

WHY ARE ORGANISMS SO DIFFERENT FROM MACHINES?

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ABSTRACT

The rise of Newtonian mechanics in the 18th and 19th century and quantum mechanics of the 20th century have given us an immense ability to build complex machines and describe their behavior with great precision. But these machines are fundamentally different from organisms. Still, the machine paradigm is often applied to organisms, only to find that any modeling of an organism as a machine is essentially incomplete, at best. The machine approach to modeling natural systems has its roots in mechanics and the highly sophisticated technologies that emerged from it. Though mechanics has great success in describing machines, it is questionable if it has the essential elements to describe biological organisms. While it is true that machines can do some of the things organisms do, it would be wrong to conclude that organisms are simply highly complex machines. Indeed, it is legitimate to wonder if there will ever be a Newtonian theory of organism that describes it as a machine.

Thermodynamics, on the other hand, has a very different character. In contrast to mechanics, irreversibility is fundamental to thermodynamics. Though it has its roots in the study of steam engines, it evolved over time to become a science of the natural world, including organisms. It gives us a way of understanding organisms without using the machine paradigm.

Non-equilibrium self-organized systems, called dissipative structures, are clearly a paradigm for organisms because the underlying physical processes that maintain dissipative structures and organisms are the same. These aspects become very clear when we note the fundamental differences between organisms and machines. In fact, dissipative structures can exhibit primitive organism-like end-directed behavior in that they can move to locations that better supply the energy that sustains the structure. Like organisms, they are self-healing: if their structure is disrupted, the processes that generated the structure restore it. Such and other complex behavior of some of the organism-like dissipative structures can be characterized in terms of entropy production. We can now begin to formulate a thermodynamic theory of organism.

Keywords: Non-equilibrium systems, open thermodynamic systems, self-organization, dissipative structures, end-directed behavior, maximum entropy production, machine paradigm