Polypeptides are fascinating materials with unique properties for various biol. materials. Recent advances in N-carboxy amino acid anhydrides (NCAs) and synthetic polypeptides were highlighted here from the aspects of chem., self-assembly and biol. applications. New synthetic methodologies, mechanistic studies and optimization of polynmr. conditions for the prepnr. of well-defined novel polypeptides were comprehensively reviewed and evaluated. Functional polypeptides, mostly prepnd. from novel NCA monomers, with ultra-stable helical conformation, stimuli-sensitive properties, or glycoprotein mimetics were summarized. A no. of interesting self-assembled structures of polypeptides in solid state and soln., with particular emphasis on those structures other than amphiphilic self-assembly was also highlighted. The biol. applications of polypeptides in drug and gene delivery were also reviewed. Future directions and perspectives were discussed in the conclusion.