ited and usually in the development stages in the analytical laboratories. To aid in developing stability-indicating assays, the formulation scientist usually will stress samples and provide to the analytical areas for generation and evaluation of monoclonal and polyclonal antibody reagents to shape the in vitro potency assays as the project continues through development.

Both biophysical and biochemical characterization is completed and multiple preclinical animal studies need to be conducted to try and identify the proper antigen/adjuvant combination and impact of minor process and formulation changes on immunogenicity [30]. This work is essential so that as the program continues to advance within the pipeline, a fundamental understanding of the degradation pathways for the product are known, enabling formulation development to focus on ways to minimize degradation and enhance the stability of the vaccine target.

Often due to limited thermal stability of vaccines, especially LVV and their expected global markets, examining lyophilized formulations for LVVs is preferred in the preformulation space to align end-to-end with commercial process. However, due to lack of drug substance (DS) availability in preformulation and capital and time-consuming lyophilization development, early stage preformulation may focus on identifying a stable frozen formulation to combat stability challenges associated with LVVs and phase I clinical development. Such knowledge gained during preformulation will help shape the design of future experiments and can be utilized in building the QbD approaches and steps to examine later in formulation development.

In preformulation experimental studies, the vaccine candidates are usually examined in both liquid and frozen conditions rather than in lyophilized forms. Liquid formulations allow a quicker read on the degradation pathways associated with the vaccine and expedite product development. In addition, liquid formulations are more convenient when completing early preclinical animal studies. Field-mixing of the antigens and potential adjuvants is easier since compatibilities may not be known and stability profiles are still being explored.

Thus, in summary, the main goal during the preformulation activities is to help the discovery areas identify the proper antigen(s) to bring forward as a preclinical candidate. Additionally, the formulation scientist is working to characterize the antigen as best they can so that as the program progresses, the main degradation mechanism has been outlined. After successfully completing preformulation development, it is likely the program has advanced into preclinical development and the main focus for the formulation scientist will be on completing initial screens to identify a formulation that will lead to a safety assessment/toxicology formulation.

Identifying an Initial Formulation for Safety Assessment and Toxicology Studies

After entering preclinical development, the formulation scientist is charged with identifying a formulation that will be utilized in safety assessment/toxicology studies. The main screening in this initial stage will likely examine the common ex-