Polymer chemists, through advances in controlled polymerization techniques and reliable post-functionalization methods, now have the tools to create materials of almost infinite variety and architecture. Many relevant challenges in materials science, however, require not only functional polymers but also on-demand access to the properties and performance they provide. The power of such temporal and spatial control of polymerization can be found in Nature, where the production of proteins, nucleic acids, and polysaccharides helps regulate multicomponent systems and maintain homeostasis.

Here we discuss existing strategies for temporal control of polymerizations through external stimuli including chemical reagents, applied voltage, light, and mechanical force. Recent work illustrates the considerable potential for this emerging field and provides a coherent vision and set of criteria for pursuing future strategies for regulating controlled polymerizations.