ECTO AND ENDOPARASITES IN MULTICELLULAR ANIMALS

MOHAN KUMAR

M.Phil., Roll No.: 142146 Session-2014-15
Department of Zoology, B.R.A. Bihar University, Muzaffarpur, India
E-mail: ananish8mohan@gmail.com

Abstract

Regardless of the number, the multiple origins of multicellularity and their subsequent consequences evoke a number of biologically important, but largely unanswered, questions. For example, do multicellular lineages share a common morphological transformational series? What if any are the selection barriers to (and the drivers toward) multicellularity? Were the ancestors of some lineages predisposed to engender multicellular organisms, or is multicellularity the result of random events leading toward larger organisms. We address these features as well. However, our primary objective is to determine, as best as currently possible, whether the evolutionary trajectory toward multicellularity manifests a common trend across as well as within clades and, if so, whether this trend is the result of genomic or physical commonalities among otherwise diverse organisms. Although we discuss trends in the fungal and animal clades, our focus is primarily on plants, which we define broadly as eukaryotic photoautotrophs (Niklas 1997, 2000) to encompass the algae as well as the monophyletic land plants (embryophytes).

Keywords: End parasites, Animals

Mohan Kumar*, *University Department of Education: B.R.A. Bihar University, Muzaffarpur*

INTRODUCTION

One of the most remarkable events in evolutionary history was the emergence and radiation of eukaryotic multicellular organisms. Perhaps even more remarkable is that this "event" occurred independently in different clades. Estimates of the exact number vary depending on how multicellular is defined. When defined simply as cellular aggregation, a conservative estimate is that multicellularity evolved over 25 times (Grosberg and Strathmann 2007). More stringent definitions requiring sustained cell to cell interconnection and communication obtain an estimate of ten eukaryotic events, that is, once in the Animalia, three in the Fungi (chytrids, ascomycetes, and basidiomycetes), and six in the three major plant clades (twice each in the rhodophytes, stramenopiles, and chlorobionta).

Regardless of the number, the multiple origins of multicellularity and their subsequent consequences evoke a number of biologically important, but largely unanswered, questions. For example, do multicellular lineages share a common morphological transformational series? What if any are the selection barriers to (and the drivers toward) multicellularity? Were the ancestors of some lineages predisposed to engender multicellular organisms, or is multicellularity the result of random events leading toward larger organisms. Put differently, are the morphological motifs that emerge in multicellular lineages the result of adaptive evolution, or the inevi consequences of physical laws and processes? Indeed, are the multiple origins of multicellularity truly independent given that all life ultimately shared a last common ancestor? These and other questions about multicellularity have been addressed in different ways. However, all perspectives share three features: (1) a comparative approach (because of the multiple origins of multicellularity, sometimes even within the same clade); (2) a treatment of how "information" is exchanged among cells and between cells and their external environment (because coordinated signaling among cells is one of the defining characteristics of multicellular biology; see Mian and Rose 2011); and (3) a consideration of functional morphological features (because these govern energy–mass exchange rates between an organism and its environment; see Gates 1980).

We address these features as well. However, our primary objective is to determine, as best as currently possible, whether the evolutionary trajectory toward multicellularity manifests a common trend across as well as within clades and, if so, whether this trend is the result of genomic or physical commonalities among otherwise diverse organisms. Although we discuss trends in the fungal and animal clades, our focus is primarily on plants, which we define broadly as eukaryotic photoautotrophs (Niklas 1997, 2000) to encompass the algae as well as the

monophyletic land plants (embryophytes). This phyto-centrism is adopted because (1) multicellularity evolved independently at least six times in the three major plant clades, which permits extensive interphyletic comparisons, and (2) the origins of plant multicellularity have been largely neglected in a primarily zoo-centric literature. A third reason for focusing on plants is that all plant clades evolved cell walls that, in contrast to animals, can restrict intercellular aggregation and communication (and requires somatic embryogenesis in multicellular plants).

In the following, we (1) characterize multicellular organisms in terms of intercellular adherence and cell-to-cell and cell-to- environment communication, (2) explore the requisite transition from fitness defined at the level of individual cells to fitness defined at the level of a truly multicellular entity (Wolpert and Szathmáry 2002; Michod et al. 2003; Grosberg and Strathmann 2007; Folse and Roughgarden 2012), (3) assess the transition from simple to complex multicellularity (sensu Knoll 2011), (4) compare character polarities among the different plant, fungal, and animal clades, and (5) discuss whether the evolution of multicellular organisms was instigated by physically based patterning modules mobilized by shared or unique molecular toolkits (Newman and Bhat 2009; Hernández-Hernández et al. 2012).

We will affirm that the evolution of multicellular organisms typically involved intermediate body plans that were achieved by similar developmental mechanisms in different lineages, but not necessarily by mechanisms sharing the same physical or biochemical components. Much like the plant organs collectively called "leaves," which evolved independently in different lineages, multicellularity is a recurrent feature of morphological evolution that was reached in many different ways. Consequently, the extent to which multicellular organisms are developmentally homologous at the most basic levels requires careful analyses, particularly since selection acts on functional traits and not on their underlying generative mechanisms, enabling different mechanisms to achieve the same functional traits.

Metazoans Are Multicellular And Eukaryotic Animals.

The metazoans have certain qualities that must be considered in concert with the basic idea of multicellularity. Inspite of difference in structure and form of different animals, there are fundamental characteristics common to various individuals. These features are used as the basis of animal classification. Some characteristic features of metazoans are as follows. a. Levels of Organisations: Though animals are multicellular, the level of organization of cells varies from one animal to another.

ECTO AND ENDOPARASITES IN MULTICELLULAR ANIMALS

Certain animals have a loose mass of cells which may be similar or show minor division of labour. These animals exhibit cellular level of organization. e.g., sponges.As we move on, the complexity of body design amplifies and thecells of metazoans are organized into function units, generally as tissues and organ with specific roles which support the life of whole animal. The cells form poorly defined tissues, and exhibit tissue level of organizatione.g. Cnidarians (=coelenterates), ctenophores.Phylum Platyhelminthes and Aschelminthes have organ level of organization. Nor-chordates such as Annelids, Arthropods, Molluscs, Echinoderms, and Chordates have specialised organ- systemfor theirphysiological activities. They have the organ-system level of organisation. Although these animals have organ-system levels of the organisation, the complexities of organ systems vary in different phyla.

Metazoan Animals Show Following Types Of Symmetry

Radial symmetry: A symmetry where any plane passing through the central axis divides the body into two equal halves is called the radial symmetry. Coelenterates, ctenophores and adult echinoderms show radial symmetry (Fig 1.1 A). Bilateral symmetry: In bilateral symmetry, only a single plane divides the body into two equal halves. Annelids, Arthropods and Molluscs etc. show bilateral symmetry However, some animals do not show any symmetry i.e. their body can't be divided into two halves in any plane passing through the centre. Such animals are said to be asymmetrical, e.g. Poriferan.

Review Literature

Islam, M.S., Roy, B.K., Rahman, M.A., and Islam, M.N. (2013). Water Quality Assessment of Ghurdaur Pond of Rajshahi University, Bangladesh. Journal of Environmental Science and Natural Resources, 6(1): 87-92. This study conducted an assessment of water quality parameters such as pH, dissolved oxygen, turbidity, and nutrient concentrations in Ghurdaur Pond and identified potential sources of pollution.

Khan, S.A., Ahmed, M., Ahmed, S., and Ahmed, Z. (2016). Ichthyofaunal diversity of Ghurdaur Pond, Rajshahi University campus, Bangladesh. International Journal of Fisheries and Aquatic Studies, 4(2): 452-456. This study documented the diversity of fish species in Ghurdaur Pond and identified potential threats to the fish population.

Barua, A., and Rashid, H. (2018). Limnological studies of a freshwater pond at Sylhet Agricultural University, Bangladesh. International Journal of Fisheries and Aquatic Studies, 6(6): 369-374. This study conducted a limnological analysis of a freshwater pond in Bangladesh and provided insights into the physical and chemical characteristics of the pond.

Haque, M.A., Rahman, M.A., Hossain, M.S., and Islam, M.R. (2020). Water Quality and Trophic State of Ghurdaur Pond, Bangladesh. Journal of Environmental Science and Natural Resources, 13(2): 25-30. This study assessed the trophic state of Ghurdaur Pond and identified factors contributing to eutrophication.

Islam, S.M.R., Islam, M.S., and Hasan, M.R. (2021). Fishing and Livelihood Pattern of Local People Around Ghurdaur Pond, Bangladesh. Journal of Fisheries, 9(2): 612-619. This study examined the fishing practices and livelihood patterns of local communities around Ghurdaur Pond and identified opportunities for sustainable resource management.

Overall, these studies provide valuable insights into the limnological characteristics of Ghurdaur Pond and the challenges and opportunities for its conservation and management. They also demonstrate the interdisciplinary nature of freshwater ecosystem research, which requires collaboration between scientists, policymakers, and local communities to develop effective and sustainable management practices.

"The Evolution of Reptiles" (2019) by Robert L. Carroll. This book provides an in-depth analysis of the evolutionary history of reptiles, including their classification, morphology, and paleontology. The author discusses the major groups of reptiles, including snakes, lizards, turtles, and crocodiles, and provides insights into their adaptations to different environments and their roles in ecosystems.

"Mammalogy: Adaptation, Diversity, Ecology" (2019) by George A. Feldhamer, Lee C. Drickamer, Stephen H. Vessey, Joseph F. Merritt, and Carey Krajewski. This textbook provides an overview of the biology, evolution, and ecology of mammals, including their classification, anatomy, physiology, and behavior. The authors cover topics such as mammalian adaptations to different environments, reproductive strategies, and conservation.

Research Methodology

Maintaining a reasonably constant water balance is a straightforward business for the majority of animals. As we saw in the last chapter, the cells and body fluids of marine animals are in osmotic equilibrium with the surrounding medium, and numerically marine animals dominate the planet However, when living organisms began to colonize more osmotically challenging habitats the seashores, estuaries, and rivers, and eventually the landathe problems of water balance became paramount. As living cells moved out of the sea, they faced real problems: water always has a tendency to move into them (from dilute surroundings such as estuaries and

fresh water) or move out of them (into the surrounding dry air of terrestrial zones), and neither of these fluxes can be left uncorrected if the cells are to continue functioning. For nonmarine multicellular life, continuing healthy existence depends upon maintaining the cells at a fairly constant water balance, i.e. in reasonable osmotic stasis, and this usually involves using the extracellular fluids to buffer the cells against excessive environmental stress. Controlling this cellular and extracellular osmotic balance ultimately depends on principles outlined in the preceding chapter: the permeation characteristics of membranes and associated surfaces throughout the organism, active processes regulating ion levels, and the control of intracellular osmotic effector levels. But for whole animals these processes have additive and interactive effects between different tissues and organs, with particular epithelia carrying out regulatory functions to maintain blood composition and thus providing osmotic stasis for the rest of the body. Therefore the problem of animal water balance can best be examined in terms of the actions, and the control, of particular effector organs.

DATA ANALYSIS

Metabolic reactions within cells are the source of all the macromolecules within a living body, synthesizing these large endproducts by anabolic processes. At the same time other large macromolecules are being broken down to produce usable energy, by catabolic processes. The free energy (ΔGo) produced by catabolism is involved in so many physiological processes that it is essential to understand the source of this energy and to consider the effects of the environmental variables that will influence its rate of production, i.e. the "metabolic rate" of an animal. The main energyconsuming processes in animals are protein turnover, the sodium and calcium pumps, myosin ATPases involved in muscle contraction, and gluconeogenesis; together these account for over 45% of the metabolic rate of a mammal. The phosphagens are the high-energy phosphate compounds that mediate energy transfers for all these processes in living organisms. Adenosine triphosphate (ATP) is the best known phosphagen and the common currency of energy metabolism for animals, providing the link between energy-yielding and energy-requiring reactions. ATP may be produced independently of oxygen (anaerobic metabolism) or through pathways which require oxygen (aerobic metabolism). Life on Earth certainly evolved in a reducing anaerobic environment, perhaps 3500 million years ago (mya). Free oxygen would be created in such an environment in small quantities by the photolysis of water, but would have been rapidly taken up by reduced ferrous rocks, which acted as an oxygen sink for at least another 1500 million years. Even after some of the prokaryotic heterotrophs acquired chlorophyll (probably around 3000 mya) and became

photosynthetic "plants" that released oxygen as a by-product, free oxygen levels stayed very low because the oceans and vast beds of reduced minerals acted as sinks. Thus the first prokaryotic organisms were necessarily dependent on anaerobic metabolism; oxygen was toxic to them.

Metabolism and Energy Supply

Perhaps around 2300–2000 mya the ocean and mineral sinks were becoming filled and free oxygen levels began to rise slowly (6.1). This change may have taken place in three stages, from total planetary anoxia, through atmospheric and surface ocean oxidization, to deep oceanic oxidization and the formation of the first geological oxidized "red beds" rich in ferric oxides (dated 2000 mya). All organisms would have had to develop O2 detoxification systems to survive, and at this point aerobic metabolism also probably began to evolve. Current thinking suggests that this important evolutionary innovation may have had multiple origins in different groups of prokaryotes, and that it became possible at about 1% of present atmospheric levels (PAL) of oxygen.

Gradual further rises in oxygen level accompanied the subsequent evolution of eukaryotic cells and then (perhaps 1000–800 mya) of the first multicellular plants and animals. Most metazoan animals now use aerobic metabolism for most of their energy requirements, reaping the benefits of pathways that are many times more efficient (generating 36–38 moles of ATP for each mole of substrate broken down aerobically, instead of just 2–6 with different anaerobic routes). However, many organisms still thrive in totally anaerobic conditions, for example in marine muds and sediments, in bogs and wetlands, or in the guts of other animals. Furthermore, nearly all organisms commonly revert to using anaerobic pathways during temporary periods of reduced oxygen availability (hypoxia) or when their rate of energy utilization is greater than can be met by the slower aerobic pathways, for example during strenuous exercise.

Metabolic Intermediaries

Adenosine triphosphate is the classic "high-energy molecule", and interconversions between it and the other adenylates (the diphosphate and monophosphate forms, ADP and AMP) are the key to many metabolic processes. ATP consists of a purine base (adenine) linked to a five-carbon sugar (ribose) to form adenosine, and then three phosphate groups linked on by high-energy esteric bonds. Hydrolysis of the terminal phosphate group (6.2) releases about 30.5 kJ mol^{-1} of ATP under normal cell conditions; remember that 1 mol of ATP is equivalent to 6×10^{23} molecules of ATP (Avogadro's number). ATP acts to transfer chemical energy to other

molecules during energy-requiring interactions, yielding ADP and inorganic phosphate (Pi) in the process; this ADP is then recharged with a phosphate group, again by cellular metabolism. As a result energy is constantly cycling through ATP, and the individual molecules have a relatively short lifetime. Around 60% of the energy that is used to recharge ADP appears as heat, due to inefficiencies in the reactions involved. Hence metabolic activity always generates heat, referred to as "metabolic heat" when considering problems of animal temperature balance (see Chapter 8). With the exception of muscles, the rate of ATP turnover is relatively low in most tissues. During the transition from rest to maximal activity, the ATP turnover (or cycling, or flux) in muscle can increase by one or more orders of magnitude, representing a massive heat production in a very active animal.
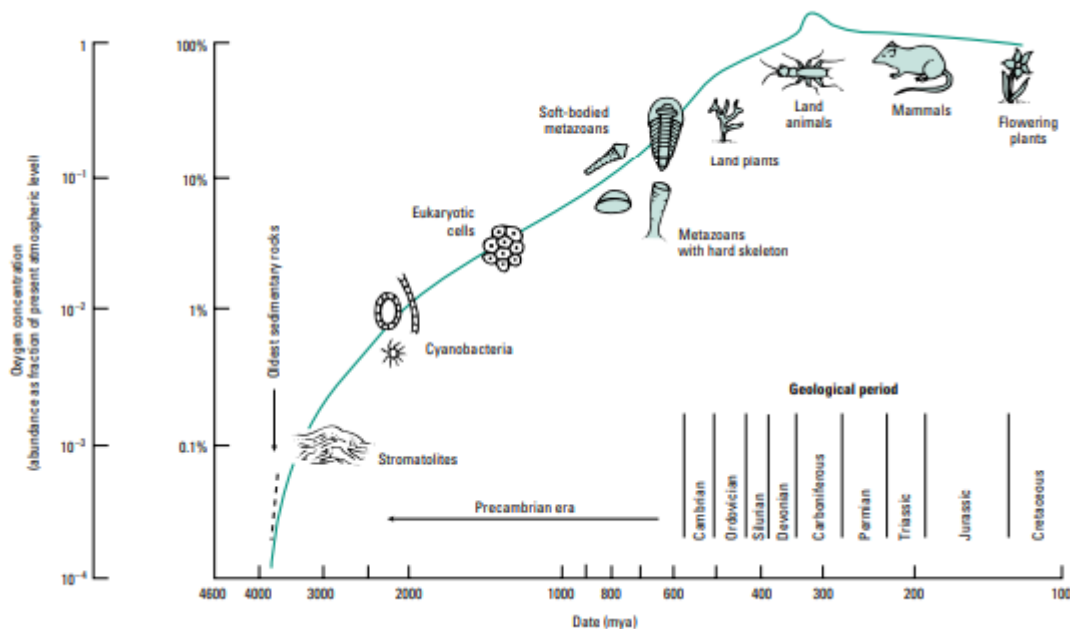

Figure 1 Atmospheric oxygen levels through the history of Earth, with key events shown. (Adapted from Wayne 1991, courtesy of Oxford University Press.)

Phosphagens: rapidly mobilized fuels

At any one time an animal does not contain a great amount of ATP, with values of only 2–8 µmol ATP g−1 being common; evidently it is not normally used to store much energy. Other phosphagens are used for this storage, the commonest being creatine phosphate (PCr) and arginine phosphate (PAr), which are phosphorylated derivatives of guanidinium compounds (6.3). These may be up to 10 times as concentrated as ATP in tissues such as muscle and brain, and they are the immediate short-term source of ATP in most animals. They may be used to provide the necessary ATP under both aerobic and anaerobic conditions; thus they act in effect

as a "buffering" system for ATP, insuring that its concentration is low and the ATP : ADP ratio is always kept favorable for ATP synthesis. Phosphagens are the simplest and most rapid precursors for generating ATP as only one enzymic step is involved, catalyzed by kinase enzyme (e.g. creatine phosphokinase, CPK).

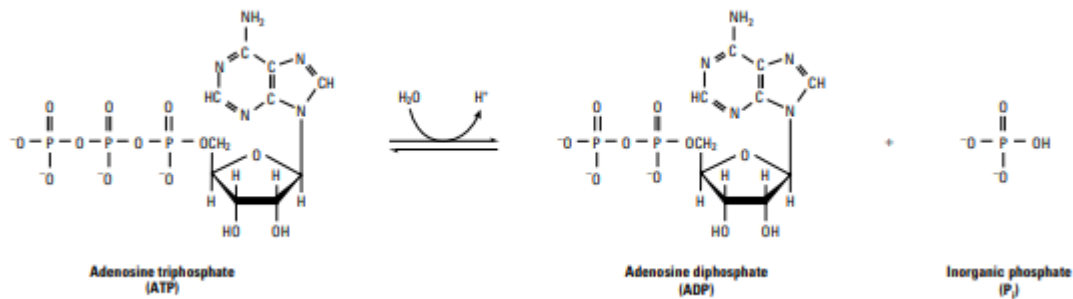Kinases belong to a class of enzymes that transfer the high-energy phosphate bond of ATP to another molecule:
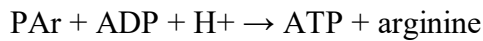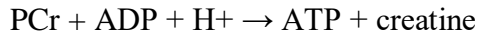
PCr + ADP + H+ → ATP + creatine

PAr + ADP + H+ → ATP + arginine

Figure 2 Structure and hydrolysis of adenosine triphosphate.
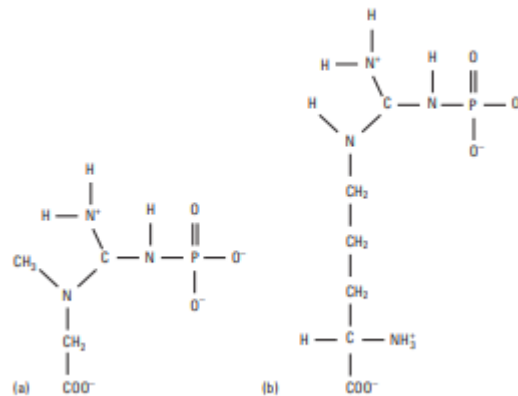

Figure 3 Structures of the phosphagens (a) phosphocreatine (PCr) and (b) phosphoarginine (PAr)

For a phosphagen to be a useful source of ATP, it must be able to transfer its high-energy phosphate bond (~P) to ADP at high rates and at the correct time. This is achieved in most cells by having large amounts of the right kinase, with the right kinetic properties, present in the

right locations in the cytoplasm. These kinases therefore occur in high concentrations in the cell as a whole, and are present as different isozymes (see Chapter 2), close to their sites of utilization and often bound to other proteins. For example, in muscles different isozymes occur, some bound to myosin ATPase, and others within the sarcolemma and sarcoplasmic reticulum with easy access to $Na+/K+$-ATPase and $Ca2+$-ATPase, respectively (6.4). The overall concentration of kinases is highest in tissues with high AT demands, such as the skeletal muscles of animals capable of very rapid movements (see section 9.12.3). These same tissues usually have high concentrations of the phosphagens. Thus the white muscle of the rainbow trout contains around 30 mmol PCr kg−1wet mass, and the adductor muscle of the scallop contains about 50 mmol PAr kg−1 wet mass. Both of these muscles are involved in escape behaviors. In slower muscles and in tissues such as neural ganglia the PCr levels may be only one-tenth of these values.

CONCLUSION

Life on Earth has evolved around the properties and peculiarities of water, and all life remains dependent upon water. In aquatic ecosystems, and in most temperate and tropical terrestrial habitats, water is abundant and its conservation within animal bodies is not too difficult, but maintaining a precise osmotic equilibrium may nevertheless be a perpetual task, requiring some proportion of the metabolic efforts of all cells or of some specialized subset of body cells. In hyposmotic habitats it is excess water uptake that must be avoided, and the proportion of the metabolic effort devoted to this may be increased. In many land habitats, dehydration is a permanent danger, and sophisticated structural, physiological, and behavioral adaptations are necessary to prevent fatal water losses. It is probably fair to say that controlling water balance is even more essential than controlling temperature stresses, and (together with acquiring a food supply) is the single most important factor in the lives of many animals.

REFERENCES

1. Brooks, D.R. & McClennan, D.A. (1991) Phylogeny, Ecology and Behaviour. Chicago University Press, Chicago.

2. Bryant, C. & Behm, C. (1989) Biochemical Adaptation in Parasites. Chapman & Hall, London.

3. Cox, F.E.G. (1994) Modern Parasitology: a Textbook of Parasitology. Blackwell Scientific Publications, Oxford.

4. Douglas, A.E. (1994) Symbiotic Interactions. Oxford University Press, Oxford.

5. Godfray, H.C. (1994) Parasitoids: Behavioural and Evolutionary Ecology. Princeton University Press, Princeton, NJ.

6. Marr, J. & Müller, M. (1995) Biochemistry and Molecular Biology of Parasites. Academic Press, London.

7. Matthews, B.E. (1998) An Introduction to Parasitology. Cambridge University Press, Cambridge, UK.

8. Poulin, R. (1998) Evolutionary Ecology of Parasites; from Individuals to Communities. Chapman & Hall, London.

9. Rohde, K. (1993) Ecology of Marine Parasites. CAB International, Wallingford, UK.

10. Roitt, I., Brostoff, J. & Male, D. (1998) Immunology. Mosby, London.

11. Rollinson, D. & Simpson, A.J.G. (1987) The Biology of Schistosomes. Academic Press, London.

12. Shorthouse, J. & Rohfritsch, O. (1992) Biology of Insect-Induced Galls. Oxford University Press, Oxford. Tinsley,

13. R.C. (ed.) (1999) Parasite Adaptation to Environmental Constraints. Cambridge University Press, Cambridge, UK.

14. Williams, M.A.J. (1994) Plant Galls: Organisms, Interactions, Populations. Clarendon Press, Oxford.