



The Social Amoebae – The Biology of Cellular Slime Molds. John Tyler Bonner. Princeton University Press, Princeton and Oxford. 2009. ix + 144 pp. Price: \$19.95/£13.95.

Bonner's Slim Magnum Opus

When I first received an invitation from *Current Science*, to review this book, I was very reluctant to accept. John Tyler Bonner was born in 1920 and as far as I know he has worked on cellular slime molds all his life. If he has written a book with the simple title '*The Social Amoebae*' at the age of 89, I reasoned that it must be his magnum opus. I imagined a massive book of a thousand pages, full of historical and technical detail and thousands of references. Hölldobler and Wilson's *The Ants*¹, Michener's *The Bees of the World*² and Jane Goodall's *The Chimpanzee's of Gombe*³, came to mind. I was in the midst of many commitments and felt I would not be able to read and do justice to Bonner's magnum opus in any reasonable time frame. On the other hand I admire Bonner and love slime molds so much that I yielded to temptation. Then came the big surprise – I received a slim 144 page book which could be read in a week. But of course, the smaller the book, the harder to review it. I have mulled over this book during the last few months and I have come to the conclusion that Bonner, or any one else, could not have written a better magnum opus.

The cellular slime molds are remarkable organisms. They grow as unicellular, solitary amoebae in the soil, feeding on bacteria and dividing until they exhaust their bacterial food supply. Once starvation sets in, they signal and attract

each other and form a multicellular slug which differentiates into a stalk of dead cells that holds aloft a fruiting body with live spore cells (together referred to as the fruiting body). This facilitates dispersal of the spores to new habitats due to wind or a passing insect so that the spores can germinate if they land in a favourable place, and the cycle repeats itself. This survival strategy of the starving amoebae is, as Bonner shows with the power of simple and elegant experiments mostly by him and being carried out to this day, greatly aided by the extreme heat and light sensitivity of the fruiting body that makes it bend itself as necessary. The aggregation of starving amoebae make them an excellent model system to study intercellular signalling; the differentiation of the multicellular slug into stalk and spore cells makes them a dream model system for studying cell differentiation; and the embryonic development and altruism of the dead stalk cells that facilitates the spores to disperse and survive makes them the simplest imaginable model for sociobiologists⁴. Not surprisingly, the cellular slime molds have been studied extensively over the past 5 or 6 decades, leading to several thousand publications by now. To quote Bonner, 'In the late 1940s and early 1950s (1945 to 1951) an average of 3.4 papers on cellular slime molds were published a year; now, over the past seven years, there is an average of 224 papers a year! We are in danger of drowning in facts.' (p. vii).

As Bonner already noted in a review ten years ago⁵, the spectacular growth of molecular biological techniques has meant that an overwhelming and ever increasing number of studies on cellular slime molds today are of the 'molecular' variety. Is that really a problem? Let me quote Bonner himself: 'In this joyous molecular roller-coaster ride there are many things about these slime molds that have to some degree been neglected, therefore stimulating me to write this book' (p. 5). Now we can see how a magnum opus can indeed be slim. Bonner starts his book by saying that 'Here I want to give all aspects of cellular slime mold biology equal time. . . This means that I want to give something closer to equal time to their evolution, their ecology, and their behaviour, as well as their development' (p. 5). And he succeeds admirably, taking us through a no-less joyous roller-coaster ride through their

taxonomy, phylogeny, life cycle, ecology, evolution, morphogenesis and differentiation. And he does much more.

Bonner tell us all about the remarkable slime molds but the manner in which he does so makes him even more remarkable. Bonner is neither shy of, nor enamoured by, the molecular techniques that have greatly advanced the understanding of some (though not most) aspects of slime mold biology. He has the unique ability of 'concentrating on all their biology, including their molecular biology'. It would have been so much easier to write a massive book highlighting only cutting edge, sophisticated molecular biological research in a manner that everyone would say 'wow' but at the same time most biologists outside the best-endowed laboratories in the developed world would quietly conclude that one more model organism has gone out of their reach. Instead Bonner shows how much we have learnt and can still learn from elegant experiments that can be done in a simple laboratory almost anywhere in the world. Bonner's book should have the effect of enticing a large and diverse number of biologists from across the world to take a shot at studying the cellular slime molds that they might find in their backyard. And that's why I think it is a true magnum opus, one that would attract rather than frighten beginners. It is also quite remarkable that Bonner cites and thus brings to the attention of the world, a large number of lesser-known or forgotten papers by investigators from around the world, a style that is by no means typical in today's competitive scientific culture. Bonner's fondness for the underdog transcends narrow boundaries of time and space. He cites extensively the work of graduate students from India in the 1990s and 2000s and laments the neglect of the work of the American developmental biologist of the 1940s: 'Today it seems particularly ironic that, starting with Alan Turing in the 1950's, we take for granted that through reaction diffusion phenomena it is easy to see how simple gradients can lead to patterns and differences in parts during development. . . But there is never a mention of Charles Manning Child or of metabolic gradients, yet they are the foundation of all of them' (p. 116).

This slim book is strewn with Bonner's words of wisdom. While speaking of the molecular phylogenetic tree for

slime molds, he says 'we still need a field guide to the cellular slime molds and should keep the old system of morphological classification alongside the molecular phylogenetic tree. Both are needed' (p. 20). While pointing out the surprising result that the 'elegant architecture and [those] other features of the two species of *Polysphondylium* namely *palladium* and *violaceum*. . . have been invented independently twice at different times, perhaps many, many years apart', he cautions that, 'the relation between these two species is based on only two genes, and it will be important to examine their differences involving more genes' (p. 21). While discussing the absolutely fascinating results showing cheating in chimaeric fruiting bodies in laboratory experiments, Bonner plays spoilsport by concluding with the cautionary note, 'It is important to know if these interesting cheaters exist in nature' (p. 30). After reviewing recent molecular studies, he cautions by saying 'However, it is difficult to see how all these activities at the level of cells could lead to the formation of a new species' (p. 32).

In his review of this book in the *Times Literary Supplement*⁶, Lawrence Hurst laments that 'The old-school classical biologists, such as Bonner, who really understand their organisms may well, like the slime mould's supporting cells, find themselves without a future', because 'Discovery via high-throughput data generation is now the order of the day . . . and it looks set to soak up the big research money for a while yet. But with this approach, carefully considered hypotheses, simple elegant experiments and a feel for the organism tend to be lost by the wayside.'

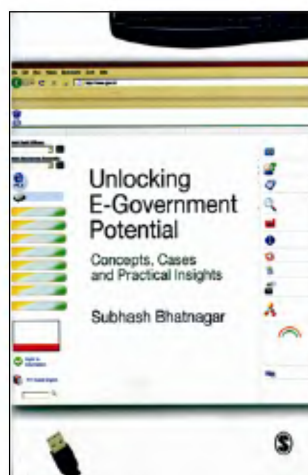
Hurst's pessimism may well be justified if scientific research is limited to well-endowed laboratories in the developed world. If less well-endowed laboratories in the developing world were to pick up the gauntlet however, I see more room for optimism because when you do not have money for high-throughput research, you have no option but to resort to 'carefully considered hypotheses, simple elegant experiments and a feel for the organism'. And Bonner would have made no small contribution to make this happen.

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Unlocking E-Government Potential: Concepts, Cases and Practical Insights. Subhash Bhatnagar. SAGE Publications, New Delhi 110 044. 351 pp. Price: Rs 450.

Computers were used by several state governments in India as early as the 1970s. In fact a Government Computer Centre was set up in Karnataka in the late 1970s which was primarily used for payroll calculations, budget preparation and tabulating the results of examinations such as SSLC. The whole scenario changed in the mid 1990s, with the advent of low cost personal computers (PCs) and the networking of computers brought about by improvements in Com-

munication Technology. Information and Communication Technology (ICT) combined and resulted in Local Area Computer Networks (LANs) and subsequently the Internet. The emergence of the Internet and the world wide web led to the development of e-commerce. E-commerce is primarily concerned with the sharing of business information, maintaining business relationships and conducting business transactions using computers and telecommunication networks. Several terms such as Business to Customers (B2C), Business to Business (B2B) and Customers to Customers (C2C) e-commerce appeared. Subsequently, government also saw the potential of using ICT and the technologies developed for e-commerce such as design of websites, portals, web-based transactions, secure communication technologies and digital signature in their operations. These technologies began to be used for carrying out transactions between citizens and government (C2G), Business and Government (B2G) and among Government departments (G2G). There are several definitions of e-government and there is no single generally accepted one. A simple definition would be the use of ICT to integrate and improve transactions between government and citizens, businesses and public institutions. The author of the book being reviewed perceives it as 'E-government is about a process of reform in the way governments work, share information and deliver services to external and internal clients. Specifically, e-government harnesses information technologies (such as wide area networks, the Internet and mobile computing) to transform relations with citizens, businesses and other agencies of the government. These technologies can serve a variety of ends: better delivery of government services to the citizen, improved interactions with business and industry; citizen empowerment through access to information or more efficient government management. The resulting benefits can be less corruption, increased transparency, greater convenience, revenue growth and/or cost reduction'. Several state governments have implemented e-governance projects. A notable one is the *Bhoomi* Project of the Government of Karnataka which issues document called record of Rights, Tenancy and Crops (RTC) to farmers. This document is used by farmers for several purposes such as getting bank loans, crop insurance, etc.