On physics and biology

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Comment on: **GP Dotto** (July 2020)

See reply: **GP Dotto** (in this issue)

I have read with interest Gian-Paolo Dottos' essay "To be or not to be", in which he discusses the relationship between the second law of thermodynamics and life (Dotto, 2020). The phenomena of living cells do not violate the laws of physics, including the second law of thermodynamics. But as physical chemist Manfred Eigen's commented, there are some unknown "laws" in cells that he called the "physics of biology". In his book *From Strange Simplicity to Complex Familiarity: A Treatise on Matter, Information, Life, and Thought* (2013), Eigen stated: "This is what I call the 'physics of biology'. It differs from the physics of inanimate matter and also from what we call biophysics, i.e. the physics behind the structure and function of all the 'gadgets' that operate in a living organism". His view echoes Philip Anderson's renowned essay "More is different": that life is not merely an assembly of molecules plus "application" of physical laws. But it is surely not intelligent design either (Anderson, 1972).

Schrödinger's influential book *What Is Life?* was inevitably mentioned. According to Max Perutz (1987), "what was true in his book was not original, and most of what was original was known not to be true even when the book was written". Nonetheless, it inspired several physicists to explore biology. In his autobiography, Maurice Wilkins

wrote "It was not just what he wrote, but how he wrote it. ... Schrödinger used the language of physicists and that stimulated me, as a physicist, to persevere with his book and its introduction to genetics, and to decide that this was the general area that I wanted to explore as a 'biophysicist'". In addition to *What Is Life?*, Schrödinger wrote a less well-known article *What is matter?* published in *Scientific American* (September, 1953), in which he discussed the particle-wave duality of matter, massless photon, and gravitational field. Actually, "What is matter?" is more fundamental than "What is life?" Since, physicists found that most of the mass of protons and neutrons (more than 90%) comes from the energy of interaction between quarks and gluons, which is in accord with Einstein's famous mass and energy equivalence (Wilczek, 2005).

Physics and chemistry have been playing important roles in the emergence and evolution of molecular biology as a discipline in its own. Arthur Kornberg (1987) wrote, "This astonishing development, this unification, is based largely on the expression of anatomy, pathology, bacteriology, and physiology in a common tongue, the language of chemistry. Anatomy, the most descriptive of these sciences, and genetics, the most abstract, are now simply chemistry".

Yet, even the great achievement of molecular biology, the discovery of the double-helical structure of DNA, cannot reduce life to chemistry either. Physicist Walter Heitler

(1967) wrote: "As Commoner put it neatly: 'It is not the DNA molecule which is the secret of life. Life is the secret of DNA'. ... In my own book I have also given a number of arguments which demonstrate the impossibility of reducing life to physics". Obviously, Heitler was concerned about the over-dominance of materialism in biology, especially to the famous announcement that "we had found the secret of life" by Francis Crick and James Watson in the Eagle Pub (Cambridge, England) on February 28, 1953 (Crick, 1979). Even with ever more sophisticated instruments, molecular biologists have not been able to break down life as something that is merely governed by the rules of chemistry or physics.

References

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