

Physics, Reductionism, and the Real World

George Ellis, in his article “Physics and the Real World,” talks about the idea that all phenomena, including things like human emotions, can ultimately be reduced to the laws of physics (PHYSICS TODAY, July 2005, page 49). He writes, “This kind of claim is in fact an unprovable philosophical supposition; the claim is without predictive power.”

The hypothesis is unprovable in an absolute sense, as are all ideas in science. But it is without predictive power only because of the way Ellis has framed it. A more general hypothesis would simply be that reductionism always works. That version is subject to refutation, which, according to theorist and philosopher Karl Popper at least, is the mark of a good scientific hypothesis. Reductionism works every time we are able to test it. And by induction we can theorize that it always works. The possibility remains open that the reductionist theory, like any other, could be refuted by observations we have not yet made, or that are beyond our ability to make, but the possibility does not invalidate it as a scientific theory.

We could make a simple analogy. If in all our observations marbles have been blue, we could form the theory that marbles are blue. We could also form the theory that they are “grue”—blue before 2006 and green after 2006. Both theories conform to all the data. However, the theory that marbles are “grue” subtly violates Occam’s razor. Having an unsupported subhypothesis about the year 2006 makes the “grue” theory more complex. Ellis’s statement about reductionism is analogous to saying “the hypothesis that marbles will be blue in the year 1 billion AD” has no predictive power. It is true that we cannot test that specific claim, and

may never be able to, but “marbles are blue” is a valid scientific theory.

In fact, the unsupportable claim here is that some sort of dividing line exists across which reductionism is invalid. No experimental evidence suggests such a divide. Ellis then says, “Everyday experience suggests that such a belief [complete reductionism] is wrong.” But as he has already pointed out, we use different models and different language to simplify and understand phenomena at different levels of the hierarchy. So whether or not complete reductionism is true, we would not expect the language and ideas of one level to adapt themselves well to phenomena of another.

What alternatives exist to the proposed divide between low-level and high-level, or intentional, causal powers? One alternative is to say that human free will reduces to deterministic laws of physics and quantum randomness. But there is another alternative, given no dividing line between high and low levels. Instead of pushing the low-level language up, we could push the high-level language down and say that we humans do have complex free will and that individual quantum events display elemental freedom. See, for example, *Free Will*, edited by Robert Kane (Blackwell, 2001). We could also claim that both views describe the same thing, but in very different language.

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If, as George Ellis suggests, civilization is indeed a complex interaction between the higher-level macro variables and the lower-level micro variables, then somewhere down the road some day we must be capable of modeling the system. Assuming that all biological systems are subject to determinate laws, one sees that free will terminates. Determinate systems simply forbid its existence. For example, a ballistic missile that is subject to the same laws flies its trajectory within a gravity field because of its performance characteristics and program instructions. It is incapable of achieving any different states. The philosopher Immanuel Kant also

viewed existence in those terms. He considered the mechanism of thought to be inseparable from the embedded gears of the rest of the world. The precise truth to these complex systems is clearly a mystery to us. The only thing we can understand for certain at this time is the implications of the models we choose.

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Ellis replies: David Gentile says that “reductionism works every time we are able to test it.” But the point of my article is that it works, and can be tested, only when we exclude the real world; it cannot tell you what move a chess player will make next, for example, or what will happen tomorrow on the stock exchange. “By induction,” says Gentile, “we can theorize that it always works.” Yes you can, and that is an untestable conjecture; whether it is a scientific proposition is therefore open to question. He says that no experimental evidence has established a boundary beyond which reductionism fails. Yes, there is evidence for such a boundary: As pointed out by Jean-Marie Lehn,¹ it is the level of supramolecular chemistry. At and above that level, history and context become as important as physics; a reductionist account cannot, for example, predict the sequence of bases in the DNA of wheat, or what gene will be read next in a cell in a bee as it dances to convey information.

Dave Rauschenfels says, “Assuming that all biological systems are subject to determinate laws, one sees that free will terminates. Determinate systems simply forbid its existence.” But the assumption is invalid; biology is subject to physics, which at its foundations is not determinate. The relation to consciousness is not clear, and has been the subject of intense debate by major quantum theorists, but please let’s admit that quantum theory underlies biology. Furthermore, as Anton Zeilinger said in remarks he made at the Princeton University gathering to honor John Wheeler in March 2002, if free will does not exist in a meaningful sense, the process of scientific investigation cannot take

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