

A third area of animal biotechnology, transgenic animals, crosses over into medical biotechnology. Transgenic animals contained foreign genes in their genome. These animals are created by a process of taking fertilized eggs, injecting the eggs with donor DNA, and then implanting the eggs into the uterus of receptive females. The offspring are screened for their ability to express the donor DNA. Those that can, generally contain the donor gene in all of their cells, including their germ cells. These transgenic animals can pass the new trait on to their offspring, thereby creating a new animal variety. Transgenic mice engineered to express human genetic disorders, such as Alzheimers, are powerful (and highly valuable) research tools. Several commercial firms have produced transgenic sheep which produce valuable human biotherapeutic proteins in their milk. Sheep have certain advantages over microorganisms and mammalian cells because their milk is produced cheaply, in large quantities and with few contaminating proteins. The use of milk animals as bioreactors is termed pharming.

Plants. As with animals, plant breeding has been revolutionized by biotechnology. Plant breeders are using genomic analysis methodologies to identify individual plants with superior genes. Plant molecular biologists are using these same techniques to identify genes responsible for agronomically valuable traits, such as disease resistance, stress resistance, nutritional quality, and oil composition. Other research areas impacting plant health is biopesticides and seed inoculants, containing genetically engineered microorganisms, such as the nitrogen-fixing bacteria species, *Rhizobium*.

However, the real revolution in plant biotechnology has come about by the invention of gene transfer technologies, of which there are two basic types; biological and mechanical. Some dicots, notably canola and tobacco, can receive DNA into their nuclei by a pathogenic bacterium, *Agrobacterium tumefaciens*. This natural process leads to a cancerous growth, or gall. Removal of the "gall" genes from *Agrobacterium* maintains the DNA transfer properties of *Agrobacterium*, without the negative plant growth effects. These disarmed *Agrobacterium* strains are used as vectors to deliver genes to plants cells. For plant species which are not infected by *Agrobacterium*, notably all cereals, donor DNA is injected mechanically into nuclei. The preferred method is biolistics which involves "shooting" mircobeads of DNA coated tungsten into plant nuclei with a particle gun. The target tissues are somatic cells which have the ability to regenerate into complete, fertile plants.

Plant transformation is now possible for all the major agricultural and horticultural species. Today, there are numerous commercial transgenic crops, including insect resistant cotton, corn, potato; virus resistant squash; herbicide tolerant soybean; and several flavored-enhanced tomatoes. The type of plants that can be created are only limited by one's imagination!

Biomass Utilization. Biomass is raw biological material, either in unprocessed form (grains, silage, trees) or in processed form (corn steepwater, paper pulp effluent, or whey). Biomass is not only a source of valuable biomolecules (starch, protein, oil, etc.), but is also an excellent feedstock for microorganisms, especially those engineered to produce valuable molecules. Biotechnology allows the development of new strains and processes for the production of novel enzymes with new catalytic properties. Genetically engineered enzymes are being designed to function under extreme conditions and to catalysis chemical transformations, previously possible only by organic catalysts. Engineered enzymes have many advantages over