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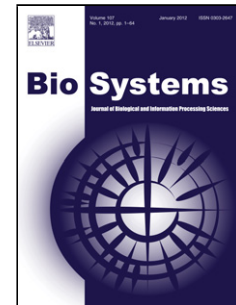
Title: “Life-bearing molecules” *versus* “life-embodying systems”: Two contrasting views on the what-is-life (WIL) problem persisting from the early days of molecular biology to the post-genomic cell- and organism-level biology

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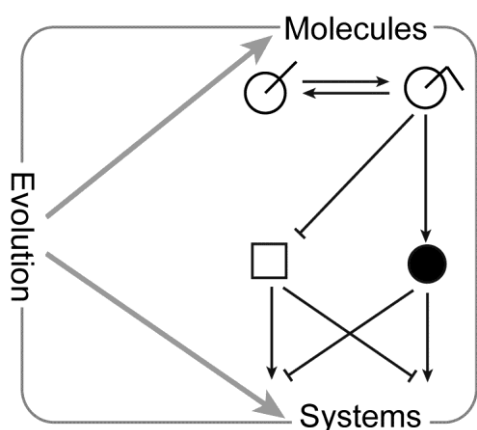
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Graphical abstract



Abstract (236 words)

"What is life?" is an ultimate biological quest for the principle that makes organisms alive. This "WIL problem" is not, however, a simple one that we have a straightforward strategy to attack. From the beginning, molecular biology tried to identify molecules that bear the essence of life: the double helical DNA represented replication, and enzymes were micro-actuators of biological activities. A dominating idea behind these mainstream biological studies relies on the identification of life-bearing molecules, which themselves are models of life. Another, prevalent idea emphasizes that life resides in the whole system of an organism, but not in some particular molecules. The behavior of a complex system may be considered to embody the essence of life. The thermodynamic view of life system in the early 20th century was remodeled as physics of complex systems and systems biology. The two views contrast with each other, but they are no longer heritage of the historical dualism in biology, such as mechanism/materialism *versus* vitalism, or reductionism *versus* holism. These two views are both materialistic and mechanistic, and act as driving forces of modern biology. In reality, molecules function in a context of systems, whereas systems presuppose functional molecules. A key notion to reconcile this conflict is that subjects of biological studies are given before we

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