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Abstract

Can qualitative information about large molecular networks inside cells teach us fundamentally new biology? In other words, is there a network biology (distinct from a network physics or network chemistry)? The answer to this question is important, because molecular networks are bridges between individual molecules, the lowest level of biological organization, and whole organisms. Both levels of organization, molecules and organisms, are intensely studied. Nonetheless, there is still an enormous gap in our understanding of how molecules collectively produce complex organismal phenotypes. Large molecular networks have the potential to fill this gap, because they contain most of the molecules that allow an organism to survive.

To find out whether large molecular networks can teach us new biology, we first need to answer a very basic question: Does natural selection influence the structure of biological networks, and if so, how? This question is key, because natural selection is the one central feature that distinguishes biological systems from all other, non-biological systems: Only biological systems have been shaped by natural selection, a process that acts on populations of organisms, and that requires heritable fitness differences among organisms.

I will here illustrate progress in answering this question with three examples. First, I discuss recent work suggesting that the function of metabolic networks influences the rates at which its constituent enzymes evolve. Second, I show how multiple small transcriptional regulation networks may have arisen through convergent evolution. These examples demonstrates how natural selection can influence the small-scale, local structure of biological networks. Third, I discuss a number of candidate cases for the influence of natural selection on large-scale network structure, cases that illustrate the great challenges ahead.