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Review Article

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STATUS OF ANIMAL PHYLA IN DIFFERENT KINGDOM SYSTEMS OF BIOLOGICAL CLASSIFICATION

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Abstract: Biological classification is the scientific procedure of arranging the organisms in a hierarchical series of groups and sub-groups on the basis of their similarities and dissimilarities. Many biologists have contributed to this method of classification, which took years for researchers to decide the most fundamental characteristics for the classification. The history of kingdom system in classification is started with Linnaeus (1735), who laid the foundation of modern biological classification by classifying the organisms into two kingdoms *namely* Plantae and Animalia. The two kingdom system was followed by three, four, five and six kingdom systems respectively. In present discussion, authors tried to discuss the current status of different animal phyla with respect to different kingdom systems.

Keywords: Animal phyla, Five kingdom system, Taxonomy, Three domain system.

INTRODUCTION

The living organisms are quite enormous in number with great diversity among them in this universe. They may be alike in their general appearance but differ in detailed characteristics because of specialization. The classification and study of these organisms on the basis of their similarities and dissimilarities are concerned with taxonomy.

'Systematics' branch of Biology deals with the study of identification, naming (nomenclature) and orderly grouping (classification) of organisms on the basis of their relationships. The term 'systematics' is derived from a *Latin* word '*Systema*', which means systematic arrangement of organisms. The Systematics includes evolutionary relationships among the organisms while 'Taxonomy' is basically the process of classification of all living organisms based on different characteristics. Mayr (1978) described the principles of systematics in detail.

Aristotle (384-322 BC), Father of Biology, Father

of Zoology and Founder of Taxonomy, was pioneer in the field of biological classification. He wrote probably the first book on Zoology 'Historia Animalium'. 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. In modern taxonomy, former is referred to as invertebrates and latter vertebrates.

A Swedish Naturalist Karl Von Linne/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. He also propagated 'Binomial Nomenclature' for all the species of organisms in 10th edition of his book 'Systema Naturae' published in 1758. This book is now known as dictionary of classification and Linnaeus as father of binomial nomenclature and founder of modern taxonomy.

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 many other unicellular protozoans and multicellular organisms without having chlorophyll and photosynthetic ability. The two kingdom system of classification of Linnaeus was not found suitable due to huge diversity among the organisms and many other limitations. Raven and Johnson (1996) have discussed a brief account of diversity, evolution, taxonomy and various kingdoms in classification.

A German Biologist Haeckel (1866) proposed a third kingdom, the Protista, for unicellular eukaryotes such as protozoans. He revised the content of this kingdom a number of times (Scamardella, 1999). An American Biologist Copeland (1956) established 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

American Ecologist Whittaker (1969) proposed the five kingdom system of classification. In his 'Five Kingdom System', he added three more kingdoms in Linnean model of two kingdom system. These were: Monera, Protista and Fungi. Whittaker succeeded to overcome the difficulties as well as demerits of two, three and four kingdom systems and to represent 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.

In five kingdom system of Whittaker, different kingdoms are as following:

1. **Monera :** Prokaryotes *e.g.* bacteria and cyanobacteria.
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.

Since, Monera are prokaryotic and virtually unicellular, they differ from the other four eukaryotic kingdoms. The eukaryotic unicellular organisms were kept into the Kingdom Protista. The unicellular organisms show several types of modes of nutrition. The three multicellular eukaryotic kingdoms distinguish themselves by the general manner in which they acquire food. Fungi are heterotrophs, generally break down large organic molecules in their environment by secreting enzymes. Plants are autotrophs and use photosynthetic systems to capture energy from

sunlight. Animals are heterotrophs and acquire nutrients by ingesting plants or other animals and then digesting those materials. The five kingdom system despite of having some demerits (Verma, 2016a), is still widely accepted.

SIX KINGDOM 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, Woese *et al.* (1990) adopted the term 'domain' in 1990 and introduced three-domain system in biological classification mainly on the basis of 16 S rRNA genes. They defined the Archea by studying 16 S ribosomal RNA in phylogenetic taxonomy. This system adds 'domain' as a 'superkingdom' a level of classification "above" the kingdom.

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. Thus, in this classification system, Woese *et al.* (1990) placed all four eukaryotic kingdoms into a single domain called Eukarya (eukaryotes). They then split the former kingdom of Monera into the Archaea (archaebacteria) and the Bacteria (eubacteria) domains. They appropriately placed most of the 'unusual' prokaryotes in the Archaea, leaving traditional bacteria in the Eubacteria. This is consistent with recent discoveries of more diversity among microbes than animals and plants that makes this system relevant (Verma, 2016b). A comparison between the five and six kingdom systems is given by Verma (2017a).

POSITION OF PROTOZOA

Protozoans are single celled organisms found worldwide in most of the habitats. Most species are free living, but some are parasitic. These are microscopic and unicellular with a relatively complex internal structure and carry out complex metabolic activities. 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 (Verma, 2017b).

Thus, initially protozoans were kept in phylum Protozoa under Kingdom Animalia as per classification of Linnaeus but later placed under Kingdom Protista. All the three, four, five and six kingdom systems retained the Protozoa under separate 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 also. Whittaker's five kingdom system, despite of having several demerits (Verma, 2016a), has been widely accepted by the biologists since its inception.

POSITION OF PORIFERA TO CHORDATA

Since the first phylum Protozoa became a part of Kingdom Protista hence phylum Porifera is now the first phylum of Animal kingdom as per pattern from three to six kingdom system. Now the series of phyla commonly in practice is as: Porifera, Cnidaria, Ctenophora, Platyhelminthes, Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Hemichordata and Chordata. Now all the phyla except Protozoa are kept in Kingdom Animalia from three to six kingdom systems.

Phylum Porifera includes multicellular, pore bearer, aquatic and sessile animals with cellular grade of organization. The phyla Cnidaria (Coelenterata) and Ctenophora comprise diploblastic radiate animals with tissue grade of organization and gastrovascular cavity. Former is characterized by the presence of nematocysts while latter is without nematocysts but having comb-like plates hence called comb jellies or sea walnuts.

Phylum Platyhelminthes includes flatworms having dorsoventrally flattened triploblastic body and organ grade of organization. True worms are included in phylum Aschelminthes. They are pseudocoelomates with organ system grade of body organization and unisexual. True coelom (schizocoel) first appeared in phylum Annelida with vermiform and metamerically segmented body and closed circulatory system.

Arthropoda is the largest phylum that occupies all the three types of habitats viz. air, water and land. They have jointed locomotory appendages and external metameric segmentation with thick cuticle. It includes Insecta as the largest class of kingdom Animalia, which is studied under Entomology branch. Mollusca is the second largest phylum having soft bodied animals; body is divisible into head, mantle, foot and visceral mass. The circulatory system is mostly open type both in Arthropoda and Mollusca. On the basis of embryonic development, Annelida, Arthropoda and Mollusca; all the three belong to Protostomia group.

Echinodermata is the phylum of exclusively marine animals having uncephalized body with no heart and without true respiratory, excretory and nervous systems. Term echinodermata means spiny skinned animals. Phylum Hemichordata includes worm-like marine animals and the body is divided into proboscis, collar and long trunk. Phylum Chordata is the highly evolved group of Kingdom Animalia. Its three fundamental characters include dorsal tubular/hollow nerve cord, notochord and pharyngeal gill slits. Last three phyla belong to Deuterostomia group with enterocoelic coelom.

The Chordata is divided into Lower Chordata and Higher Chordata. The Higher Chordata is represented by a single subphylum Vertebrata in which notochord is replaced by vertebral column. The Vertebrates have ventral muscular cardiac system bearing 2-4 chambers. A vertebrate has notochord during its embryonic development which is replaced by a cartilaginous or bony vertebral column called as backbone in adults. Taxonomically higher chordates belong to a subphylum Vertebrata that includes seven classes of living animals *viz*. Cyclostomata, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves and Mammalia.

Fishes (Chondrichthyes and Osteichthyes) are exclusively aquatic animals with streamlined body. They have gills for respiration and lateral line sense organs. Amphibians constitute a class of vertebrates that live on land but breed in water. The class Amphibia comprises of three orders: Apoda (Gymnophiona) that includes limbless amphibians such as ceacilians, Urodela (Caudata) that includes newts and salamanders and Anura (Salientia) that includes frogs and toads. Fishes and amphibians collectively constitute the anamniotes or so called lower vertebrates whereas reptiles, birds and mammals are popularly known as higher vertebrates or so called amniotes (Verma, 2020a, 2020b).

Fishes, amphibians and reptiles are cold blooded or poikilothermic animals. The reptiles were the first exclusively terrestrial vertebrates with crawling or creeping mode of locomotion. Reptiles and birds both have monocondylic skull. In general the class Reptilia includes four orders of living animals *viz*. Chelonia (turtle and tortoise), Rhynchocephalia (tuatara), Squamata (lizards and snakes) and Crocodilia (crocodiles). They are the first amniotes of the earth.

Birds (Aves) also referred to as masters of air, are homoiothermic or warm-blooded egg-laying vertebrates characterized by the presence of feathers and modification of forelimbs as wings for flight. Jaw bones are prolonged into a toothless beak to serve like hands and mouth concurrently.

Mammals are warm-blooded *i.e.* homoiothermic vertebrates having a muscular diaphragm and the skin is more or less covered with hair. They give birth to young ones (viviparous) except for the small group of Monotremes (most primitive mammals comprising the only extant members of Prototheria). The young ones are nourished with milk. Presence of mammary glands is the most unique feature of this group. The class Mammalia includes egg laying mammals (Prototheria), pouched mammals (Metatheria) and higher viviparous mammals (Eutheria). Both the amphibians and mammals have dicondylic skull.

NEW KINGDOM SYSTEM

Cavalier-Smith (1981) proposed eight kingdom system and divided all organisms into eight kingdoms *namely*: Bacteria, Eufungi, Ciliofungi, Animalia, Biliphyta, Viridiplantae, Cryptophyta, and Euglenozoa. Later, some protists were reported with no mitochondria (Cavalier-Smith, 1987). He revised this system particularly in the light of the general acceptance of Archaebacteria as separate group from Bacteria and designed eight kingdoms as: Eubacteria, Archaebacteria, Archezoa, Protozoa, Chromista, Plantae, Fungi and Animalia. Later, total number of kingdoms was reduced from eight to six as: Animalia, Protozoa, Fungi, Plantae, Chromista and Bacteria (Cavalier-Smith, 2007). Ruggiero *et al.,* (2015) revised the system of classification and reintroduced the division of prokaryotes into two kingdoms, Bacteria (Eubacteria) and Archaea (Archebacteria).

CONCLUSION

Microbial biodiversity was initially poorly understood hence five kingdom system of biological classification got global acceptance in the last few decades. When microbiologists discovered unicellular organisms that look-like prokaryotes but were extremely distinct in ultrastructure and other characteristics from the traditional bacteria then updating in five kingdom system seemed necessary.

Woese's scheme has been increasingly accepted by evolutionary biologists since its inception and is now the standard paradigm. Woese's three domain system of biological classification correlates the biodiversity with evolutionary relationships and seems to be more logical, ethical, justified and appropriate from evolutionary, microbial diversity and modern nucleic acid sequencing point of views. Biodiversity is the 'foundation of human life' on earth and for human's survival and sustainable development; it must be maintained at any cost. As far as Kingdom Animalia is concerned, it is retained as such from two to six even seven and eight kingdom systems except the phylum Protozoa. 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 a part of Kingdom Protista. All other animal phyla including Porifera, Cnidaria, Ctenophora, Platyhelminthes, Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Hemichordata, Chordata *etc*. are included in Kingdom Animalia till date.

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