Industrial uses for Genetically Engineered Organisms

In a market economy, industry searches for methods to make its products cheaper, easier to build and less labor intensive. Genetic engineering has the capability to create or modify organisms with the transferring, changing or inserting of DNA. When combined, these two fields are capable of developing genetically engineered industrial organisms which are efficient, are made to exhibit specific properties and are developed for specific uses.

Genetic Engineering allows the possibility of changing an organism to be more efficient. Positive results from these changes are ability to turn on and off processes, ability to control dangerous resultant organisms and better use of existing materials. A few dangers of genetic engineering are unwanted changes and inadequate genetic adaptation.

Genetic switching can be accomplished by preventing the production of certain proteins. This ability to switch processes on or off allows less overhead for unwanted or useless activities. "Molecular switches may also prove useful in cases where some secondary metabolites produced in desired large quantities may poison the producing bacteria... We could grow a giant colony of microorganisims, then use the molecular switch to obtain a large amount of end-product by the time the colony died... it would not matter that they used up so much energy that they could not produce a viable amount of their own proteins" (Sylvester, p.172).

Better uses of existing materials and animals can be developed with engineering of DNA. Bovine somatotropin allows milk producers to increase efficiency of a cow's milk production. "BST.. when injected or implanted into cows can increase milk yield up to 25 percent... It achieves this in two ways: by increasing the cow's appetite.. and then by causing the cow to divert a greater proportion.. into milk" (Tudge, p. 235). The use of BST is a simple and effective method of increasing the milk versus animal ratio without engineering new cows.

Controlling dangerous creatures is made easier with genetics. Because of the efficiency of some new organisms, genetic methods to prevent overthrow of native species need to be developed. "Introduction of sterile as opposed to reproductively fertile fish into a natural environment is clearly preferable to introducing animals with reproductive potential"(Rollins, p. 130). With many laboratory animals, genetic omissions prevent the ability to survive in the outside world. "...one scientist predicted, 'We'll someday need... to protect our strains from being killed off by a hostile outside world that might get in here... ' "(Sylvester, p. 144).

Unwanted changes in the results of gene modification presents both a technical and ethical problem. Technical challenges to prevent occurrences of unwanted changes would depend on 'guess and test' or extremely difficult genetic understanding of all possible effects. For example, "eland antelope from Africa have often been tamed for draft and milk, and show tremendous promise to replace cattle in arid countries because they have a quite extraordinary ability to survive drought. However, as soon as eland are husbanded – kept under control – many of their advantages disappear. ...Under these circumstances, they do not outperform conventional cattle quite so convincingly.... once restraints are imposed upon them, their excellent qualities can be compromised" (Tudge, p. 241). In the effort of optimization, engineers must be aware that the organism may not be easily optimized without serious changes. Ethical difficulties with specialized organisms must be determined to prevent changes that might adversely affect other organisms or to prevent extremely unnecessary harm to the test organism.

> "The 'worst case' scenario for [rDNA] would play itself out as a true nightmare: A research scientist inserts the genes that produce the deadly botulin toxin into a colony of E. coli. A few bacteria accept the gene, so they now produce the poison of botulism. ..There is an accident... and some of the deadly E. coli infect the researcher... Unfortunately, the deadly E. coli are very good survivors; they spread through the city, over the countryside... in an epidemic unmatched in history" (Sylvester, p. 138).

Although unlikely with today's containment laboratories, no decent and ethical scientist would want to be remembered as the one who 'let the critter go wild'. Efficencies however large or small, while a tempting target, may not be worth the consequences due to unwanted changes.

Inadequate genetic adaptation of engineered animals could cause problems with disease resistance or slow genetic improvement. With some short lifespan organisms, traditional genetic selection is faster and easier. "..the poultry industry is in fact reluctant to employ genetic engineering, for in the time it takes to introduce a new gene construct... the industry can make vast progress in efficiency by traditional breeding" (Rollin, p. 113). When using BST, the dairy cows do produce more milk at the expense of other problems which might reduce the advantages in normal cows. "But extra production implies extra strain which, in some animals at least, has led to increased udder infection... This can be overcome by better husbandry, but on real, modern, cut-to-the-bone economy farms this often is not possible" (Tudge, p. 236).

Properties of materials can be modified and optimized through the use of genetics. Changing characteristics such as strength and heat resistance can create new and better uses for materials in current use.

Cellulose in plants is responsible for their stiffness. "But for all the industrial uses of cellulose, nobody knew how plants make it. Now, Richard Williamson and colleagues at Australian National University report... that a gene called RSW1 synthesizes the enzyme responsible for cellulose production."(Important cellulose gene). These super-strong plants would be useful in agricultural plants such as wheat and corn. "Altering the cellulose ratio in trees, for example, could yield stronger timber or trees that are more easily processed into paper"(Important cellulose gene). Super strong fibers would have immediate uses in house construction and clothing industries. The aviation industry, especially with smaller companies and individuals, might return to the use of wood and natural fibers for certain aircraft applications.

The creation of heat resistant organisms is useful to the development of industrial processes. One example of the use of these organisms is the PCR machine. "The DNA is heated to split it into single strands... The mixture is cooled slightly and polymerase is added, which then builds a complementary strand of DNA... this is all very tedious... Then scientists began to take a serious interest in the thermophilic... bacteria that live, miraculously, in the near-boiling water of hot springs. ...they survive the surges of heat needed to separate the DNA strands" (Tudge, p 259). On the cold side, "Insect hysteresis proteins, fish antifreeze proteins, and bacterial ice nucleation proteins have either the potential to reduce or increase freezing. ...Ice nucleation protein has already been successfully applied in increasing frost resistance of tomato root tissue" (Basra, p.450). Organisms with the ability to survive in industrial settings will become necessary to allow a steady-state process with few catalyst-organism replacements.

The major advantage of genetic engineering is the ability to manufacture specific-use organisms. With these organisms, dangerous situations or monotonous work can be controlled or performed easier. Nitrogen fixing, heavy metal cleaning and synthesis of chemicals are examples of specific-use genetically engineered organisms.

The dependency of plants on nitrogen and the abundance of nitrogen on earth presents a problem of how to change nitrogen from one state to another. "...the plants must absorb the nitrate before it is washed away in the soil water, or acted upon by other bacteria that convert it into oxides of nitrogen, in which form it disappears into the atmosphere. ...any nitrate left in the soil... is liable to be washed away... and thus to pollute the ground water" (Tudge, p. 230). The method of converting nitrogen in the atmosphere to nitrates falls mainly on the bacteria Rhizobium, whose genes make the proteins required for nitrogen fixation (Basra, p.74).

Because of the abundance of nitrogen, any nitrogen fixing plant is unlikely to absorb all of the local nitrogen. "the new nitrogen-fixing plants would not achieve "rampant colonization" because, although they would solve their own nitrogen problems, they would soon run out of something else. ...An "escaped" nitrogen fixing plant might not smother the entire world, but it could (and probably would) invade a delicate ecosystem" (Tudge, p. 344). If any of these new plants did escape and were not affected by other factors, most native plants would be forced to become more competitive or specialized.

Engineering plants to absorb heavy metals would greatly aid in cleaning contaminated sites without extra and continuous human work. The plants must be able to absorb the contamination without being fatally affected. "Chlorophyll biosynthesis, photosynthetic electron transport, and photorespiration are all highly sensitive to increased heavy metal concentrations" (Basra, p.447). The only problems would be the amount of contaminated plant mass produced. In spite of these problems, this method of absorption of contamination would be easy, cheap and low maintaince, once developed.

Synthesis, with the help of engineered catalysis organisms, would decrease the cost and increase the availability of chemicals. The use of microbes in industry is not new; however, the ability to engineer microbes to certain specifications is new. During the First World War,"[The] Prime Minister of Britain... asked the young Chaim Weizmann to find a way to increase output of acetone, vital for the production of explosive. Within a few weeks Weizmann showed that strains of Aspergillus would produce acetone in endless quantity" (Tudge, p. 214). These methods of synthesis are not always practical. Also, alcohol is useful as a fuel, industrial chemical and entertainment liquid. Synthesis with engineered microbes could cut the cost "to 10 cents per gallon of alcohol" (Sylvester, p. 17). One of the limiting factors is availability of base materials needed by the engineered microbes. "It has been estimated... that to run only 20the country's entire corn crop in a record year into alcohol... And there are other, technical problems as well" (Sylvester, p. 18).

Genetically engineering organisms makes possible the creation of efficient, property optimized and specific-use organisms for industrial use. With a critical look at possible consequences and problems, genetic engineering should be able to produce better organisms and methods for manufacturing and industry.

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