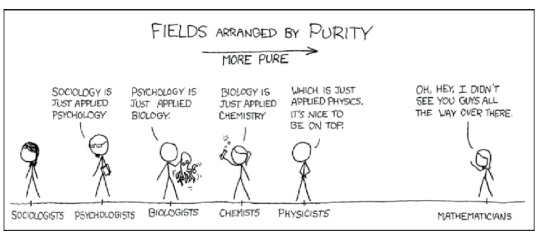
More and different at the interface

Fifty years since the publication of Phil Anderson's 'More is different', we ponder how reductionism and emergence shape the relationship between physics and other disciplines.

"All science is physics or stamp collecting," Ernest Rutherford is reputed to have said. Although the notion that other fields are trivial applications of physics lives on, it's fair to say that for most physicists, this kind of simple reductionism is passé (pictured). But what does this attitude shift mean for physics? This month, on the 50th anniversary of the publication of Phil Anderson's 'More is different'[1], which famously countered reductionism with emergence, we ponder how these ideas have shaped our field and how it relates to other disciplines.

Reductionism is a powerful way of thinking. As scientists, we don't have to look at every object or phenomenon in the Universe separately; instead, it is meaningful to break things down into constituent parts. But, as Anderson pointed out, reductionism doesn't imply an inverse constructionism: chemistry obeys the laws of physics, yet, knowing those laws does not make one a chemist. Emergence is the name for this notion that when there are many simple constituents, they can together behave in a way unexpected from the behaviour of the individuals. To explore this idea further, in this issue we publish a Viewpoint in which scientists working on complex systems, from the origins of life to the mathematics of networks, share some of the most exciting emergent phenomena in their fields.

Interestingly, many of the researchers working on complex emergent phenomena are physicists by training who use tools and ideas from physics in their work. And traditionally, much of complexity research has been published in physics journals and carried out in physics departments. At the same time, like all interdisciplinary work, complexity research can struggle to find a 'home' and can fall through the cracks at funding agencies.



The question of the relationship between disciplines is not new. Indeed, around the time that Anderson published 'More is different', the biologist Edward Osborne Wilson was developing the new field of sociobiology, which brings evolutionary biology into contact with sociology by using the mechanisms of evolution to explain social behaviour in animals (an application of reductionism, and not without controversy). In his 1977 essay, 'Biology and the social sciences'[2] he introduced the idea he called "antidisciplines". In a similar picture to that painted by Anderson, Wilson saw disciplines as sitting in a hierarchy of "organization": particle physics, then many-body physics, and so on down the line to chemistry, then molecular biology, then cellular biology, and so on. Antidisciplines were those "at adjacent levels of organization", and the terminology was intended to "emphasize the special adversary relation that exists initially" between practitioners of the two disciplines at the start of interdisciplinary discussions, as those from the more fundamental discipline attempt to use the laws of their discipline to reformulate the other. In his view, the introduction of sociobiology meant that biology and the social sciences had become antidisciplines.

Perhaps in a similar way, complexity science — by bringing physics and mathematics methods into new contexts — is forming new pairs of antidisciplines, such as physics and urban planning, or physics and finance. Certainly, Wilson's "adversary relation" exists in the (perhaps stereotypical) cases where physicists have a reputation for jumping into other fields, assuming that the details must be irrelevant and that everything can be reduced to an Ising model. But, when physics methods are applied thoughtfully and used to help answer questions that are actually being asked by biologists, economists and so on, the relationship can be fruitful. Indeed, Wilson held out hope that "[the] relationship [between antidisciplines] is also creative, and with the passage of a great deal of time it becomes fully complementary." It is this kind of creativity and complementarity that we hope to foster as we publish review and commentary articles from the interfaces between physics and other disciplines.

1. Anderson, P. W. More is different. *Science* **177**, 393–396 (1972).
2. Wilson, E. O. Biology and the social sciences. *Daedalus* **106**, 127–140 (1977).