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Protozoans: Animals or Protists?

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ABSTRACT

Protozoans are single celled eukaryotes found worldwide with rich biodiversity. The protozoan species live in different habitats as free living or parasite having different shapes and adapted for various physiological activities. These are microscopic unicellular eukaryotes that have a relatively complex internal structure and carry out complex metabolic activities within a cell by highly specialized subcellular organelles like pseudopodia, flagella and cilia. Initially protozoans were kept in phylum Protozoa under kingdom Animalia as per classification of Linnaeus but later placed under kingdom Protista from three to six kingdom systems. In present article, author attempted to discuss the position of protozoa from two to six kingdom system of biological classification and finally concluded that protozoans are now protists, and not the animals.

Keywords: Biological classification, Domains of life, Kingdom systems, Protozoa, Whittaker.

INTRODUCTION

The word 'protozoa' was coined in 1818 by Zoologist Georg August Goldfuss, who created Protozoa as a class containing what he believed to be the simplest animals (Goldfuss, 1818). Originally, the group included not only single-celled micro-organisms but also some 'lower' multicellular animals, such as rotifers, corals, sponges, jellyfish, bryozoans and polychaetes (Goldfuss, 1820). Von Siebold (1848) raised the group protozoa to the level of a phylum containing two broad classes of microorganisms: Infusoria (mostly ciliates and flagellated algae) and Rhizopoda (amoeboid organisms).

The protozoans are primitive, microscopic and unicellular; often called acellular because the same single cell performs all the vital activities necessary for an independent existence as a complete organism. They are therefore more than a single cell having the magical capacity to perform all vital activities within a cell with the help of highly specialized subcellular organelles like pseudopodia, flagella and cilia. They have protoplasmic or subcellular grade of organization with predominant asexual reproduction and less pronounced sexual reproduction.

The protozoans occur in all the three types of habitats *viz.* air, land and water and constitute ecologically dispersed group with rich biodiversity. They show structural, habitat, functional and generic diversity. The rich biodiversity helps to maintain the ecological balance (Ashok, 2017; 2018). The protozoans live in different habitats as free living or parasitic forms with varied shapes and adapted for various physiological activities and conditions (Kudo, 1954).

Historical background

The living organisms are large in number with diverse characters; they may be similar in their general appearance but differ in detailed characteristics because of specialization mainly in their form, structure, metabolism and life cycle. It is almost impossible to study all the living organisms; hence methods of classification were developed. The classification of these organisms on the basis of their similarities and dissimilarities are concerned with taxonomy.

Aristotle (384-322 BC), Father of Biology, Father of Zoology and Founder of Taxonomy, was pioneer in the field of biological classification. Aristotle (c. 350 BC) classified the animals into two main groups *namely* (a) Anhaima: animals without red blood and (b) Enhaima: animals with red blood. Today, former is referred to as invertebrates and latter vertebrates in broader sense.

A Swedish Naturalist Carolus Linnaeus (1758), for the first time classified the living organisms in a systematic way, introduced the hierarchic system both in plants and animals. He laid the foundation of modern biological classification by classifying the organisms into two kingdoms *namely* Plantae and Animalia. His classification is now popularly known as Two Kingdom System. The Kingdom Plantae (Plant Kingdom) included chlorophyll containing green plants, mosses, ferns, many colourless and coloured unicellular organisms, moulds, fungi, lichens, bacteria and multicellular seaweeds while Kingdom Animalia (Animal Kingdom) included unicellular protozoans and multicellular organisms without having chlorophyll and photosynthetic ability. The Protozoa was mentioned there as a part of kingdom Animalia. When the first unicellular organisms were discovered by Antoine van Leeuwenhoek in 1674, they were placed in one of the two kingdoms of living beings, according to their characteristics. The two kingdom system of classification of Linnaeus was not found suitable due to huge diversity among the organisms and many other limitations.

The two kingdom system began to weaken, with the growing awareness that fungi did not belong to the plant kingdom, and that most of the unicellular protozoa were no more closely related to the animals than they were to the plants. This led to the development of concept of multi-kingdom systems. A German Biologist Haeckel (1866) proposed a third kingdom, the Protista, for unicellular eukaryotes such as protozoans.

Later, the development of optic and electronic microscopy showed important differences in cells, mainly according to the presence or absence of distinct nucleus, leading Édouard Chatton to distinguish organisms in prokaryotes (without a distinct nucleus) and eukaryotes (with a distinct nucleus) in his paper entitled 'Pansporella perplex: Reflections on the Biology and Phylogeny of the Protozoa' during 1925 (Sapp, 2005). Chatton later expanded his studies to include marine protists, helping to contribute to the description of the dinoflagellate protists (Soyer-Gobillard, 2006). On the basis of this new finding, American Biologist Copeland (1956) proposed a four-kingdom system, moving prokaryotic organisms, bacteria and blue-green algae, into a separate kingdom Monera. In this way, he created the fourth kingdom, Monera, to include bacteria and blue green algae. A comparative historical account of these different kingdom systems is given by Verma (2017a).

Five kingdom system

The position of fungi was not well established both in three and four kingdom systems, oscillating between kingdoms Protista and Plantae hence there was a need to rethink about it. American Ecologist Robert H. Whittaker (1969) thought and proposed a fifth kingdom 'Fungi' to include them and to fill this genuine gap. In his 'Five Kingdom System', he succeeded in overcoming the difficulties as well as demerits of two, three and four kingdom systems and represented the living organisms according to the evolutionary relationships among themselves. He also defined the kingdoms by a number of special characteristics such as whether the organisms possessed a true nucleus or not. Whittaker's five kingdom system of classification is based on (a) mode of nutrition (b) cell structure and complexity (c) phylogenetic relationship (d) body organization and (e) reproduction. The five kingdom

system despite of having some demerits is still widely accepted (Verma, 2016a; Verma and Prakash, 2020). Different kingdoms in this system are:

1. Monera: Prokaryotes e.g. Prokaryotes e.g. bacteria and blue green algae

2. Protista: Unicellular eukaryotes e.g. unicellular algae, diatoms and protozoans.

3. Fungi: Multicellular decomposers e.g. fungi and moulds.

4. Plantae: Multicellular producers e.g. plants.

5. Animalia: Multicellular consumers e.g. animals.

Three domain system

With the advancement in biological researches, profound knowledge of microbial diversity and DNA sequencing resulted in elaboration of five kingdom system into six kingdom system. An American Microbiologist, Carl Woese and others adopted the term 'domain' in 1990 and introduced three-domain system in biological classification mainly on the basis of 16 S rRNA genes. This system adds 'domain' as a 'superkingdom' a level of classification "above" the kingdom (Woese *et al.*, 1990).

The three domains are: Archaea, Bacteria and Eukarya (Eucarya). The domain Archaea includes only one kingdom Archaebacteria (ancient bacteria); domain Bacteria also includes only one kingdom Eubacteria (true bacteria) whereas domain Eukarya includes remaining four kingdoms namely Protista, Fungi, Plantae and Animalia. The Archaea and Bacteria domains contain prokaryotic organisms that do not have a membrane bound nucleus while the Eukarya domain includes eukaryotic organisms that have a membrane bound nucleus. The Archaea is divided into three major groups *namely* (1) Methanogens that occur in oxygen-depleted environments of soils and gut of several ruminants and produce methane, (2) Extreme halophiles that live in high salt concentration and (3) Hyperthermophiles that normally grow in extremely hot environments. This is consistent with recent discoveries of more diversity among microbes than animals and plants that makes this system relevant (Verma, 2016b).

Cavalier-Smith (1981) proposed eight kingdom system and divided all organisms into eight kingdoms *namely:* Bacteria, Eufungi, Ciliofungi, Animalia, Biliphyta, Viridiplantae, Cryptophyta, and Euglenozoa. Levine *et al.* (1980) described the Protozoa as subkingdom and divided it into 7 phyla *namely* Sarcomastigophora, Labyrinthomorpha, Apicomplexa, Microspora, Ascetospora, Myxospora and Ciliophora. Cavalier-Smith (1993) erected the Protozoa as kingdom and divided it into 18 phyla. Sina *et al.* (2005) revised the Levine's classification and recognized six clusters of eukaryotes that may represent the basic groupings similar to traditional 'kingdoms.'

CONCLUSION

Protozoans, the single celled eukaryotes are found worldwide in all the three types of habitats with rich biodiversity. As per classification of Linnaeus, when there were only two kingdoms *namely* Plantae and Animalia then Protozoa was the first phylum under Kingdom Animalia. With the gradual enhancement in understanding and advancement in biological researches, evolution of three, four, five and six kingdom systems occurred. As a result of these advancements, phylum Protozoa is separated from Kingdom Animalia and included as a part of Kingdom Protista.

Thus, only Linnean model of classification included the Protozoa as a phylum of Animal kingdom but all other models from three to six kingdom systems recognizes protozoans as part of Kingdom Protista. Although the inclusion of Protozoa under Kingdom Protista seems a better choice but there is improper grouping of Kingdom Protista, as it includes organisms with diverse form, structure and life cycle, therefore it needs to be improved. Inclusion of dinoflagellates under Protista is not logical, as they are not eukaryotic but rather are mesokaryotic. Similarly, slime moulds placed under Protista differ considerably from the rest of protists. The separation of Protozoa from kingdom Animalia and inclusion under Kingdom Protista is continuously maintained from three to five kingdom systems and even in six kingdom system too (Verma, 2017b). Thus, it may be concluded that protozoans are now protists, not the animals, however can be treated as primitive relative or ancestor of animals.

Protist cells can be distinguished from plant, animal and fungal cells by their ability to move on their own. They may move using one or more subcellular structure as flagella, tiny hairs on the cell membrane (cilia) or long, arm-like extensions of the cell membrane (pseudopodia). A protist cell is a complete organism and can survive on its own while the cell of a

larger organism cannot. The protists constitute a diverse kingdom, including all eukaryotic organisms that are neither animals, nor plants, nor fungi.

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