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Does biological advantage imply biological origin?

Shaun Doyle

The origins of sexual dimorphism and multicellularity are two of the greatest mysteries to evolution. For either of them to evolve either requires massive restructuring of the biological system from the molecular to the organismal levels. Moreover, there are massive selection and energetic barriers that must be crossed to get from unicellular to multicellular life and to evolve sexual dimorphism. Two recent news articles have claimed that certain biological advantages in sexual dimorphism[1] and multicellularity[2] provide a reason why they evolved in the first place.

Intra-cell communication and sexual dimorphism

The first study discusses the question: why are there two sexes?[3] In terms of evolution, it's not the best number of mating types because it only allows us to mate with half of the population. However, researchers have proposed that inheriting mitochondrial DNA (mtDNA) from just one parent instead of both may serve to offset this disadvantage. Most sexually reproducing creatures only receive nuclear DNA from their father but get the other half of their nuclear DNA plus their entire cellular structure, including mtDNA, from their mother. The researchers proposed that because this setup only passed one set of mtDNA to offspring, it allowed for more efficient 'synchronization' between the nucleus and mitochondria, and between mitochondria, than would be possible if mitochondria were inherited from both parents. According to their modelling, they were correct—uniparental inheritance of mitochondria (UIM) produced fitter offspring than biparental inheritance

of mitochondria (BIM) under most realistic selection constraints.

But the researchers also explore this question: "Could uniparental inheritance of mitochondria have arisen to facilitate better co-adaptation of mitochondrial and nuclear genes, and so explain the evolution of two sexes?",[3] to which they ultimately give a positive answer. However, this misplaces the important question for the evolution of any new trait—how it arose in the first place. Essentially, they perform a cost–benefit analysis between UIM and BIM, determine that UIM is the better system, and then conclude that UIM *must* have evolved from BIM. But this skips over the succession of events that supposedly led to the evolution of UIM from BIM because the researchers assume that since UIM and sexual dimorphism exist, they *must* have evolved. This is clearly begging the question of evolution, but it's worse. Evolution is taken as so incontrovertible that questions of *how* (the succession of evolutionary events) are deemed superfluous, and all that matters is *why* UIM evolved. However, all they have established is that UIM provides the *functional* grounds for sexual dimorphism in eukaryotes, and the origin of that function is the very question which the fact of its functionality does not directly address.

Kinship and the evolution of multicellularity

Another recent study showed how high-relatedness between cells is a necessary prerequisite for multicellularity.[4] The researchers ran two experiments on the amoeba *Dictyostelium discoideum*, one where they tested the effects of low-relatedness on *Dictyostelium*'s ability to form multicellular fruiting bodies, and the other tested the effects of mutation accumulation in a single clonal line. The researchers found that when different lines were mixed, it didn't take long for 'cheater' mutants to take advantage of the fruiting bodies and propagate ahead of the non-cheaters, to the point where there were so many 'cheaters' that many lines were unable to form fruiting bodies at all by the end of the experiment. In contrast, fruiting ability was never lost in the mutation accumulation experiment where high-relatedness was maintained, as per conditions in the wild. As a result, the researchers concluded that high relatedness was necessary and sufficient to maintain the viability of the multicellular stage in *Dictyostelium*'s life cycle. The researchers then applied their findings to multicellular life in general:

> "Thus, we conclude that the single-cell bottleneck is a powerful stabilizer of cellular cooperation in multicellular organisms."[5]

This is a fair application of their research. It highlights a necessary prerequisite for functional multicellularity, and it doesn't extend *all* the conclusions about high-relatedness in *Dictyostelium* to all multicellular life. But compare this to the questions the news article says this research answers:

> "How could the extreme degree of cooperation multicellular existence requires ever evolve? Why aren't all creatures unicellular individualists determined to pass on their own genes?"[2]

This presupposes that functional multicellularity evolved, and proposes that the mere existence of high-relatedness among cells is the reason why it evolved. However, creationists can also presuppose the necessity of high-relatedness among cells for functional multicellularity to be possible without an appeal to evolution.[6] We have here confusion between the functional grounds of a trait and the historical cause of a trait. If multicellularity evolved, then it must have evolved from a population of clones, but this tells us very little about the succession of events that led from a unicellular ancestor to the first metazoan or plant. Therefore, it is not a helpful explanation of the evolution of multicellularity.

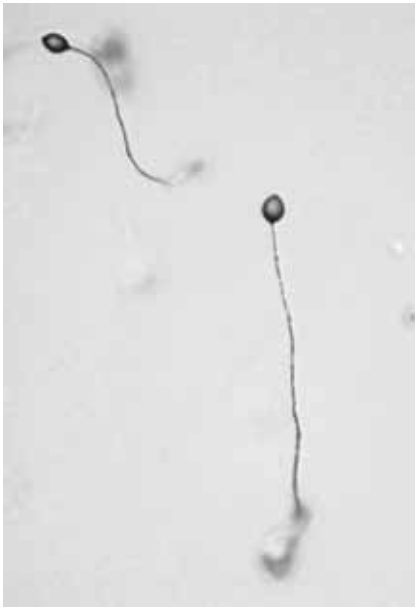

Photo courtesy of Wikipedia

Figure 1. Multicellular fruiting bodies of *Dictyostelium discoideum*.

How useful is Dictyostelium for studying the evolution of multicellularity?

But is *Dictyostelium* a model organism for studying how the evolution of multicellularity might proceed? The researchers point out that 'cheaters' are not a problem for *Dictyostelium* colonies even if they were the size of a blue whale.[7] However, even the news article admits that a blue-whale-sized *Dictyostelium* colony is not the same thing as a blue whale.[2] But it fails to describe why. It is one thing to grow a colony to the size of a blue whale, but it is a different thing to *maintain* the colony at that size *in a multicelled state* over a period of decades. The researchers admit that little cell division occurs in the multicelled phase of *Dictyostelium*.[7] In a multicellular stage that has little cell division, there is obviously no need for strategies such as serial differentiation[8] to maintain the multicelled state. Thus it is not surprising that the multicelled stage in *Dictyostelium* does not last very long—a day or less.

Moreover, 80% of the individual *Dictyostelium* cells survive the multicelled phase, and then go on to reproduce as unicellular organisms. Even volvocine algae,[9] which do not

possess the separation of totipotency and cellular immortality (e.g. reduced mitotic capacity or multipotency) that is the hallmark true differentiated multicellularity,[10] sacrifice thousands of somatic cells in their multicellular phase to produce perhaps a dozen or so germ cells. This proportion drastically increases again out of necessity when the organism possesses a functional cellular differentiation program designed to structure and maintain the multicelled state.[8] While there is an analogy to unicellular 'bottlenecking' in the dispersal of the spores at the end of *Dictyostelium*'s multicelled phase, *Dictyostelium* has nothing like the proportion of cellular sacrifice that occurs in multicelled life. Volvocine algae are likely the closest that life capable of free-living unicellularity can ever come to true differentiated multicellularity, and *Dictyostelium* doesn't even approach this level of multicellular coordination, let alone what is found in plants, animals, and fungi. Therefore, *Dictyostelium* can only tell us so much about multicellular life, and it can provide little information on the historical sequence necessary to evolve true differentiated multicellularity.

Does an advantage provide an origins narrative?

Both of these studies have been said to answer some important questions about evolution. Both have been said to provide a reason why this or that trait evolved because these traits have been demonstrated to convey a certain selective advantage above the presumed ancestral condition, or the acquisition of a new trait has proved impossible without a certain feature.

The reasoning basically goes like this: "Why did x structure evolve? Because it conveyed y advantage." There is a major fallacy here: note that this doesn't deal with *how* it evolved because key causal links between the ancestral and the descendant traits have been ignored. The question of *how* involves discussions of evolutionary mechanisms, such as specific mutations, specific regulatory and developmental changes, their effects, and the selection mechanisms that have contributed to the preservation of these changes. Explaining the advantages of a rewired system does not explain the rewiring sequence that took place to change the old configuration into something completely new, and it does not directly explain how the wiring got there in the first place. In fact, the soundest inference from such parameters as proper wiring and fitted function is to an intentional creation, not unintentional nature.

Rarely is this sort of detailed, step-by-step narrative ever provided for even the smallest evolutionary events, let alone the massive morphological restructuring involved in turning (for example) a free-living unicellular organism into one with differentiated multicellularity, or even turning a sarcopterygian ancestor into a tetrapod descendant. On the few occasions that such plausible narratives are constructed, they are only for "incidental (and accidental) biological function", not "essential biological structure".[11]

For any fruitful debate to proceed regarding the plausibility of evolution, the right questions need to be asked and answered. Asking why one structure has an advantage over another is the wrong question with which to seek origins answers. A serious researcher would instead inquire into the feasibility of each step along a hypothetical evolutionary path, like from unicellularity to multicellularity.[12] However, the science media typically obfuscates these matters, and even researchers fail to appreciate the depths of explanation that evolutionary theory needs to provide a truly compelling narrative for the history of biology capable of outweighing the design explanation with which it competes.

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