

Life can be viewed as a four billion year long history of evolutionary adaptations and innovations. These range from dramatic macroscopic innovations like the evolution of wings or eyes, to a myriad molecular changes that form the basis of macroscopic innovations. We know many examples of such innovations – qualitatively new phenotypes that provide an advantage to their bearer –, but we have no systematic understanding of the principles that allow organisms to innovate. Most phenotypic innovations result from changes in three classes of systems: metabolic networks, regulatory circuits, and protein or RNA molecules. I will discuss evidence that these classes of systems share two important features that are essential for their ability to innovate.