
JUMPING ON THE GENE WAGON

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Biotechnology potentially presents the third industrial revolution. Discovery of DNA composition holds unlimited gene transfer possibilities. Genes, the basis of inheritance, can be modified leading to mutation. Genetic engineering is beneficial to the petrochemical, medical and agricultural fields. Larger companies acquire smaller companies to save on R&D costs. Genetically engineered food and crops could replace pesticides and medicine. Consumer resistance to genetic engineering is the biggest risk factor. SA government released a strategy document relaying their action plans. Volatility in industry presents an insecure future with public opinion catalytic to success.

Classification:**Subject field:** Strategic management**Type of business:** Private company**Industry sector:** Biotechnology**Theme:** The implications of biotechnology on the business environment**Core aspects:**

- Genetic engineering allows scientists, businesses and governments to manipulate the natural world at the genetic level. It allows them to transfer genes between totally unrelated species and across all biological boundaries creating improved (but genetically altered) products.
- Biotechnology companies are experiencing wide consumer fears, combined with a new business environment where they must reconsider their business, financial as well as merger and acquisition strategies.
- Biotechnology companies must also make large research and development investments with uncertain returns and they must enter into complex partnerships and affiliations.
- Biotechnology faces demanding challenges, but the benefits of biotechnology cannot be ignored.

Aspects for discussion:

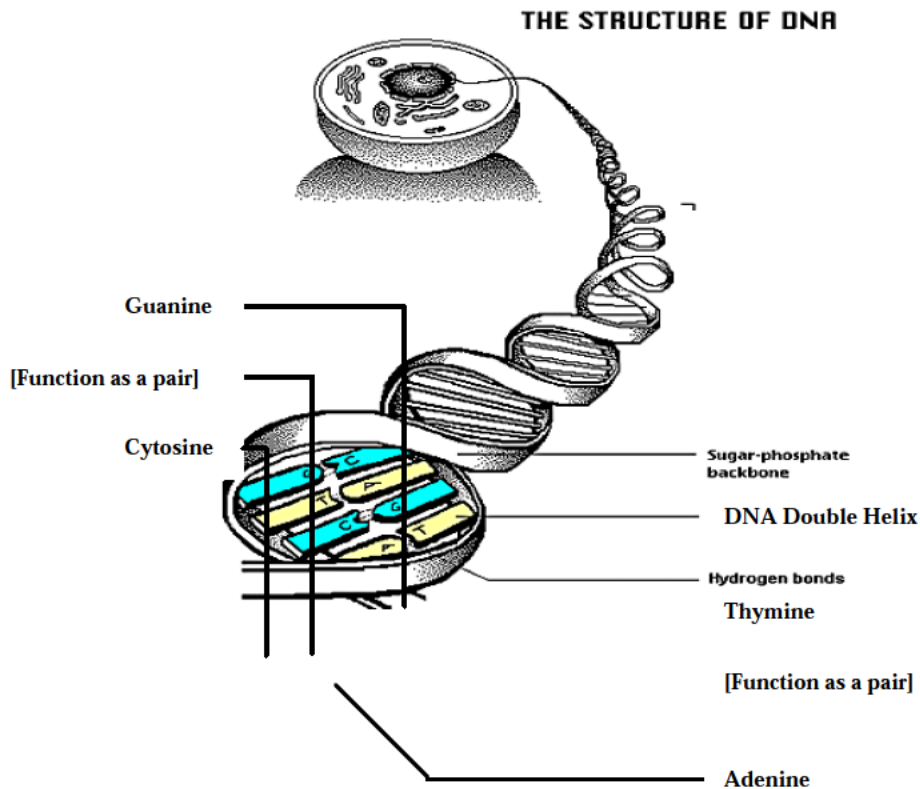
- The extent to which management practices influence the future of biotechnology.
- The type of strategies for biotechnology organisations.
- The type of strategies for biotechnology organisations to ensure consumer acceptance.
- Ethical and environmental considerations of biotechnology
- Genetic engineering present business growth opportunities
- Consumer apprehension and resistance poses the primary threat to the commercialisation of genetic engineering
- Biotechnology is depicted as having significant life/industry altering potential
GE presents a threat for some industries of becoming obsolete if they continue in the traditional manner

Time allocation:**Participant preparation:** 30 minutes**Class discussion:** up to 4 - 5 hours

The development of biotechnology

1. The first Industrial Revolution (1700 – 1850) arose from the application of new resources of energy to the mass production of goods. The second Industrial Revolution (1875 – 1905) developed from the extension of information theory to industrial processes. Both these revolutions produced social and political upheavals with concomitant changes on all levels of the physical world. Biotechnology could be the beginning of the third Industrial Revolution, but this revolution will be different from the previous two as it is concerned with the biological world, including humans.
2. Crops and animals have been selectively bred for centuries to produce novel strains of use to humans, but conventional breeding is a very slow process and is also limited to those organisms that could be “*gender-crossed*”. In the 1950s James Watson and Francis Crick discovered the molecular structure of Deoxyribonucleic Acid (DNA). Their discovery opened the door to biotechnology (genetic engineering). Genetic engineering deals directly with modifying the genetic composition that determines the structure of all organisms, but without the limitations of conventional breeding. Genetic engineering allows for the transfer of genes directly and immediately to totally unrelated species, for example between humans and bacteria.
3. Genes are the basic units of inheritance - it consists of specific lengths of interlocking double stranded DNA, and consists of only four different nucleotides, which is adenine (abbreviated as A), cytosine (C), guanine (G), and thymine (T) (Figure 1). The DNA molecule is held together with the different nucleotides, which function in pairs as chains between the DNA's double helix (resembling a spiral staircase). The particular gene codes function as the blueprint for the production of a particular protein or part of a protein. These proteins could manage embryonic development; other proteins function as enzymes (catalysts which control the cellular metabolic reactions) and others become part of the body structure. The visible appearances of the actions of genes are called traits. The *trait* may be one gene or a combination of many genes. A good example of a genetic trait is the colour of the eyes. Whenever the DNA (comprising of genes) undergo a structural change or modification, the gene codes are modified to be compatible to the altered protein, which is referred to as *mutation*. The structure of the DNA is shown in figure 1

Figure 1 **Representative of the DNA double helix**



The possibilities of genetic engineering

4. Genetic engineering creates the possibility to design organisms to a specification for carrying out industrial processes, for example, placing enzymes in petrol and diesel engines to monitor the exhaust gases and send the data, regarding the degree of pollution, to a microprocessor that will adjust the engine to rectify the pollution; also to use microbes to gather valuable trace metals from the ocean water.
5. However, to put the use of genetic engineering in perspective, the most successful commercial applications of genetic engineering involves presently the diagnosis and treatment of diseases, and the development of agricultural products with improved attributes.

6. In the agricultural industry there have been 4,600 genetic modifications recorded of organisms field-tested. This includes 9 modifications on carrots, 11 on apples and numerous modifications on tomatoes.
7. In the pharmaceutical industry drugs like insulin (for diabetics) and tissue plasminogen activator (for heart attack victims), as well as animal growth hormones like bovine, are being produced by bacteria that have received the appropriate human, cow, or pig gene.
8. Crops and medicine are not the only areas where genetic manipulation have been evident; scientists have been attempting to clone sheep for 20 years to guarantee sheep that are robust and reliable to ensure a vibrant and long-living herd. Dolly, the first genetically cloned sheep, appeared in Roslin, Scotland in July 1996 as a perfect copy of another sheep.

The challenges facing the biotechnology industry

9. Genetic engineering allows scientists, businesses and governments to manipulate the natural world at the genetic level. It allows them to transfer genes between totally unrelated species and across all biological boundaries – plant, animal, and human – creating new life forms. Companies are jumping on the “*gene wagon*” for commercial success through clone propagation, mass-producing countless replicas of their creations and releasing this into nature.
10. In the continuously changing business environment genetically engineered foods will bring new challenges and opportunities to the micro-, market-, and macro-environments of business. The major players in the industry, Monsanto and DuPont, are finding that operating within the biotechnology industry presents numerous difficult challenges. Biotechnology companies must redesign their business, financial and Merger & Acquisition (M&A) strategies and make large Research & Development (R&D) investments with uncertain returns. On a corporate level, biotechnology organisations must enter into complex partnerships and affiliations and in the market environment biotechnology organisations must contend with negative consumer attitudes toward genetically engineered products.
11. Biotechnology organisations rely heavily on R&D for success. The R&D strategies of biotechnology organisations require large capital spending to thoroughly develop and test any potential new product. Uncertainty and expense

usually accompany the R&D programs. R&D programs do not guarantee success, and coupled with a large capital outlay, the biotechnology organisations are facing a demanding challenge. The R&D strategy should also be in-line with the organisation's strategy. The M&A strategy of a biotechnology organisation also serves as a powerful method of R&D. Smaller, research based, biotechnology organisations are being acquired by the large biotechnology organisations for the valuable R&D that they have done. However, not only biotechnology organisations are interested.

12. Pharmaceutical and chemical companies are also acquiring the smaller biotechnology organisations. Genetically engineered seeds constitute a direct threat to chemical companies. Seeds can be genetically engineered to resist pests and diseases, which could mean that chemical companies are becoming redundant. Farmers will be able to reduce their dependency on expensive chemicals and reduce the negative impact these chemicals usually have on the environment.
13. Just as crops can be designed to have higher nutritional value, they can also be designed to have higher medicinal value. Broccoli, for instance, is known to have anti-neoplastic characteristics (to stimulate the body's defences against cancer). Some biotechnology organisations are currently researching the characteristics of a wild Italian broccoli, which appears to be 100 times more effective in building up cancer defences, to engineer these into commercial varieties.
14. The benefits of genetic engineering are also evident to pharmaceutical companies, which is the reason why Novartis, Schering-Plough and Zeneca are also attempting to acquire biotechnology companies.
15. The benefits of biotechnology are being recorded all around the world. Table 2 represents some of the most recent advances in biotechnology around the world.
16. Regardless of the considerable progress in gene technology, the concerns of consumers are one of the biggest challenges facing biotechnology organisations. Consumer fears are particularly strong in Europe, where a series of food scares, ranging from mad cow disease to contaminated Coke, have undermined consumer's trust in the European regulatory authorities. While 90% of Americans believe the US Department of Agriculture statements on biotechnology, only 12% of Europeans trust their national regulators.

Table 2 Recent biotechnology advances around the world

Indonesia	Farmers are reporting a productivity increase in cotton production. The genetically modified cotton averages 2.2 million kilograms per hectare, compared with 500 kg using conventional varieties.
Kenia	The first harvest of genetically engineered sweet potatoes achieved a resistance to the feathery mottle virus which was devastating to farmers, destroying up to 80% of a crop.
Hawaii	The annual papaya production fell in the span of four years from 1993 to 1997 from 58 million pounds to 26 million pounds, thanks to the papaya ringspot virus. In 1998 a new genetically engineered papaya was introduced which brought the production level back to 53 million pounds by 2001.
Australia	Biotechnology allowed a 50% reduction in the number of chemical sprays on cotton in Australia. Australia is also expecting that the second variety of genetically modified cotton will reduce the number of chemical sprays by as much as 90%.
Scotland	Dutch elm disease has destroyed more than 20 million trees across Britian in the past 30 years. Scottish scientists have developed a genetically modified English elm tree that are resistant to fungus. The elm trees have been cultivated under strict laboratory conditions and have not been introduced into the environment. Scientists are waiting for approval to release the genetically modified elm into the environment to resist the destructive Dutch elm disease.
China	In 1998 Eastern China faced an outbreak of bollworm that threatened their cotton crops. In 2000 farmers started to grow cotton genetically enhanced to resist these pests. The cotton has saved in labour and reduced the need for pesticides, as well as minimising the risk of poisoning.
France	French scientists have developed a genetically modified potato that produces 19 times the normal amount of fructose, a key ingredient in soft drinks and sweeteners.

17. Many European companies like Nestlé, Danone, Marks & Spencer and Unilever are responding to the consumer concerns by marketing products free from any genetic modification, but stating that biotechnology does have significant benefits. The concern of consumers (Table 3), which also represents some of the possible disadvantages of biotechnology are mainly found in religion, environmental impact, animal welfare, safety, guidelines, need, fairness, patenting and labelling.
18. The actions of biotechnology organisations contribute to a large extent to the future of the biotechnology industry. Top management policies and the way consumer concerns are managed by biotechnology organisations, are shaping the biotechnology industry for future success or failure.

Table 3 The main consumer concerns and possible disadvantages of biotechnology

Religion	For example pig genes in genetically engineered food consumed by people from the Muslim faith.
Environmental impact	For example herbicide-resistant genes could “ <i>transfer</i> ” from transgenic crops to other wild or domesticated species, producing “ <i>super-weeds</i> ” that would resist conventional control methods.
Animal welfare	For example livestock and poultry consume large amounts of corn and soybeans, commodities that are likely to be genetically modified, the prospect of antibiotic resistance might be a possibility.
Safety & guidelines	Whether safety programs that provide guidelines and are responsible for advice on composition, chemical safety, toxicological issues, environmental issues and ethics need to be established to control the safety of genetically engineered products.

Need & fairness	For example, does a need exist to increase the milk production (i.e. the use of the hormone BST) which may put some dairy farmers out of business because of a over supply of milk and, is it fair to the farmers of third world countries that might not have access to BST hormones to increase milk production.
Patenting	Organisations argue that patenting is necessary to reap the rewards of the research, and to fund further research, however, from a religious perspective the patenting of life forms may be forbidden, for example Judaism forbids the ownership of life.
Labelling	The question emerges: Should genetically engineered products be labelled if the product contains a copy of a gene derived from a human; a plant that contains a gene derived from an animal; or contain animal genes which is subject to religious dietary restrictions.

The South African situation

19. Compared to the United States, South Africa has failed to extract value from the more recent advances in biotechnology. Biotechnology can make an important contribution to the national priorities of South Africa, particularly in the area of human health (including HIV/AIDS), food security and environmental sustainability.
20. The South African biotechnology strategy, released by the Department of Arts, Culture, Science and Technology in June 2001, includes the creation of regional innovation centres (RIC) to act as nuclei for the development of biotechnology platforms, from which a range of businesses offering new products and services can be developed. The RICs will be required to work in close collaboration with academia and business in order for the centres to become active nodes for the growth of the biotechnology sector.
21. Using both existing funds and new allocations specifically designated for biotechnology, and employing well-trained scientists, engineers and technologists in a multi-disciplinary environment, the centres will stimulate the creation of new intellectual property. The successful protection and exploitation of intellectual property will be made possible by a new venture capital fund and an array of new and existing support structures.

The future of biotechnology

22. If the current business situation persists, wherein changes take place, biotechnology might become one of the largest industries. But, biotechnology is still far from that point. Mergers, acquisitions and partnerships will continue to alter the structure of the industry. The actions executives take now, both in shaping their businesses and in shaping public opinion, will go a long way toward determining the ultimate role their companies play in the biotechnology industry.

Example questions for discussion

1. What strategy should be proposed for an upstart company entering the biotechnology industry?
2. Discuss the strategic importance of R&D for a biotechnology company.
3. Discuss the importance of M&A strategies for a biotechnology company.
4. How should a biotechnology company address negative consumer attitudes towards genetic engineering?
5. What safeguards should be addressed by a biotechnology company to ensure their products do not have a negative effect on the environment?
6. What elements should be in any biotechnology company's vision and mission?
7. To what extent will the current management practices influence the future of the biotechnology industry?
8. Discuss the ethical and moral considerations concerning genetically engineered foods.
9. What strategy should South Africa follow to ensure commercial success in the biotechnology industry?
10. Discuss the benefits and risks of biotechnology on the business environment.

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11. It is stated that given the high cost of R&D larger companies acquire smaller companies. This does not make business sense. Discuss why acquisition of smaller companies is of strategic value rather than a cost saving exercise.
 12. Discuss how the chemical industry could turn the advancement of genetic engineering into an opportunity rather than a threat.
 13. You are the public relations consultant for the company that have bought the "Dolly Cloning rights". The company will be going in to mass production. With consideration of the consumer reservations listed in case produce a public positioning paper allaying consumer fears
 14. Can SA become a player in the Biotechnology game? Advise government on the matter with consideration of the strategic importance of participation
 15. Mergers and Acquisitions are redefining the shape of the industry. As a UN representative on the subject of GE suggest and recommend methods for stabilising industry dynamics and preventing monopolistic GE empires

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