Abstract

Mechanical forces play a crucial role in biological processes at the molecular and cellular levels. Recent advancements in dynamic force spectroscopies (DFS) have enabled the application and measurement of forces and displacements with high resolutions, providing insights into the mechanical pathways involved in various diseases, including cancer, cardiovascular disease, and COVID-19. Among the various DFS techniques, biomembrane force probe (BFP) advancements have improved our ability to measure bond kinetics and cellular mechanosensing with pico-newton and nano-meter resolutions. In this review, we provide a comprehensive overview of the classical BFP-DFS setup and highlight key advancements, including the development of dual biomembrane force probe (dBFP) and fluorescence biomembrane force probe (fBFP). BFP-DFS not only enables the investigation of dynamic bond behaviors on living cells, but also contributed significantly to our understanding of the specific ligand–receptor axes mediated cell mechanosensing. Besides, we explore the contribution of discoveries made possible by BFP-DFS in cancer biology, thrombosis, and inflammation, as well as predict future BFP upgrades to improve output and feasibility. Although BFP-DFS is still a niche research modality, its contribution to the growing field of cell mechanobiology is unparalleled, and its potential to elucidate novel therapeutic discoveries is significant.