Biological Applications of Pattern-Formation Physics

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In the past several decades, physicists have made great strides in understanding how spatial patterns can arise in systems driven far from equilibrium. Of course, many important issues and significant challenges remain. But, with this sense of progress, many researchers began addressing the question of whether the study of pattern formation could help elucidate the formation of structure
in biological systems, often called morphogenesis. Of course, living matter is much more complex than non-living. Yet, this talk will hopefully convince you that not only is this physics-based approach possible, but is in fact extremely promising. There are many processes one could choose to discuss; for definiteness, I will focus on the life cycle of the soil amoeba Dictyostelium discoideum. In this organism, starvation triggers a day-long series of transformations that take solitary amoebae and create a cooperative multicellular organism; the process culminates in a plant-like fruiting body containing spore cells specialized for survival in harsh conditions. Ideas from the physics of pattern formation have been used to help explain the wave field used for cell guidance, the streaming of cells into the aggregate and the collective motions seen in multicellular stages. Currently, several groups are working on the single-cell chemotactic response from a similar perspective.