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BIOLOGY

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CLASS 11&12th

CLASS 12th

Biotechnology

Applications

01. Introduction

Biotechnology essentially deals with industrial scale production of biopharmaceuticals and biologicals using genetically modified microbes, fungi, plants and animals. It finds application in medicine, therapeutics, diagnostics, bioremediation, agriculture, waste treatment, food science (process food) and energy production. The thrust areas of biotechnologies include:

(i) Improved organism mostly a microbe or pure enzyme acting as the best catalyst.
(ii) Providing optimum conditions through engineering for catalyst to act.
(iii) Downstream processing technologies to purify the protein/organic compound.

Knowledge Cloud
Norman Ernest Borlaug (March 25, 1914 – September 12, 2009) was an American **agronomist, humanitarian,** and **Nobel laureate** who has been called "the father of the Green Revolution".

What is Green Revolution?

Period in which significant increase in agricultural productivity of grains (particularly wheat and rice) was observed in 20^{th} century, resulting from

(i) Introduction of improved crop varieties *i.e.*, high-yielding varieties.
(ii) Better management practices (irrigation, mechanisation and soil conservation technique).
(iii) Use of agrochemicals (fertilisers or pesticides).

Use of genetically modified crops is a possible solution

Gene cloning provides a new dimension to crop breeding by enabling direct changes to be made to the genotype of a plant, circumventing the random process inherent in conventional breeding. Two general strategies have been used:

(a) **Gene addition :** In which cloning is used to alter the characteristics of a plant by providing it with one or more new genes.
(b) **Gene Subtraction :** In which genetic engineering techniques are used to inactive one or more of the plant's existing genes.

Transgenic plants have been useful in many ways. For instance genetic modification has:

(i) Made crops more tolerant to abiotic stresses (cold, drought, salt, heat).
(ii) Reduced reliance on chemical pesticides (pest-resistant crops).
(iii) Helped to reduce post harvest losses.
(iv) Increased efficiency of mineral usage by plants (this prevents early exhaustion of fertility of soil).
(v) Enhanced nutritional value of food, *e.g.*, Vitamin 'A' enriched rice.

The Science behind Golden Rice : Golden rice was developed by **Ingo Potrykus** and Peter **Beyer** to combat vitamin A and Iron deficiency as this could accumulate more β–carotene.

Golden rice is a transgenic variety of rice (*Oryza sativa*) which, contains good quantities of **β–carotene (provitamin A** – inactive state of vitamin A). β–carotene is a principal source of vitamin A. Since the grains (seeds) of the rice are yellow in colour due to β–carotene, the rice is commonly called **golden rice**.

Knowledge Cloud

The gene-encoding hirudin was chemically synthesized and introduced into brassica napus using Agrobacterium-mediated transformation. The resulting transgenic plant yielded seeds in which hirudin accumulates. The hirudin is purified and used as medicine. In this case, the transgenic product itself is the product of interest.

The endotoxins of *Bacillus thuringiensis*

Several types of bacteria have evolved defense machanisms against insect predation, an example being *B. thuringiensis* which, during sporulation, forms intracellular crystalline bodies that contain an insecticidal protein called the endotoxin.

The endotoxin that accumulates in the bacterium is an inactive precursor. After ingestion by the insect, this protoxin is cleaved by proteases (**alkaline conditions in gut**), resulting in shorter versions of the protein that display the toxic activity, by binding to the inside of the insects mid gut and damaging the surface epithelium by creating pores that causes swelling and lysis. So, that insect is unable to feed and consequently starves to death. This toxin called **Bt toxin** as produced by *Bacillus thuringiensis* has been cloned in bacteria and been expressed in plants to provide resistance to insects without the need for insecticides in effect created a bio-pesticide. Examples are **Bt cotton, corn, rice, tomato potato** and **soyabeen** etc. This toxin is encoded by a gene named ***cry.*** These genes are effective against various types of insects e.g. **Lepldopterans** (tobacco budworm, armyworm), **Coleopterans** (beetles) and **dipterans** (files and mosquitoes).

Use of anti-sense RNA in creating pest resistant plants

A nematode *Meloidegyne incognita* infects the roots of tobacco plants causing a great reduction in yield. The most cost effective and sustainable management tactic for preventing such damage was to bioengineer resistant plant that prevent the nematode from feeding on the roots.

The strategy adopted to prevent this infestation is based on the process of RNA interference (RNAi)

This mecahnism is used for the regulation of specific genes and is also applied as adefence against viruses. This method involves silencing of a specific mRNA due to formation of dsRNA molecule formed by binding of complementary RNA (anti-sense RNA) molecule to original mRNA, thereby preventing translation of the original mRNA (silencing). The source of this complementary RNA could be form infection by viruses having RNA genomes or mobile genetic elements (transposons) that replicate via an RNA intermediate.

Using *Agrobacterium* vectors, nematode specific genes (responsible for parasitism) were introduced into the host plant. The introduction of DNA was such that it produced both sense anti-sense RNA in the host cells forming dsRNA. These two RNA’s being complementary to each other formed’s dsRNA that was taken up by the parasitic nematode andi initiated RNAi, thus silenced the specific mRNA of the nematode. The consequence was that the parasite could not survive in a transgenic host expressing specific interfering RNA. The transgenic plant therefore got itself protected from the parasite.