**Genetic Engineering and effects on the Agricultural Arena**

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**The morality of genetic engineering has long since been a controversy. Over the years**

**however, genetic engineering has become more widely used and accepted. Though the**

**public may not be fully informed and may not completely understand the processes used in**

**the genetic altering of agriculture. Farmers, however, are up to date with recent plant**

**biotechnology and are continuing to improve the quality and quantity of their crops.**

***A. tumefaciens***

**Some of the early steps that eventually led to a way around the limits of traditional**

**breeding occurred in the first decade of the twentieth century with work on a disfiguring**

**plant disease known as crown gall. Crown galls are bulbous tumor-like growths that,**

**when well developed, protrude from the stems of many infected food plants, including fruit**

**trees, grape vines, and berry canes. Crown gall disease makes plants grow poorly and**

**can cause substantial crop losses. In 1907, Erwin Smith and C. O. Townsend, of the U.S.**

**Department of Agriculture, discovered that the cause of crown galls was a rod-shaped**

**soil bacterium, Agrobacterium tumefaciens.**

**In 1974, Flemish scientists Jeff Schell and Marc Van Montagu isolated the tumor-**

**inducing genes of the crown gall bacterium, and found that they were carried on a**

**mobile unit of DNA in the bacterium known as a plasmid. The next step was to determine**

**whether the genes on this bacterial plasmid were transferred into the chromosomes of**

**plant cells when the bacteria infected the plants.**

**A number of elegant techniques had been developed that enabled researchers to cut and**

**splice DNA to preselected specifications. To convert the A. tumefaciens plasmid a useful**

**tool, called a vector, for introducing desired genes into plants, researchers first had to**

**locate and then remove the tumor-inducing genes. Scientists in several laboratories were**

**able to accomplish this task in the late 1970s and early 1980s. By 1983, plant molecular**

**biologists had developed the first plasmid vectors that promised to remove the limits of**

**traditional plant breeding for plants naturally infected by A. tumefaciens.**

***Bacillus thuringiensis***

**A tool for introducing genes into plants is useful only if scientists have found genes that**

**they want to transfer. Part of the hunt for desirable genes began inadvertently in Japan in**

**1901, when bacteriologist Ishiwata Shigetane was asked to investigate the cause of a**

**disease outbreak that was killing large numbers of silkworms. Shigetane discovered that**

**the cause of the outbreak was a previously unidentified species of spore-forming bacteria,**

**later named Bacillus thuringiensis, or Bt.**

**Researchers then zeroed in on identifying the genes associated with the production of Bt**

**proteins. Information about the genes was gathered by a pair of microbiologists looking**

**into why the Bt genes triggered production of their toxic protein only when Bt bacteria**

**started to produce spores. In 1981, Helen Whiteley and Ernest Schnepf, then at the**

**University of Washington, discovered that the insecticidal proteins were found in a**

**crystal-like body that was produced by the bacteria. They used recombinant DNA**

**techniques to isolate a gene that encodes for an insecticidal protein. By 1989, more than**

**40 Bt genes, each responsible for a protein toxic to specific groups of insects, had been**

**pinpointed and cloned by various researchers.**

**When both the A. tumefaciens vector for gene transfer and cloned Bt genes became**

**widely available in the mid-1980s, a number of researchers realized that the two could be**

**combined to modify crop plants so that they produce Bt proteins and thereby protect**

**themselves from insect pests. Such plants would get around many of the limitations of Bt**

**insecticides. Insects that had once hidden from Bt sprays would find the Bt toxins in**

**whatever part of the plant they bit into, and sunlight or rain would not affect the**

**persistence or potency of the toxins. Genetic engineers also could transfer genes for**

**several different proteins, so that plants would be protected from several different**

**predators.**

**For centuries, farmers have made improvements to crop plants through selective breeding**

**and hybridization, the controlled pollination of plants. Plant biotechnology is an extension**

**of this traditional plant breeding with one very important difference, plant biotechnology**

**allows for the transfer of a greater variety of genetic information in a more precise,**

**controlled manner.**

**Unlike traditional plant breeding, which involves the crossing of hundreds or thousands of**

**genes, plant biotechnology allows for the transfer of only one or a few desirable genes.**

**This more precise science allows plant breeders to develop crops with specific beneficial**

**traits and without undesirable traits, such as those that would reduce crop yields.**

**Many of these beneficial traits in new plant varieties fight plant pests, insects, disease and**

**weeds, that can be devastating to crops. Others provide quality improvements, such as**

**tastier fruits and vegetables. An example of processing advantages, are tomatoes with**

**higher meat content. Other improvements are nutritional enhancements, such as oil seeds**

**that produce oils with lower saturated fat content. Crop improvements like these can help**

**provide an abundant, healthful food supply and protect our environment for future**

**generations.**

***Insect Protection***

**Anyone who has planted a backyard garden is familiar with the potential devastation**

**caused by insect pests. Farmers also face these problems, but on a much larger scale.**

**Bacillus thuringiensis (B.t.), a naturally occurring bacterium present in soil, is known for**

**its ability to control insect pests. Different strains of B.t. control different pests. First**

**discovered in 1901, gardeners have been using B.t. for decades as a biological insecticide**

**spray. B.t. produces a protein that disrupts the digestive system of targeted insects, while**

**remaining harmless to other insects, people, birds and other animals.**

**Now through biotechnology, researchers are introducing the B.t. gene into plants, which**

**allows the plants to protect themselves from certain insect pests. For example,**

**Monsanto’s NewLeaf potato plants are protected from the Colorado potato beetle. They**

**have also developed cotton with the Bollgard gene that protects the crop from the tobacco**

**budworm, cotton bollworm, and pink bollworm. YieldGard corn, which is protected from**

**the European corn borer, is also produced by Monsanto. These products give today’s**

**farmers an alternative to chemical insecticides normally needed to control these pests.**

**When farmers decrease chemical insecticide use, beneficial insects can survive to help**

**control other harmful insects.**

***Disease Protection***

**Plant disease, including fungal and viral diseases, can devastate the yield and quality of**

**crop production. To minimize the economic loss resulting from plant disease, farmers**

**often must plant more acreage than they expect to harvest. This extra acreage increases**

**farmers’ planting, fuel, water and fertilizer expenses, which must be passed on to the**

**consumer.**

**Not all farmers can afford the costs of these traditional methods of disease control. The**

**expense of chemical insecticides is prohibitive in many parts of the world, such as parts of**

**Africa, where, for example, the feathery mottle virus can destroy up to 80 percent of**

**farmers’ sweet potato harvests.**

**Biotechnology makes possible the development of crops protected from certain types of**

**plant viruses. By introducing a small part of the DNA from a virus into the genetic**

**makeup of a plant, researchers have developed crops that have built-in immunity to**

**targeted diseases.**

**Disease-protected crops offer agricultural, economic and environmental benefits to**

**farmers. Farmers will be less dependent on chemical insecticides used to control insects**

**that carry viral disease, and they will be able to protect their crop yields. Farmers can**

**reduce resources used, such as the expense of labor, fuel, pesticides, seed and equipment**

**used to plant "extra" acres.**

***Weed Control***

**Farmers have battled weeds since the beginning of farming. Weeds not only compete with**

**crops for water, nutrients, sunlight and space, but also harbor insect and disease pests;**

**clog irrigation and drainage systems; undermine crop quality; and deposit weed seeds into**

**crop harvests.**

**Farmers can fight weeds with tillage, herbicides or, typically, a combination of these**

**techniques. Unfortunately, tillage leaves valuable topsoil exposed to wind and water**

**erosion, a serious long-term consequence for the environment.**

**Herbicide-tolerant crops offer farmers a vital tool in fighting weeds and are compatible**

**with reduced-tillage methods, which help preserve topsoil. Herbicide-tolerant crops give**

**farmers the flexibility to apply herbicides only when needed, to reduce total herbicide use**

**and to use herbicides with preferred environmental characteristics.**

**Monsanto researchers have developed herbicide-tolerant crops, such as oilseed canola,**

**corn, cotton, and soybean, that can tolerate Roundup herbicide, known for its favorable**

**environmental characteristics. Roundup effectively controls a broad range of grasses and**

**broadleaf weeds by inhibiting an enzyme essential to plants’ growth. In other words,**

**Roundup inhibits growth by establishing a roadblock in plants’ metabolic pathways. The**

**gene inserted into these herbicide-tolerant crops, known as Roundup Ready crops,**

**increases the enzyme in the plants, providing a detour around the roadblock. This detour**

**makes it possible for Roundup Ready crops to thrive even after Roundup is used over the**

**top of the growing crop to control weeds.**

**Roundup is desirable from an environmental and safety perspective because it binds**

**tightly to soil particles and quickly breaks down in the soil into naturally occurring**

**components, such as carbon dioxide.**

***Other Crop Improvements***

**By introducing a gene or genes into a crop plant, many other advantageous features may**

**be possible. Such as a genetic trait that controls the ripening of tomatoes, peppers and**

**tropical fruits. This trait allows time to ship crops long distances and results in tastier**

**foods far from crops’ native regions.**

**Potatoes and tomatoes  have been developed with higher solids content. This trait offers**

**decreased processing costs because less energy is needed to extract water when**

**producing potato and tomato products. The higher solids content of potatoes holds the**

**potential to bring consumers lower fat French fries. Because oil replaces water during the**

**frying process, potatoes with higher solids content (and less water) absorb less oil.**

**Corn and soybeans with increased essential amino acid content ,the building blocks of**

**protein have been produced. This trait can improve the quality of protein in food products**

**and animal feed made from these crops.**

**Other advancements include, naturally decaffeinated coffee, corn and peas that retain**

**their natural sweetness, and crops with modified fatty acid content, allowing for the**

**production of more healthful oils.**