Biopharming / Science of biopharming

As living organisms, plants can be used to produce complex therapeutic proteins, such as monoclonal antibodies, to treat a wide range of diseases in humans.

There are two main ways to genetically modify plants to turn them into mini factories or "bioreactors" for biologic drug production: through a process called "transient expression" or by developing lines of "stable transgenic" plants.

Transient expression in plants

Transient expression methods, such as PlantForm's *vivo*XPRESS® system, involve infiltrating plant leaf material with an *Agrobacterium* suspension containing the genetic material for a target therapeutic protein or antibody.

Fully grown plants, four to six weeks old, are immersed in the *Agrobacterium* suspension under vacuum pressure, allowing the *Agrobacterium* to penetrate the plant cells to introduce the genes of interest through a natural process, which alters the plant's DNA and directs it to begin to manufacture (express) the protein. After the plants are treated in this manner, they grow for another week, generating biomass, and are then harvested and the protein material extracted and purified to make a biopharmaceutical drug. See a diagram explaining how the *vivo*XPRESS® transient expression system works.

Stable transgenic plants

Stable transgenic plants are developed by stably altering the DNA of a plant's nuclear or chloroplast genomes. Seed lines are then developed for continual propagation of plant biomass using traditional agricultural techniques and equipment.

A downside to stable transgenic plants is the length of time it takes to generate and select for the desired seed lines. Furthermore, stable transgenic (nuclear-transformed) plants typically produce lower yields of recombinant proteins compared to transient expression systems.

Advantages of plant-based biopharma systems

Plant-based systems for recombinant protein production offer a number of important advantages over fermentation systems using animal, yeast or bacterial cells to produce biologic drugs. The advantages include:

- lower costs and rapid scalability
- lower manufacturing facility costs
- fast turnaround/response times, high-yield production
- enhanced safety, with lower risk of contamination with animal and/or human pathogens
- the ability to produce novel and complex molecules