



# molecular Farming

Using Plants to manufacture High Value Products



Transgenic organisms are already being used to produce many common biopharmaceuticals. For example, **bacteria** are used to produce simple proteins, such as insulin.

More complex proteins such as the anti-cancer antibody Herceptin are produced in **cells of mammalian origin** - the ovarian cells of the Chinese hamster (CHO cells). Although well established in the pharmaceutical industry, these systems are costly, and relatively limited in scale.

***Molecular Farming uses plants as an alternative.***

## Why plants?

Plants are **easily cultivated** around the world and do not require expensive specialist equipment. They are particularly easy to grow in extremely large quantities, which enables **economic production** and the potential to address the provision of medicines that are needed in extremely large amounts.

Molecular Farming could provide important solutions for the management of many **major global diseases**, particularly those that disproportionately affect the poor in developing countries.



# Plant production platforms

A variety of production platforms have been developed for Molecular Farming. These can be regarded under two major groups, **stable transgenic plants**, and those that use non-transgenic plants that are employed as **transient bioreactors** for induced protein production.

Most plant species can be used for Molecular Farming and can be cultivated using a range of containment options.



The target product can be directed to accumulate specifically within seeds, leaves or fruits.

**Accumulation of high-value proteins in seeds** utilises plants' natural storage system and provides the advantage of long term stability and extended shelf life of highly concentrated raw material.

**Leaf-based production systems** are also widely used, as they offer the possibility of rapid and high volume production.

Not only is it possible to use whole plants, but plant cells can also be grown in large sterile **bioreactors** and induced to produce Molecular Farming products. This approach offers the ultimate in **production control and product containment**.

In the open field, cultivation of transgenic crops for Molecular Farming has to be separated from that of other plants. An alternative is to grow plants in a greenhouses or plant cells in sterile bioreactors.

The idea of using plant production systems has matured to the state when first products have entered the market.

# First products

## Growth factors and cytokines

Over forty different ISOkine™ growth factors and cytokines produced for use in basic and applied medical scientific research, cell culture media and diagnostics are being produced in barley grain.

ORF Genetics, Iceland

## Skin care products

EGF BIOeffect™ Serum is a skin care product, which contains epidermal growth factor (EGF) that was produced in barley plants. This cellular activator stimulates renewal of skin cells and slows down biological processes of aging.

Sif Cosmetics, Iceland



## Some advanced products approaching the market

A human enzyme for the treatment of Gaucher's disease has been produced in carrot cells. The enzyme proved its efficacy in clinical trials and is now in the final stage of the review process by the US Food and Drug Agency.

Protalix, Israel

Safflower plant seeds are used to produce efficient and low-cost human insulin. Using this plant-system the global demand for insulin could be accommodated with as few as three commercial farms.

SemBioSys, Canada

Different antibodies, ones for fighting cancer for example, are produced in moss in contained photo bioreactors.

Greenovation, Germany





## **Molecular Farming**

*is the use of plant biotechnology to make high value products. Examples are proteins that are biopharmaceuticals or enzymes that may be used in industrial processes.*

## **Biopharmaceuticals**

*are products that are used for diagnosis, prevention or treatment of diseases. They include antibodies, serum proteins, growth hormones, enzymes and vaccines. The conventional source for these types of products has been human or animal fluids, more recently many are now manufactured using modern, but expensive biotechnological production systems.*

**The COST FA804 Molecular Farming Action** provides a pan European coordination centre, connecting academic and government institutions and companies from 23 countries. We aim to advance the field by encouraging scientific interactions, providing expert opinion and encouraging commercial development of new products.

The COST Action also provides grants allowing young scientists to visit participating laboratories across Europe for scientific training.



# Molecular Farming A field of opportunity

Visit **[www.molecularfarming.org](http://www.molecularfarming.org)** and **[www.cost.esf.org](http://www.cost.esf.org)** for more information.

To join us, please contact the chairperson of the Action  
Prof. Kirsi-Marja Oksman-Caldentey ( [kirsi-marja.oksman@vtt.fi](mailto:kirsi-marja.oksman@vtt.fi) ),  
the vice-chairperson Prof. Julian K-C Ma ( [ma@sgul.ac.uk](mailto:ma@sgul.ac.uk) ) or your national representative.