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Biopharming: An Approach for Future Medicine

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SUMMARY

Biopharming uses genetic engineering to insert genes that code for useful pharmaceuticals into plants, turning them into miniature factories to produce pharmaceutical proteins and industrial chemicals that they do not naturally make. This technology involves the insertion of foreign genes coding for medically important proteins, such as therapeutic proteins, monoclonal antibodies, and vaccines, into plant cells. The history of biopharming, also known as plant molecular farming, dates back to the early 1990s when Canadian plant scientist Dr. J. Christopher Hall pioneered plant-based technology for producing antibody drugs.

INTRODUCTION

Plants have always been crucial to human health and well-being throughout history. Naturally occurring substances have been demonstrated to offer advantageous qualities for medical usage, and both wild and grown plants have been used for food, clothing, and components of shelter. Recent developments in plant genetic engineering have opened up new ways to profit from plants; as a result, plants are now a rich source for the synthesis of bioactive compounds with both medicinal and economic value, as well as recombinant human and animal proteins. Protein therapies have been produced for the past thirty years through the widespread usage of transgenic animals, microbial systems, and altered animal cells. However, as the volume of genomic and proteomic data has exploded, so too have the number of target molecules and worries about the expense and safety of the current animal- and microbe-derived systems. It's getting harder for mammalian cell-culture facilities to keep up with the volume of products and size of the market. Bioengineered plants represent an extremely promising method for the synthesis of therapeutic proteins due to the convergence of these elements and the ready ability to produce higher quantities of safer goods at a lower cost. The applications of biopharming are as diverse as the plant kingdom itself. Plant-based pharmaceuticals have already made significant strides in the treatment of conditions ranging from cancer and infectious diseases to autoimmune disorders and rare genetic conditions. For example, the FDA-approved drug Elelyso, used to treat Gaucher disease, is produced in genetically modified carrot cells. Similarly, ZMapp, an experimental treatment for Ebola, contains antibodies derived from tobacco plants.Beyond traditional pharmaceuticals, biopharming holds immense potential for addressing global health challenges especially in addressing urgent medical and pharmaceutical needs, as demonstrated during emergencies like the COVID-19 pandemic. With the ability to produce vaccines and therapeutics on a large scale and at a fraction of the cost of traditional methods, biopharming could help bridge the gap in access to essential medicines, particularly in underserved regions of the world. Additionally, the use of plants as bioreactors offers a sustainable and environmentally friendly alternative to traditional pharmaceutical manufacturing processes, reducing reliance on synthetic chemicals and minimizing waste.

Methods of gene expression systems in biopharming

Transient Expression Systems:

In this system of gene expression involves introduction of foreign nucleic acid into host (plant) to express for a limited time period

Stable Transgenic Systems:

In this system the plant genome is altered for the expression of particular target proteins with stable synthesis over a long time

Character	Transient Expression	Stable Transgenic
Manipulation	No alteration in genome involved	Genome of host is altered
Time period	Rapid about 7-10 days	Takes time for expression
Yield	Higher yield	Lower but consistent
Application	Rapid and emergency needs	Long term

Steps involved in biopharming

Steps involved in plant molecular farming:

Gene Identification and Isolation:

The gene of interest based on the biomolecule (proteins, enzymes, antibody) to be produced is selected and isolated from the host.

A transgene construct

It is the gene of interest that has to be transform into the host cell (Fig.1)

- A promoter that acts to turn the gene on and off in the cell.
- A selectable marker that is used to select cells that successfully obtained the construct during the transformation process
- A terminator sequence
- A Selectable Marker that allows for the identification of successfully transformed cells

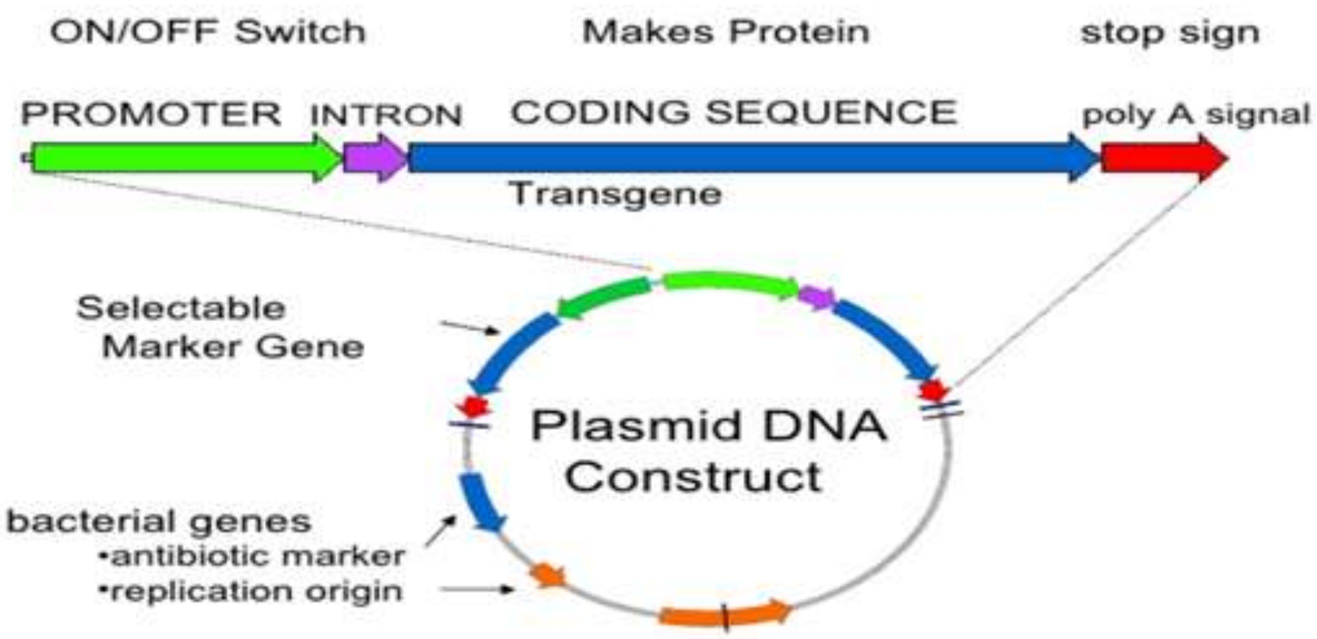

Figure.1: transgene construct and its components

Gene Insertion (Transformation):

The isolated gene is inserted into the plant DNA (in which biomolecules have to be produced) using transformation methods like vector-mediated or biolistic to create genetically modified plants that produce interested compounds.

It includes different methods such as

- Agrobacterium-Mediated Gene Transfer
- Gene Gun (Biolistic) Method
- Electroporation
- Protoplast transformation
- Chloroplast culture

Among these methods Agrobacterium mediated transfer is most popular which includes fallowing steps (Fig.2)

Explant preparation: This involves preparing the plant tissue that will be used for genetic transformation. The tissue is usually wounded to make it more susceptible to Agrobacterium infection.

Agrobacterium preparation: The Agrobacterium strain is prepared by growing it in a culture medium containing the desired gene of interest. The Ti plasmid carries the T-DNA region, vir genes, and genes encoding opine catabolism, called as transgene construct.

Infection: The prepared Agrobacterium strain is then introduced to the wounded plant tissue, allowing it to transfer the T-DNA region into the plant genome.

Co-cultivation*:* The infected plant tissue is then co-cultivated with the Agrobacterium strain in a culture medium to allow for the integration of the T-DNA region into the plant genome.

Selection and regeneration: Transformed plant cells are then selected and regenerated into whole plants.

Rooting: The regenerated plants are then rooted and acclimatized to prepare them for further studies or cultivation

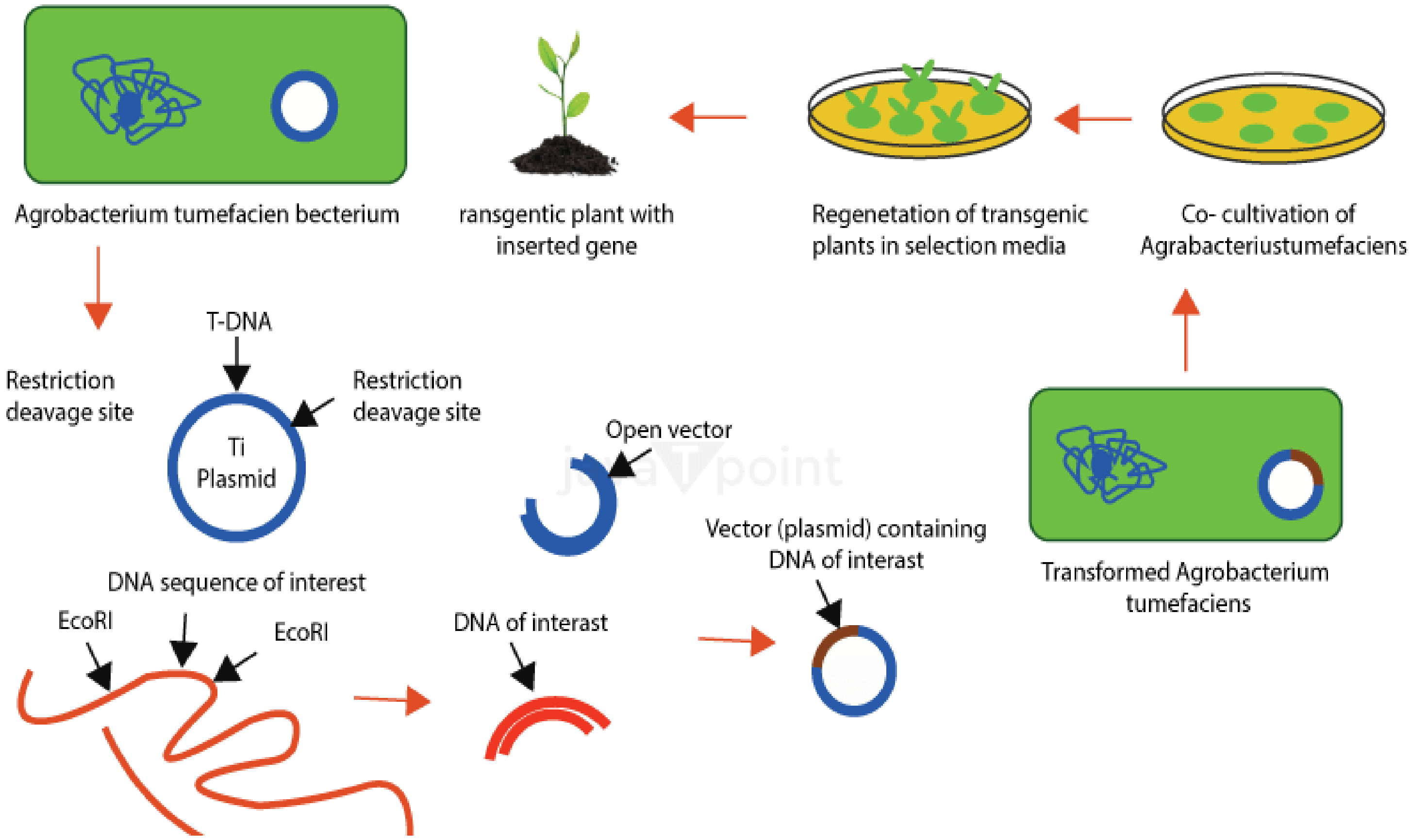

Figure.2: steps involved in Agrobacterium mediated transfer in biopharming

Plant Cultivation:

The modified plants are to be grown under controlled environmental conditions to avoid contamination as these plants are rich in particular biologically beneficial compounds within their tissues.

Harvesting:

Once attaining physiological maturity, the plants were harvested and further processed for extraction of biomolecules.

Some key potential applications of biopharming in medicine include:

Production of Therapeutic Proteins:

Biopharming can be utilized to produce therapeutic proteins, monoclonal antibodies, and vaccines to treat various medical conditions such as cancer, inflammatory diseases, and other life-threatening or debilitating conditions.

Development of Novel Vaccines:

Biopharming enables the production of vaccines through genetically modified plants, offering a cost-effective and efficient method for vaccine production. This includes the development of edible vaccines, like vaccine-carrying bananas, which could be a practical and effective delivery method, especially in developing regions.

Creation of Biologics:

Biopharming can be used to produce biologics, which are pharmaceuticals derived from living organisms. These biologics can include a wide range of products such as antibodies, enzymes, and other complex biologics that are essential for treating various diseases.

Improved Drug Production:

Biopharming can lead to the production of drugs, antibodies, and vaccines more cost-effectively and efficiently. This technology has the potential to produce biologics that are inexpensive and can be used to test new drugs without risking human subjects.

Addressing Nutritional Deficiencies:

Biopharming can help address nutritional deficiencies by creating genetically modified crops like golden rice, which contains beta-carotene, a precursor to vitamin A. This innovation has the potential to combat malnutrition and improve public health in regions where vitamin deficiencies are prevalent.

Some of Food and Drug Administration (USA) Approved drugs

Drug	Characteristics	Target
Elelyso (taliglucerase alfa)	enzyme produced in carrot cells	Gaucher's disease
ZMapp		Ebola virus
Zarxio (filgrastim-sndz)	Biosimilar drug	Infection during chemotherapy.
Omnitrope	Biosimilar drug natural growth hormone	Retarded growth

CONCLUSION

This method of synthesis minimizes dependency on chemical synthesis, which generates various secondary compounds that pose serious threats to the environment and human health. Biopharming processes have potential future scope for producing biomolecules naturally and sustainably.

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