
A CALL FOR METAPHYSICAL REFORM

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PRECISION OR IMAGINATION?

Whether science is more in need of imaginative new approaches or greater precision is basically a metaphysical question. One could answer glibly that both are required, but such truism ignores the historical constraints that Enlightenment metaphysical beliefs place upon the issue.

Now, some will eschew any mention of metaphysics in connection with science, convinced as they are that science is a rational scaffold constructed upon self-evident truths. The foundations are clear and immutable: All is determined by material acting according to scientific laws. Should anything appear to be messy or chaotic, more precision is certain to bring matters into focus. Hence, precision appears to hold clear priority over imagination in the current worldview.

Such perspective involves no small measure of Neo-Platonism: The world is of a fixed essence, and change is more an illusion than an integral part of the cosmos. Chance is a misapprehension, which at worst is relegated to the netherworld of the microscopic.

Critics of this Eleatic picture antedate the postmodern era and include Charles Saunders Peirce, Alfred North Whitehead, Karl Popper, Robert Rosen, Walter Elsasser and Gregory Bateson. This last author (1972), in fact, regards the conventional scientific metaphysics as an outright travesty that leads to (and arguably has already caused) enormous suffering. He maintains that nothing short of a radical change in perspective can return science to a humane and sustainable course. Whence, increasing precision in pursuit of a misleading ideology becomes otiose at best. Priority is better given to imagination in the service of rebuilding the foundations of science.

THE ENLIGHTENMENT PICTURE

Two pillars of Enlightenment science were implicit in the foregoing—closure and determinism (Depew and Weber 1995). Closure requires that legiti-

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mate scientific discourse be limited to mechanical and material causes. *Determinism* means that, given sufficiently precise initial conditions, the future states of a system can, in principle, be predicted within specified bounds.

The *modus operandi* of much investigation rests upon the further assumption of *atomism*. Systems are considered to be strongly decomposable into stable least units, which can be built up and taken apart again. In addition, the fundamental laws of physics are all symmetric and thereby conservative (Noether 1905), so that *reversibility* characterizes all events. Finally, physical laws are considered *universal*. They apply everywhere, at all times and all scales. In combination with determinism, universality implies that nothing occurs except that it be elicited by a fundamental physical law.

These five fundamental assumptions about nature evolved during the Eighteenth Century in the wake of Newton's *Principia*. Scarcely had they been formulated than serious exceptions became apparent. Sadie Carnot, for example, demonstrated the irreversibility of any real process. Some thirty years later, Charles Darwin invoked history (irreversibility and indeterminism) into his narrative, and at the beginning of the twentieth century relativity and quantum theories arose to pose serious challenges for universality and determinism.

Despite such erosion, most today hold tenaciously to the frayed remnants of the Enlightenment metaphysic. Closure, for example, is strictly enforced in the neo-Darwinian scenario of evolution (Dennett 1995.) Atomism and reductionism fuel the prominence of contemporary molecular biology. Even determinism persists among a surprising minority, who contend that probability theory simply papers over an underlying determinacy (e.g., Bohm 1989).

The appeal of such hard materialism lies in its simplicity, but anchoring science on a minimalist picture is becoming difficult to reconcile with the evolving story of the universe. In the Big Bang scenario, for example, material as it is now known did not appear until several epochs into the history of the cosmos. Furthermore, quiescent matter at equilibrium remains but an insignificant fraction of the mass of the universe. Why, then, choose for the foundations of natural philosophy that which is neither prior nor predominant?

THE AGE OF COMPLEXITY

The Achilles Heel of Enlightenment metaphysics was grasped clearly by Bateson (1972) when he pointed to the generic nature of what physics treats (e.g., matter and energy) as distinct from the individual character of living tokens. But homogeneity and repeatability are pinions not only of

classical physics, but of probability theory as well. Walter Elsasser (1969) warned that once chance events can be distinguished from one another, probability theory may no longer pertain, especially if unique, random occurrences of compound events predominate over simple generic ones.

Consider, for example, the chance convergence of 75 distinguishable entities, be they organisms in an ecosystem, individuals at a public forum or whatever. The probability that any such combination will reoccur by chance is less than one in 75-factorial. Because at most 10^{106} simple events could possibly have occurred in the universe since the Big Bang, the likelihood of reoccurrence is physically unrealistic. The compound event can safely be regarded as unique (and thus beyond the ken of probability theory). But in ecology, such compound events are not rare. They happen all the time, everywhere, and at all scales.

Elsasser's calculations pertain as well to the scope of physical laws. There are four physical force laws and two thermodynamic principles. These laws could account for about 720 ($6!$) parametric combinations. By comparison, an organism with some 35 characteristics that could change incrementally and independently could morph over roughly 10^{40} separate pathways. Even though organisms are highly (internally) constrained, it is obvious that a huge number of different combinations would correspond to any particular parametric specification of the physical laws. That is, laws always constrain what happens, but they are insufficient to determine the exact outcomes.

THE ORIGINS OF ORDER IN LIVING SYSTEMS

If the preponderance of singular events seems disturbing, order and pattern nevertheless persist among living creatures. What then, if not laws, could possibly account for such regularities? In a single word, the answer is "process." Here process is taken to mean the interaction of random events with a set of physical constraints such that the outcome is non-random, but indeterminate (Ulanowicz 2009). An artificial example of a process is Polya's Urn (Cohen 1976), a game of successive draws from a mixture of red and blue balls, wherein any chain of draws converges to a constant ratio of ball types. If the process were started anew, however, it would converge to a completely different ratio.

Such indeterminate dynamics are often exhibited in nature by feedback processes, and the most intriguing results derive from a type of feedback called autocatalysis, whereby each member of a closed loop of processes accelerates its immediate downstream neighbor. For example, if process A facilitates another process, B, and B catalyzes C, which in its turn augments A, then the activity of A indirectly abets itself. The same goes for B and C. The constraints engendered by autocatalysis, when impacted by

random singular events, give rise to a host of non-mechanical characteristics:

Firstly, autocatalysis imposes selection pressure upon all its participants. For example, if there is an arbitrary increase in the rate of process B, and that change makes B either more sensitive to facilitation by A, or a better catalyst of C, then its increased activity will be rewarded. Conversely, if the change either makes B either less sensitive to A or a poorer facilitator of C, then B will receive less stimulus from A. That is, changes that enhance facilitation will be rewarded, whereas those which interfere with catalysis will be decremented. One should note that the selection pressure is exercised by autocatalysis *within* the configuration, not from an external source (as with Darwinian "natural selection").

A related attribute is even more central to living systems. Each process requires energy and material to continue. It follows that an increase in any input to a process will be rewarded. The net result is that autocatalytic activity pulls ever more resources into its orbit via all possible inputs—a phenomenon called "centripetality."

It becomes clear that centripetality drives system growth—a much-neglected element in the Darwinian scenario. It follows that centripetalities generated by multiple autocatalytic structures within a limited pool of resources are what induces competition among the *configurations*. Simply put, competition cannot arise without cooperation (mutuality) already occurring at the next level down (Ulanowicz 2009).

REFORM THROUGH ECOLOGY

The augmented scenario of evolution just sketched rests upon three fundamental assumptions: First, singular chance events are recognized as affecting the system (thereby foiling determinism.) Secondly, causation can arise via feedback *at* the level of the system (a violation of closure.) Thirdly, for autocatalysis to persist, the *history* of the system must be stored among its material or dynamical structures (the antithesis of reversibility.) Atomism and universality are simply irrelevant to the new narrative. These three suppositions comprise the foundation of an ecological metaphysic for evolution, and each stands in contradiction to its Enlightenment counterpart.

In conclusion, it appears that further precision in the context of the classical metaphysic will purchase little in the way of further understanding the phenomenon of life. New and penetrating insights are more likely to arise under the ecological assumptions. The strength of the classical approach lies, however, in the mathematical tools it has spawned. The quantitative treatment of ecological network configurations remains inchoate in comparison (Ulanowicz 2004.) Hence, to understand better the

phenomenon of life, a more comprehensive, quantitative treatment of configurations of processes is necessary. Satisfying that need will demand an abundance of imagination!

REFERENCES

- Bateson, Gregory (1972), *Steps to an Ecology of Mind*. New York: Ballantine Books.
- Bohm, David (1989), *Quantum Theory*. Mineola, NY: Dover.
- Cohen, J. E. (1976), "Irreproducible results and the breeding of pigs," *Bioscience* 26:391-394.
- Dennett, D. C. (1995), *Darwin's Dangerous Idea: Evolution and the Meanings of Life*. Simon and Schuster, New York.
- Depew, David J. and Bruce H. Weber (1995), *Darwinism Evolving: Systems Dynamics and the Genealogy of Natural Selection*. Cambridge, Massachusetts: MIT Press.
- Elsasser, Walter M. (1969), "A causal phenomena in physics and biology: A case for reconstruction," *American Scientist* 57: 502-516.
- Noether, A. (1983), *Gesammelte Abhandlungen*. [Nathan Jaconson, ed.] Springer Verlag, New York.
- Ulanowicz, R.E. (2004), "Quantitative methods for ecological network analysis," *Computational Biology and Chemistry* 28:321-339.
- Ulanowicz, R.E. (2009), *A Third Window: Natural Life beyond Newton and Darwin*. Templeton Foundation Press, West Conshohocken, PA.