

# *Continuous Protein Crystallization*

WENQIAN CHEN, HUAIYU YANG AND JERRY YONG  
YE W HENG\*

Imperial College London, Department of Chemical Engineering,  
South Kensington Campus, London SW7 2AZ, UK

\*E-mail: jerry.heng@imperial.ac.uk

## **10.1 Downstream Processing of Proteins**

Proteins are polymers of amino acids with more than 50 residues according to the IUPAC nomenclature.<sup>1</sup> Numerous proteins have been used for medicinal purposes due to their biological activities. The most famous example is insulin, whose human version consists of one acidic polypeptide (21 amino acids) and one basic polypeptide (30 amino acids) joined by disulfide bonds.<sup>2</sup> The discovery of canine insulin in 1921–1922 and the subsequent industrial production of insulin were important breakthroughs in the history of medicine, providing the treatment for diabetes which had remained incurable for centuries.<sup>3–11</sup>

Over the past three decades, protein-based biological products (*i.e.* biologics) have been an important channel of innovation in the pharmaceutical industry.<sup>12</sup> Between 1993 and 2015, a total of 107 biologics have been approved,<sup>13</sup> accounting for a global market of \$175 billion.<sup>14</sup> With the growing significance of protein-based biologics, the large-scale production of these compounds has gained more industrial interest.