speaking North America. *Funga* has not been included in the 10th edition of Dictionary of the Fungi (2008)⁴ but, probably, it will be in the upcoming edition owing to its frequent use in Europe.

With regard to the use of the term of "fungarium", its acceptance is fairly recent globally. A few years ago, mycological research collections were still referred to as the "fungal herbarium or mycological herbarium". The current increase of the use of "Fungarium" indicates that it is gaining recognition it deserves both in Europe and in North America to specify it as an organization for fungi collections preserved in a dehydrated state or other states for study and research purposes. Kew Gardens (the Royal Botanic Gardens) is one of the first internationally renowned institutions to adopt fungarium for its impressive Fungi collection. In Canada, the Royal Ontario Museum in Toronto and the Fungarium of Cercle des mycologues de Montréal were the first institutions to adopt the term of fungarium respectively. Following these examples, some amateur mycologists create their fungarium for their collection of dried mushrooms but do not use the obsoleted "herbarium of mushrooms". It implies that despite resistance fungarium is, gradually, getting independence from herbarium to be a unique entity of its own.

Mycology is an evidence-based science. Its advancement depends on the implementation of new knowledge deriving from current research evidence. Consequently, changes and adjustments (e.g., to be independent from plant and the use of new taxa and terminology) are not avoidable. The purpose is *not* to discredit any historic foundation established but aims to progress from this foundation paved for further development.

Nevertheless, changes are challenged by either negligence of current rules and standardization or ignorance of recent empirical scientific evidence of mycology. The use of obsolete concepts and terms to describe the fungal kingdom and mycology still persists among some professional mycologists, researchers or mycology teachers. This persistence may create confusion, misconception and biases or partiality in the study and the education of fungi.

Misconception of Fungi and Mycology

Fungi are not plants! This statement is no longer disputed in science. To identify and describe new species of plant or fungi, there is a set of rules and recommendations dictating by a code of nomenclature. In 2011 at the Melbourne International Botanical Congress, the name of the code was changed from International Code of Botanical Nomenclature (ICBN) to International Code of Nomenclature for algae, fungi and plants (ICN). To limit confusion, "botanical" was removed from the code to acknowledge that fungi and algae are not plants.

³ Hibbett D et al (2007). A higher-level phylogenetic classification of the Fungi. *Mycological research*. 111: 509-547.

⁴ Kirk PM et al (2008). Ainsworth & Bisby's Dictionary of the Fungi, Tenth ed. CABI Publishing, Wallingford.

When certain scientific popularization insistently uses outdated or obsolete mycological terminology because of its popularity and a history of using it in a community, this type of scientific popularization propagates errors and misconception of fungi. For example the term of "mycoflora" involves two organisms in its formation, i.e., "fungi plants". Fungi are not plants and plants are not fungi, joining two together to form a term to describe fungi indicates a rejection to scientific evidence that confirms fungi are not plants but close relative of animals. The persistence of using this term is an example to show either negligence or ignorance explained in previous section.

The negative impacts of perpetuating use of erroneous terminology in mycology on fungi research as well as teaching and learning of fungi are observed. The phylogenetic classification of the kingdom of Fungi was proposed in 2007. This classification has been accepted universally in mycology since then. One of the goals aims at eliminating inconsistencies that creates confusion, especially for students and nonspecialists¹. The implementation of this in fungal terminology can resolve issue stated.

Why is it useful to Amateur Mycologists to apply exact mycological terminology?

In the field of macroscopic fungi (macrofungi), it is well known that amateur mycologists have expertise surpasses scientific (or professional) mycologists at the level of macrofungi recognition across a large diversity of species. Despite the lack of thorough knowledge in biology, the field experience of these "macromycologists" empowers them to be experts in a restricted area of mycology of their choice or interest; in the eyes of the general public they are perceived as experts in mycology. They play a vital role in popular education in their community. Thus, their ability to use updated mycological terminology fosters the transmission of accurate information of mycology to the general public.

Besides, owing to public recognition of their expertise in macrofungi, especially, in arena of edibility of wild mushrooms, amateur macromycologists have often been consulted by hospitals to determine the causes of fungal intoxication. Their ability to use accurate mycological terms facilitates communication of medical assistance.

In addition to these important roles, macromycologists are frequently requested by ecologists and professional mycologists to provide detailed characteristics of macrofungi inventories. Mycoblitz becomes popular in ecological study due to the importance of knowing the macrofunga⁵ in a territory. The participation of "amateur" macromycologists provides a most useful contribution. For example, a professional mycologist (a researcher) at University of Toronto, who publishes frequently in fungi phylogenetic, has informed the author that he was invited to participate a mycoblitz. He felt very uncomfortable because he could not identify the majority of the mushrooms in the field or on the exhibit tables in comparison to many amateur mycologists.

During the interaction between professional and amateur mycologists, they exchange scientific knowledge and learn from one another. When obsolete or inaccurate information is conveyed, confusion or mistake learning occurs, and mycologists may pass on this mistaken information during formal and public education or medical consultation. Its negative impacts can hinder advancement of knowledge and practice in mycology and in their community at large. The implication is that the use of precise and accurate terms to describe fungi among amateurs and professional mycologists is essential.

Mycology at university teaching

Universities are mega educational institutes that are slow in changes. Their current biological sciences curriculum for the first degree programme has not matched with current states of science discovery of mycology. Some universities do not offer mycology courses in their biological sciences while some other universities still considered mycology to be a sub-unit of botany. It is not a surprise that mycology and fungi have still taught under botany in undergraduate programmes. On one hand, fungi are only examined within a general botanical or plant diversity course, where they often represent less than 10% of the content. This poses reluctance in teaching fungi among university professors; related topics have been touched in whatever seems appropriate to them in botany. On other hand, students may finish their first degree in biology with superficial knowledge of fungi and without understanding the importance of the interactions of fungi with the rest of biological diversity. It implies that this university education does not educate students to be future mycologists or citizens who understand fungi and their roles in our nature and environment, and that changing the system requires funding and curriculum reform.

⁵ Funga design the Fungi on a territory, without regard they are macroscopic or microscopic. By extension, macrofunga is apply specifically for the macrofungi on a territory. (The author)

Conclusion

The standardisation of classification proposed in 2007 was accepted and applied. It has big impacts on the advancement of phylogenetic classification of Fungi, as well as on knowledge exchange and communication between mycologists of all levels including professionals, amateurs, and students. It promotes the increase of accuracy but limits confusion. Thus, leaders in mycology may consider advocating this standardization for the mycological terminology. Speaking the same language is important for the clarification of conceptions of mycology and of term definitions in the enhancement fungi knowledge and mycology education.

In terms of education, fungi should be taught and learned in a programme dedicated to mycology in biological sciences. Fungi are composed of many diversified organisms of extremely varied characteristics and ways of living in biodiversity. Nature and attributes of Fungi are very different from prokaryotes, plants and animals. Thus, Fungi are unique entities that deserve to be studied as a major in biological sciences at university.

Currently, mycology is not offered as a major in biological sciences. When students complete the first degree at their university, some of them can say that they are plant biologists, animal biologists, ecologists or microbiologists (bacteriologists). A question arises: *Are some of them qualified to be fungal biologists (mycologists)?* When the answer is no, it indicates that the next generation may not be able or interested in carrying the torch. This leads to a call for leaders in mycology and our effort to resolve this issue in collaboration.

The advancement of fungi and mycology knowledge depend on leadership and mycological organizations that devote to advocate research on nature of Fungi and significance of mycological sciences as one of the five major kingdom of life. Among things to be done, its primary step is the compliance with new rules and standards for naming fungi, so that, the same fungi vocabulary can be used in knowledge exchange for effective mutual understanding among mycologists and educational practitioners. This leads to another call for strong leadership to implement standardization in the mycological terminology.



Plant Kingdom

Animal Kingdom

***What I learnt
when I was at
college (before 1970)***



Plants

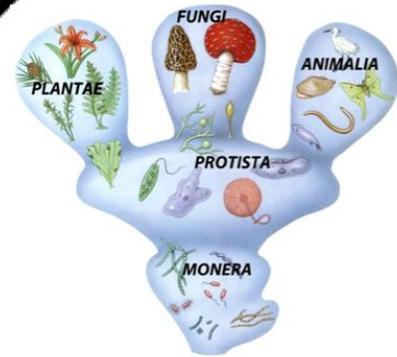


Fungi



Animals

***What I discovered at the
University, in the 70s :
The Fifth Kingdom***





Plants

Plants
kingdom,
FLORA



Fungi

Fungi
kingdom,
FUNGA



Animals

Animal
Kingdom,
FAUNA

FLORA

OPISTHOKONTA

**What has occurred
in the DNA age ?**

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