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PMPs - Plant-Made Pharmaceuticals

Plant molecular farming, one application of biotechnology, involves growing and harvesting genetically modified crops for the production of biological pharmaceuticals or industrial materials. These plants are not produced for food, feed, or other agricultural commodities, but rather become bio-factories that can produce proteins that are difficult or expensive to make by other means. The proteins themselves are used in the production of therapeutic drugs and for certain industrial materials, such as bioplastics.

Pharmaceuticals made in plant-factories are also known as Plant-Made Pharmaceuticals (PMPs). PMPs can be new, critically needed drugs, or widely used generic drugs. Their active element is usually a protein too complex to be produced by the usual chemical synthesis technologies. In order to produce such proteins, genetically transformed living organisms, like cells in culture, transgenic animals, or plant-factories, must be used. It is estimated that in 2010 PMPs might represent up to 35% of drugs sold.

The plant connection

Since the 1980's, new therapies called 'biologics' have been developed by the best pharmaceutical and research labs of the world to help cure cancer, arthritis, heart conditions and other severe or chronic diseases. However, current production methods are insufficient, and some of these novel drugs may never even reach the patient because of excessive costs or lack of production capacity.

Plants offer an effective and economical way to produce these valuable products. Through genetic engineering, they can be transformed to produce a wider variety of more suitable antibodies than bacteria and at higher concentrations. The harnessing of gene technology allows plants to be turned into factories for medicines and other value-added commodities. Combining plant genetics, molecular biology, and gene delivery systems, genes can be taken from other sources, such as microorganisms, and spliced into a plant's genome. During normal growth these genetically engineered plants synthesize 'recombinant' proteins, which can be therapeutics, vaccines, blood substitutes, enzymes, monoclonal antibodies, or diagnostics that are then extracted from the crop.

Plants will allow for large-scale production capacity at a cost that could be much lower than current manufacturing methods. They also allow for rapid scale-up of production. If demand for a new PMP increases more fields can be planted. Another advantage is that plants do not carry human diseases, reducing the risk of drugs being contaminated with animal pathogens, prions, or disease-causing germs.

Application

There are currently over 50 human therapeutic products being produced in plant and animals that are in or are close to being ready for clinical human trials. Among those in development are therapeutics for: Alzheimer's Disease, cancer, cholera, Cystic Fibrosis, heart disease, Hepatitis B, HIV, Multiple Sclerosis, obesity, rheumatoid arthritis, spinal cord injuries, tooth decay and many others (see Table 1).

New technologies and safety

Like any new technology there are concerns to deal with and precautions to take. For example, plants with novel traits for molecular farming may be considered unsafe for the environment if a novel compound is produced that may be toxic or inhibitory to wildlife. They may also be considered unsafe for the environment if the novel trait can be transferred to other plants of the same or related species. Some plants used for molecular farming may produce compounds (such as pharmaceuticals) that affect human or livestock health.

Measures will have to be taken when growing plants containing therapeutic agents to ensure they do not get into the regular food or animal feed supplies. They will have to be fully contained and will probably be grown in non-food crops such as certain weed species.

Table 1: Examples of current Plant-Made Pharmaceutical research

Alfalfa	Plasma proteins
Arabidopsis	Human intrinsic factor (vitamin B12 uptake)
Corn	Anti-HIV and anti-Herpes simplex antibodies Microbicides for pulmonary infection MABs for cancer, arthritis, and other auto-immune diseases like Crohn's disease Vaccines for Hepatitis B transmission and Traveler's disease TGEV for animal health Aprotinin for blood loss and heart surgery Vaccines and antibodies for animal disease prevention Antibodies
Lemma	Human plasminogen for peripheral arterial occlusion Alpha interferon
Moss	Factor IX for treatment of haemophilia B
Rice	Alternatives to antibiotics in poultry diets Lysozyme for gastrointestinal health, topical infections and inflammations
Safflower	Pharmaceuticals and oil-body-based products for oral and dermal delivery
Spinach	Protective antigen for vaccine against *Baccillus anthracis*
Tobacco	TGF-b glucocerebrosidase for Gaucher's disease Alpha galactosidase for enzyme replacement therapy IgGs for the prevention of dental decay, prevention of common cold, and neutralization of chemotherapeutic drug toxicity GAD 7 cytokines for type 1 Diabetes IL-10 for inflammatory bowel disease Glycoprotein B of human cytomegalovirus (hCMV)
Tobacco Corn	Gastric lipase for cystic fibrosis Lactoferrin for gastro-intestinal infection and dry eye syndrome
Tomato Potato Potato tuber	Edible vaccines against *E.coli,* Norwalk virus, Hepatitis B Antimicrobial peptides

In Canada, the government recognizes that, in order to secure the benefits of biotechnology and molecular farming, it is essential to first protect the health and safety of Canadians, the environment, the food supply, and animals.

Canada has a well-balanced stewardship approach, the cornerstone of which is the Federal Regulatory Framework for Biotechnology. This framework provides a transparent and rigorous regulatory system, based on the best available science. This is to ensure Canadians have confidence in, and benefit from, safe and effective biotechnology-based products and services, including those associated with PMPs. In Canada, the responsibility of regulating molecular farming is shared by the Canadian Food Inspection Agency, Health Canada, and Environment Canada.

Researchers, government regulators, and industry are working together to develop a regulatory system that will ensure the safety of Canadians and our food supply while at the same time will allow the new technology. A technology that can have tremendous benefits for human and animal health.

For more information:

National Research Council
Plant Biotechnology Institute:
http://www.pbi.nrc.ca/en/media/advance3a.htm

Canadian Food Inspection Agency:
http://www.inspection.gc.ca/english/plaveg/pbo/mf/mf_pharme.shtml

Biotechnology Industry Organization:
PMP page: http://www.bio.org/pmp/
Consumer benefits: http://www.bio.org/pmp/PMPBenefits.pdf

To find out more about agricultural biotechnology or to book a tour of the Saskatchewan Agricultural Biotechnology Information Centre (SABIC), contact:

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