Connecting Philosophy, Science and Sociology through Example: Weak Emergence and Computation

Ty Branch, PhD Candidate, University of Waterloo

The whole-versus-parts debate is a longstanding discussion in philosophy that has broad social relevance. This tension can be seen in how we conceptualize living organisms: are they a collection of cells programmed by DNA or is there something to be learnt from looking at the capacity for these cells to form organs, systems and organisms? Since the relationship between wholes and parts applies to the nature of explanation, the structure of scientific theories and so forth, it is a genre that has flourished within the philosophy of science and interested many outside the academy. I put forward the example of emergence as a case for how themes in one discipline can be used to reach out to other disciplines and hold appeal for the general public.

One aspect of the discussion of whole-versus-parts is the concept of emergent phenomena. Emergent phenomena are events that occur at high-levels within a system and are unpredictable from the lower-level components of the system. Note that 'what constitutes a level', the 'number of levels', what is a high relative to a lower-level, are all dependent on the system. The designation of what determines a system is also context dependent and can range from atom to organism. Emergence is also used to describe human behaviour.

The relationship between high-level emergent phenomena and lower-level parts is a matter of debate that has resulted in two main categories: strong and weak. The argument between strong and weak emergence regards whether or not higher-level phenomena can be reduced to lower-level phenomena. Strongly emergent phenomena are described as being irreducible whereas weakly emergent phenomena can be reduced to lower-level components. Reduction is the defining distinction between the two emergent categories and has led to conflict within the emergence literature and how we discuss living organisms.

The reason philosophers keep returning to emergence is because it offers potential to reconcile basic philosophical discrepancies between higher and lower-level parts. From an alternative perspective, contemporary theories of emergence actively critique classic reductionism but what ought to be even more compelling is how systems biologists can contribute to philosophy by providing us a means to forward our own understanding of the concept. This not only gives a novel view of the issue, but acts as a way for philosophy to connect with other disciplines including science and sociology.

My research supports philosopher Mark Bedau's notion of computation[1] for reduction while moving forward his claim that computation is a way to enlarge the category of weakly emergent phenomena by giving two examples. The use of computation is a reflection of the relationship between technology and knowledge which is directly related to what we value and prioritize as research worthy.

i) Distinguishing between Strong Emergence and Weak Emergence

An effective way to deliberate about the definition and potential of weak emergence is to consider the limitations of strong emergence. A classic example of strong emergence is consciousness. Consciousness does not seem predictable from lower-level atomic reactions and appears to be impossible to trace back to this lower-level. In the case of strong emergence, the relationship between higher-level and lower-level phenomena is not reductive and so does not have a complete mechanistic explanation.

[1] Bedau, Mark A. "Is weak emergence just in the mind?." *Minds and Machines* 18.4 (2008): 443-459.

On the contrary, the defining characteristic of weak emergence is that it is reducible to lower-level elements. Classic examples of weakly emergent phenomena are the flock formations of birds and the swarming behavior of insects. These patterns are novel, but explicable. Though these high-level phenomena are reducible to the movement of their individual parts, they remain unpredictable from the starting conditions of the system. As a result of this reduction, it is possible to have a mechanistic explanation of the relationship between higher-level and lower-level phenomena. Depending on the degree of complexity of the higher-level phenomena, computational assistance in the form of mapping interactions or tracking elements may be required for the reduction.

Discussions of consciousness and flock formations along with other emergent phenomena have implications across disciplines. Emergence can serve as a concept to promote cross-disciplinary work and engagement with the public because of the familiar examples it describes. Thus, emergence lends itself to assessment through various philosophical, social, technological and scientific lenses.

ii) The Connection between Examples (philosophy) and Explanation (science)

What is valuable about a mechanistic explanation is that it is subject to empirical testing. Strong emergence cannot be reconciled with empirical investigation because the fundamental irreducible feature of strong emergence produces an explanatory gap that distorts causal relationships. The explanatory gap is the area between the higher-level emergent phenomenon and the lower-level parts of the system through which a reductive relationship cannot be constructed.

I look at examples in proteomics because biological organisms have complex top-down and bottom-up relationships many of which, like consciousness, are thought of as strongly emergent. Instead I argue that these phenomena are actually weakly emergent. This is important socially because of science’s role in the public perception of explanation and justification.

iii) The Relationship of Synthetic and Systems Biology to Emergence

Since several proteins are able to perform multiple tasks depending on the environmental conditions of the organism, tracking their interactions can be challenging. However, computation has allowed systems biology to map and track these proteins at this higher-level as well as verify these lower-level relationships by using synthetic biology to enhance or delete certain genes to test the integrity of the system. The higher-level systems’ interactions of the proteins are reducible to the lower-level synthetic markers in the organism making this method of verification weakly emergent. What is most interesting is that scholars like Bar-Yam (2004)[2] and Boogerd et al.(2005)[3] have mistakenly used similar proteomic examples as strongly emergent which suggests there might be several other examples thought to be genuinely strongly emergent that can be reduced through computation and considered weakly emergent.

I propose that weak emergence is able to reduce novel higher-level phenomena to lower-level phenomena with the assistance of computation which can significantly reduce the number of strongly emergent phenomena and show the category of weakly emergent phenomena to be much larger than initially believed. Specifically this can have a societal impact on how we view reductionism; but more broadly, emergence shows how philosophers can connect across disciplines and discuss matters relevant to the general public.

---

[2] Bar-Yam, Yaneer. "A mathematical theory of strong emergence using multiscale variety." *Complexity* 9.6 (2004): 15-24.

[3] Boogerd, Fred C., et al. "Emergence and its place in nature: a case study of biochemical networks." *Synthese* 145.1 (2005): 131-164.