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Holism is wholesome

It would be difficult to find a more succinct argument than the excellent article by Chandrashekaran[1] on the classical/modern 'schism' in biology to state clearly what science itself is all about. Not being a biologist, I have never been able to tell whether the doubts one felt about the ultimate validity of complete 'molecular reductionism' in matters biological were justified or not. It was instructive to learn that the verdict was not so unanimously in favour of the wholly 'microscopic approach' (as one says in physics). As there appears to be a vague feeling among scientists and others not directly involved in the physical sciences that there is no such dichotomy of thought or approach in as 'exact' or 'hard' a science as physics, it might be worth pointing out[2] that this is not so.

There are really two different dichotomies involved, and they happened to coincide in the case addressed by Chandrashekaran: classical versus modern, and holism versus reductionism. There has long been a similar argument in physics, spanning many decades, with the rival positions actually shifting with time. Two striking examples:

1. Classical versus quantum mechanics, as one of the original subjects of the classical-versus-modern debate. It is well known how classical dynamics languished (relatively speaking) for decades, while the applications of quantum mechanics to molecules, atoms, nuclei, subnuclear particles, ... went from success to success. The advent of deterministic chaos and the uncovering of the incredibly rich mathematical structure of classical dynamics has changed all that, leading—not surprisingly—to a better understanding of the delicately poised nature of the quantum laws themselves. (It is sobering to realize, too, that we are only now beginning to get to the layer beneath the skin, after 150 years or so of intense activity.)

What is even more ironic is that quantum mechanics, which one would assume represented the ultimate *reductionist* viewpoint, is in fact based on dramatically holistic, 'mysterious', nonlocal features that force us to give up the very idea of local, observer-independent objective reality. Even more remarkable is the fact that these nonlocal correlations do not violate special relativity[3].

2. As regards the holism/reductionism debate, the most telling example in physics seems to be the following. In a system with a very large number of interacting degrees of freedom, the whole may often possess properties that cannot even be *defined* (in many cases) for the constituent parts. A trite example is a bunch of atoms, undoubtedly colourless (in the conventional sense), making up a piece of coloured material. (This is actually a misleading example, although it is often cited; see below.) The vast ramifications of this circumstance are continually rediscovered in different subareas of the physical sciences, and given different names in different contexts—cooperative phenomena, synergetics, dissipative structures, spontaneously broken symmetry, generalized rigidity, self-organization and so on. Of course all these terms have precise meanings, differing from each other in technicalities, but the basic idea is the existence, or 'emergence', of properties that are not immediately evident in an analysis based on reductionism, requiring deeper analysis for their uncovering. (In this sense the 'colourless atoms leading to coloured matter' example is misleading, since the optical properties of a collection of atoms *are*, in principle, understood from a consideration of atom light interactions.) The existence of these *emergent properties* (one of the currently fashionable labels[4] for the general phenomenon mentioned) in various circumstances is actually reasonably well understood, at least in principle, by contemporary physicists. And there is a healthy respect for the surprises nature can spring in this regard, together with an awareness of the limitations of (naive) reductionism.

At a philosophical level, this dichotomy (reductionism versus holism, much as one hates to use clichés) is perhaps the ultimate 'complementarity principle', one that is destined to be with us forever, no matter how deep we go into things. What is amusing (and certainly less edifying) are the strident claims from one camp or the other regarding the priority of insights and discoveries in what is surely just one more aspect of a general fact of nature.

It is appropriate to conclude with a mention of one of the finest examples of classicism (the dictionary meaning of which, we have been reminded[1], is 'standard; first class') we have been privileged to witness in our lifetime: the works of Professor S. Chandrasekhar, spanning at least six decades[5].

1. Chandrashekaran, M. K., *Curr. Sci.*, 1991, **61**, 309.
2. Chandrashekaran, M. K., private communication.
3. These matters are discussed in numerous books and articles. An excellent discussion (for a general audience) is given in J. D. Barrow, *The World Within the World*, Clarendon Press, Oxford, 1988.
4. Anderson, P. W., *Physics Today*, July 1991, p. 9.
5. Wali, K. C., *Chandra*, Viking Press, New Delhi, 1991.

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