limited due to formidable technical challenges. However, the formulation itself can be implemented to gain a competitive advantage. This chapter mostly focuses on parenteral formulations. Different routes of administration, e.g., subcutaneous, intravenous, intramuscular, intraperitoneal, intravitreal, etc., may require varying formulations to be compatible with its specific application.

In general, a minimal expiry of 2 years is required for commercialization. Since real-time stability data are required for setting expiry, preliminary stability data at the target storage condition, i.e., 6 months, are required before recommending the formulation for commercial purposes. When introduced before phase III clinical trial(s), the real-time stability data can be obtained concurrently with the pivotal study.

Frozen Formulations

It is important to acknowledge that frozen formulations are not competitive for commercial purposes. The market will be limited to areas where an adequate cold chain can be established. Maintaining the cold chain itself can become very expensive, especially when specific freezing conditions need to be provided. Also, the time and effort involved in thawing a product before use is inconvenient to the administrator of the product.

Liquid Formulations

In general, liquid formulations, especially when presented in a prefilled syringe, should be considered the best option for commercialization. It is preferred over lyophilized formulation due to the convenience of direct administration without preparation. This attribute is essential when competing products exist in prefilled syringes with convenient devices such as auto-injectors or pen injectors. Even when liquid formulations may not be feasible during the initial entry to market, many protein formulations are switched from lyophilized to liquid formulations during life-cycle management for competitive reasons. Readers are referred to other references for various options for liquid formulation development [8].

Lyophilized Formulations

As many biopharmaceuticals are not sufficiently stable to achieve a 2-year expiry in a liquid state, more than 50% of currently marketed biopharmaceuticals are introduced as lyophilized formulations. Lyophilized formulations offer other advantages over liquid formulation due to their superior stability during transportation and storage. In addition, the enhanced stability of lyophilized drugs often avoids the emergence of stability issues during later stages of development or at the commer-