Complexity begets complexity

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Keynote Abstract

To possess a telescope without its other essential half, the microscope, seems to me a symbol of the darkest incomprehension. The task of the right eye is to peer into the telescope, while the left eye peers into the microscope.

–Leonora Harrington, *Down Below*, 2017

Biology is replete with rich empirical descriptions of microscale (individual level) interactions for a wide range of systems from molecular to societal. Although many models and simulations like Conway's Game of Life elegantly show complexity can arise from simplicity, the empirically grounded microscopic descriptions we now have for biological and social systems suggest complexity begets complexity. Cells, whole organisms, and cities are more similar in complexity than textbook diagrams suggest and, although complexity might increase in a Russian doll sense as we move up organizational levels, it is not at all clear that complexity increases in any other sense—new solutions are computed and new stuff is produced but old stuff is also jettisoned or ignored. In this talk I sketch the beginnings of a new theory of emergence—The Hourglass Theory—in which there is indeed a role for simplicity but not quite the one typically ascribed to it. Rather simplicity and novelty result as adaptive systems coarse-grain microscale complexity to reduce uncertainty and use these sometimes-accurate-sometimes-error-prone perceived regularities to tune behavior.

Jessica Flack *is a professor at the Santa Fe Institute, director of SFI's Collective Computation Group (C4), chief editor of the new, transdisciplinary journal, Collective Intelligence, and, previously, was founding director of University of Wisconsin-Madison's Center for Complexity and Collective Computation in the Wisconsin Institutes for Discovery. Flack is interested in the roles of information processing and collective computation in the emergence of robust but evolvable structure and function in biological and social systems. This work sits at the intersection of evolutionary theory, statistical mechanics, information theory, theoretical computer science and cognitive science. Flack's work has been covered in many publications and media outlets, including the BBC, NPR, Nature, Science, The Economist, New Scientist, Current Biology, The Atlantic, and Quanta Magazine. Flack also writes popular science articles on collective behavior and complexity science for magazines like Aeon. In 2020 her work with several collaborators including Nihat Ay and David Krakauer on the information theory of individuality was chosen as a science breakthrough of the year by Quanta Magazine.*