A STUDY IN LONG-TERM TECHNOLOGY STRATEGY
AT AN AMERICAN CHEMICAL COMPANY

by

Osamu Nakagawa

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The University of Tokyo, Japan, 1989

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Signature of Author: ____________________________________________

Alfred P. Sloan School of Management
May 8, 2000

Certified by: ______________________________________________________

Lester C. Thurow, Thesis Supervisor
Jerome and Dorothy Lemelson Professor of Management and Economics

Accepted by: _____________________________________________________

Toby W. Woll
Director, The MIT Sloan Fellows Program
A Study in Long-term Technology Strategy
at an American Chemical Company

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Osamu Nakagawa

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ABSTRACT

In the mid of its nearly 200 years history, E. I. du Pont de Nemours and Company (Du Pont) made a transformation from a gun powder company to a diversified chemical company with intensive R&D capability. Now the company is making another major change into a company with integration of biotechnology and chemistry.

This thesis analyzed Du Pont's long-term technology strategy. The company is going to make a strong commitment in development of biotechnology as well as integration of biotechnology and chemistry. The company will utilize existing materials businesses as a cash source.

The thesis concludes that the company should keep its strategy. However, considering that Du Pont was relatively late to have made commitment in biotechnology, the company will have a tough time. Also, the fact that Du Pont has strong capability in scientific research could arise an organizational issue.

Thesis Supervisor: Lester C. Thurow
Title: Jerome and Dorothy Lemelson Professor of Management and Economics
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Chapter 1. Prologue

On the face of its 1999 annual report, E. I. du Pont de Nemours and Company (Du Pont) put a “To Do List,” which declares Du Pont would achieve sustainable growth and increase shareholder value through:

a) Integrated science (modern biology + world-class chemistry),

b) Knowledge-intensive products and businesses, and

c) Productivity gains using six sigma.

The annual report further explains that:

a) Integration of biotechnology and chemistry is applicable to several business areas such as food, feed, agriculture, health care, wellness, materials, sensors and electronics. Examples include improvement of soy’s taste and digestibility, bio-based polymer Sorona™, anti-hypertensive drug Cozaar®, and anti-HIV drug Sustiva™. In order to promote agility in developing bio-based materials and bio-based processes, the company also formulated 5 years research alliance with MIT.

b) Knowledge intensity is a term the company created to describe how it generates value from its intellectual capital. Du Pont puts emphasis on scientific strengths that the company has built through the whole twentieth century and it has a strong confidence in applying its knowledge intensity both to its traditional businesses and to new businesses along new economic models. The company also claims that going into e-commerce is the biggest near-term payoff from its knowledge intensity.
c) Productivity gains through six sigma will be applied not only to manufacturing processes but also to distribution, sales, finance, and R&D activities.

At the turn of the century, Du Pont is also making a step into the third centenary of the company’s history. The company was founded in 1802, spent its first centenary as a gun powder manufacturer, its second centenary as a petrochemical superpower with a strong capability in science and R&D activities. Now the company seems to shift into an integrated business domain of chemistry and biotechnology.

We were interested in how an existing large manufacturer of materials with a reputable scientific capacity and established strong brand names can transform itself and steer into a new business area. This thesis analyzes Du Pont’s long-term strategy and attempts to predict if the company will be successful as it declares in the 1999 annual report.
Chapter 2. Brief History of Du Pont

Du Pont is one of the oldest continuously operating industrial enterprises in the world.

1. A Gun Powder Company

The company was established in 1802 near Wilmington, Delaware, by a French immigrant, Eleuthère Irénée du Pont de Nemours, to produce black powder. E. I. du Pont had been a student of Antoine Lavoisier, the father of modern chemistry, and he brought to America some new ideas about the manufacture of consistently reliable gun and blasting powder. His product ignited when it was supposed to, in a manner consistent with expectations. This was greatly appreciated by the citizens of the fledgling republic, and many heroes of early America owed their success, and their lives, to the dependable quality of Du Pont's first product.

2. A Diversified Chemical Company

At the beginning of twentieth century, the first transformation of the company began when the company lost its competitive advantage in gunpowder to burgeoning competition. Shareholders voted to sell the assets to the highest bidder, but three great-grandsons of the founder—Thomas Coleman du Pont, Alfred I. du Pont, and Pierre Samuel du Pont—offered to buy and operate the firm, issuing notes and stock in a new corporation. The offer was accepted and in 1902 the company was restructured to look for new business and create new products through research. Du Pont's research organization dates to this time, with the foundation of the Eastern Laboratory in New Jersey. Eastern was one of the first industrial research laboratories in the United States.
Construction of the Experimental Station, just outside Wilmington, Delaware, quickly followed. The Experimental Station originally had responsibility for process research but, by 1909, had expanded into new fields such as the investigation of synthetic fibers. This period marked the beginning of Du Pont's transition from an explosives manufacturer to a diversified, chemical company.

Toward the end of the 1920s the next important breakthrough for the company came as a result of fundamental rather than applied research. The company included in the budget for 1927 an item of $20,000 to cover what may be called pure science or fundamental research work, to establish or discover new scientific facts. Soon after that, the research group under this budget had developed an understanding of condensation polymerization and the structure of condensation polymers. This led to the invention and commercialization of nylon in 1938—the beginning of the modern materials revolution.

Many synthetic materials have been developed by Du Pont research after that, forming the basis for many global businesses and products including household names such as Teflon® fluoropolymer resins and Kevlar® brand fiber, Nomex® brand fiber and paper, Lycra® spandex fiber, Tyvek® spunbonded olefin, Cordura® nylon fiber.

Du Pont research has been aimed at developing materials and systems to help its customer companies achieve competitive advantage. In new product research, materials substitution remained an important interest. Just as Du Pont polymers replaced or augmented natural fibers in many applications, now more advanced polymer products
are beginning to replace or augment metal. One example is the development of a forced
Zytel® nylon composite with a special blend of tougheners and other additives that
offers a 50-60 percent weight reduction over a comparable metal part, such as
aluminum-made automotive air intake manifold.

In response to growing international competition in the 1970s and 1980s, the company
put more emphasis on marketing, and it sought growth through diversification. During
1980s, Du Pont invested more than $10 billion in over 50 acquisitions and joint ventures
in its diversification efforts. A major part of this investment was the purchase in 1981 of
Conoco, a fully integrated oil, gas, and coal company with operations around the world.
A driving force behind the international expansion of Du Pont in the last half of the
twentieth century has been the recognition that, to grow share in global markets, the
company needed to build facilities within those markets to serve local customers.

3. Technological Innovation Cycles within Du Pont

It is observed that there have been cyclical patterns of basic technological innovations
within Du Pont through most of the twentieth century. Since 1927, four cyclical periods,
each between 15 and 20 years in length, have been identified. Within each, the emphasis
shifts from a period of discovery, during which new products and related new
businesses are created and expanded, to a period of consolidation, during which core
manufacturing-based businesses are restructured to achieve efficiencies. (See Figure 1
and Table 1) These cyclical patterns have created and reinforced Du Pont’s strong
confidence in its R&D capability, with a notion of historic business model—“invent,
make and sell.” (See Figure 2)
(Figure 1) The Cycles and the R&D Focus in Each Period

Source: Miller, "The Re-Emergence of Discovery Research in DuPont"
(Table 1) Typical 17-year Cycle of R&D within Du Pont in the Twentieth Century

| Years 1-3 | There is dismay at a perceived shortage of good ideas. Studies are made of research to see if it can be made more productive. Various avenues for growth are explored. Employees in leadership positions have excellent skills in consolidation and cost control, but less experience in growing and developing new businesses. |
| Years 3-5 | New ideas, including some previously held in abeyance, are brought forward. Discovery research flourishes, and new acquisitions in technology-based businesses are made. The groundwork for new opportunities is laid. |
| Years 5-7 | Investments are made in the results of discovery research, and in new ventures and businesses. New venture managers learn to grow new businesses. |
| Years 7-9 | Concerns are expressed that not all developments can be funded and that some new ventures have become a financial drain. Those in leadership positions now have not had significant experience in making difficult cost-cutting decisions. |
| Years 9-12 | Funding is constrained for new developments. For R&D, the emphasis is on tailoring and improving current products and manufacturing processes. New venture managers find other assignments or leave the Company. Any new initiatives are conducted with very low profiles and funding is a significant challenge. Often outside funding is sought. |
| Years 12-15 | The emphasis continues on cost reduction and reorganization. Budgets are constrained, efforts focus on product quality, and some businesses are discontinued or sold. |
| Years 15-17 | While costs are carefully controlled and more efficient methods of carrying out all business activity are found, there is talk of the need to grow and to increase revenues. However, these objectives are difficult to carry out. |

Source: Miller, "The Re-Emergence of Discovery Research in DuPont"
(Figure 2) Du Pont Company Shaped by the Innovation Cycles

Materials and services to other industries
Fluorochemicals
Adipic acid
Sulfuric acid
Agricultural chemicals
Specialties
Gas
Oil
Coal
Ores

Materials from nature

Chemicals

Bulk materials
Engineering polymers
Packaging materials
Elastomers
Coatings
Fluoropolymers
White pigments

Shaped and active products
Fibers
Films
Sheets
Nonwoven fabrics
Photopolymers

Consumer products

Materials for recycle

Markets
Automotive
Construction
Home furnishings
Apparel
Packaging
Electronics
Aerospace
Printing

Source: Miller, "The Re-Emergence of Discovery Research in DuPont"
4. Entrance to Life Sciences

In 1980, Du Pont signaled to the business world that it would stake much of its future welfare on research and development in the biosciences. The company planned to increase the number of Life Science researchers from 630 to 1,730 in four years. The work would be roughly divided between plant-related and human-health-related sciences. To accommodate these researchers, a principal Life Sciences laboratory was opened in 1984.

Prior to this time, the company spent several decades on trials and errors in venturing into pharmaceuticals. As early as 1916, Du Pont included pharmaceuticals in its major diversification program. But the company’s attempt to internally generate and commercialize pharmaceutical products had almost always failed, mainly due to the lack of pharmaceutical marketing capability and lack of experience in dealing with the Food and Drug Administration (FDA). Du Pont had been successful only in some agricultural chemicals businesses.

Finally, in the late 1960s, the company concluded that acquisition of a “real” drug company was the only means by which it could become successful in pharmaceuticals. By this time, however, buying a pharmaceutical firm was difficult because the industry had become one of the most profitable and fastest growing areas of U.S. business.

In 1969, following a wide search for acquirable companies, Du Pont purchased Endo Laboratories, who manufactured an anticoagulant named Coumadin that captured 85 percent of the U.S. market. Endo had grown at a rate of almost 9 percent per year in the
previous ten years, compared to the industry’s average of 7.7 percent, and its sales in 1968 were about $20 million with earnings $3 million. Although Endo proved to be too small for Du Pont to achieve its growth objectives, the acquisition bolstered Du Pont’s commitment to becoming a player in pharmaceuticals and helped set the stage for the company’s major commitment to biosciences in the 1980s.

In the late 1970s, Du Pont realized the emerging technology field of recombinant DNA and this was the final drive for the company to declare its commitment to biosciences. It was predicted that the technology had numerous possible applications for drugs such as hormones, vaccines, antibiotics, as well as antiviral agents, superior plants that might fix their own nitrogen, new catalysts for the production of chemicals, and many other related uses.

In 1990, Du Pont agreed with Merck to form a 50-50 joint venture, Du Pont-Merck Pharmaceutical Company. It was one of a number of alliances and acquisitions Du Pont made to help drive growth in the bio-industrial, pharmaceutical, feed and food industries. In 1998, the company further agreed to buy Merck’s interest in the Du Pont-Merck Pharmaceutical. In the same year, Du Pont also announced to divest Conoco.

Thus, the company made clear that it focuses on life sciences as the centerpiece of the strategy for profitable growth.
Chapter 3. Analysis of Strategies

1. Strategies

Considering Du Pont’s recent business decisions and what the company declares, its long-term business strategies can be summarized as follows. (See Figure 3)

Strategy 1: To keep petrochemical materials businesses, in which the company has core competencies, and to rely on them as cash resources.

- Fibers,
- Polymers,
- Coatings,
- Films, and
- Electronic Materials.

Strategy 2: To divest energy business and focus on bio-chemical businesses.

---Through Conoco split, Du Pont earned $21 billion one-time cash.

Strategy 3: To enhance and establish bio-technology-related businesses.

- Crop Protection,
- Seeds,
- Grains,
- Proteins, and
- Pharmaceuticals.

Strategy 4: To enhance materials businesses by adding bio-based materials and achieving bio-based processes.
(Figure 3) Du Pont’s Long-term Strategies

Evaluation of Each Strategy

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Opportunity or Strength</strong></td>
<td>+Product differentiation</td>
<td>+Some good news</td>
<td>+Market growth</td>
</tr>
<tr>
<td></td>
<td>+Brand assets</td>
<td></td>
<td>+High possibility of new product introduction</td>
</tr>
<tr>
<td><strong>Threat or Weakness</strong></td>
<td>-Over-capacity and price competition (semi-commodities)</td>
<td>-Du Pont has too much confidence in its R&amp;D capability (&quot;Not invented here&quot; syndrome)</td>
<td>-Highly competitive market</td>
</tr>
<tr>
<td></td>
<td>-Product innovation is slowing.</td>
<td></td>
<td>-Du Pont is a latecomer</td>
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<td></td>
<td></td>
<td></td>
<td>-Anti-GM public sentiment</td>
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</table>
2. Analysis

Petrochemicals businesses:

This business area is where Du Pont sees itself to have core competencies. Indeed, the company has more than 2000 trademarks and brands in this area. Du Pont has focused on specialty, high-performance materials rather than commodities such as PET. Goldman Sachs Investment Research breaks down these businesses into three categories:

- Class Acts (specialty fibers, performance coatings and polymers),
- WorkHorses (pigments, chemicals and specialty polymers), and
- Monetization Candidates (nylon and polyester).

Class Acts and WorkHorses are the greatest income contributors for the entire company. They include many good businesses and show continuous growth or upward trends. On the other hand, Monetization Candidates show low or negative profitability mainly due to decreasing prices caused by over capacity in the industry. (See Table 2.)

On the other hand, innovation in petroleum-based products is slowing. (See Table 3) Also, Du Pont’s own product introduction rate has begun to tail-off as new end-use applications and high value properties become more difficult to find.
(Table 2) Profitability in Each of Du Pont’s Business Segments

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</thead>
<tbody>
<tr>
<td>CA</td>
<td>4,600</td>
<td>519</td>
<td>11.3%</td>
<td>4,600</td>
<td>525</td>
<td>11.4%</td>
<td>6,100</td>
<td>645</td>
<td>10.6%</td>
</tr>
<tr>
<td></td>
<td>17.8%</td>
<td></td>
<td></td>
<td>16.8%</td>
<td></td>
<td></td>
<td>20.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance Coatings</td>
<td>3,300</td>
<td>708</td>
<td>21.5%</td>
<td>3,300</td>
<td>662</td>
<td>20.1%</td>
<td>3,400</td>
<td>731</td>
<td>21.5%</td>
</tr>
<tr>
<td>&amp; Polymers</td>
<td>12.8%</td>
<td></td>
<td></td>
<td>12.0%</td>
<td></td>
<td></td>
<td>11.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialty Fibers</td>
<td>3,800</td>
<td>513</td>
<td>13.5%</td>
<td>3,700</td>
<td>581</td>
<td>15.7%</td>
<td>3,700</td>
<td>625</td>
<td>16.9%</td>
</tr>
<tr>
<td></td>
<td>14.7%</td>
<td></td>
<td></td>
<td>13.5%</td>
<td></td>
<td></td>
<td>12.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WH</td>
<td>4,000</td>
<td>575</td>
<td>14.4%</td>
<td>4,000</td>
<td>608</td>
<td>15.2%</td>
<td>4,300</td>
<td>666</td>
<td>15.5%</td>
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<tr>
<td></td>
<td>15.5%</td>
<td></td>
<td></td>
<td>14.6%</td>
<td></td>
<td></td>
<td>14.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigments &amp; Chemicals</td>
<td>2,200</td>
<td>187</td>
<td>8.5%</td>
<td>2,800</td>
<td>(7)</td>
<td>-0.3%</td>
<td>2,600</td>
<td>(39)</td>
<td>-1.5%</td>
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<tr>
<td></td>
<td>8.5%</td>
<td></td>
<td></td>
<td>10.2%</td>
<td></td>
<td></td>
<td>8.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialty Polymers</td>
<td>4,600</td>
<td>372</td>
<td>8.1%</td>
<td>4,600</td>
<td>406</td>
<td>8.8%</td>
<td>4,500</td>
<td>389</td>
<td>8.6%</td>
</tr>
<tr>
<td></td>
<td>17.8%</td>
<td></td>
<td></td>
<td>16.8%</td>
<td></td>
<td></td>
<td>15.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyester Enterprise</td>
<td>22,500</td>
<td>2,874</td>
<td>12.8%</td>
<td>23,000</td>
<td>2,775</td>
<td>12.1%</td>
<td>24,600</td>
<td>3,017</td>
<td>12.3%</td>
</tr>
<tr>
<td></td>
<td>87.2%</td>
<td></td>
<td></td>
<td>83.9%</td>
<td></td>
<td></td>
<td>84.2%</td>
<td></td>
<td></td>
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<tr>
<td>Subtotal</td>
<td>25,800</td>
<td>3,484</td>
<td>13.5%</td>
<td>27,400</td>
<td>3,290</td>
<td>12.0%</td>
<td>29,200</td>
<td>3,439</td>
<td>11.8%</td>
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<tr>
<td></td>
<td>100.0%</td>
<td></td>
<td></td>
<td>100.0%</td>
<td></td>
<td></td>
<td>100.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$ millions. ATOI: after tax operating income (before non-recurring items)
CA: Class Acts, WH: Work Horses, MC: Monetization Candidates (according to Goldman Sachs)
data source: Du Pont 1999 annual report
(Table 3) Number of New Polymer Class Commercialization Per Decade

<table>
<thead>
<tr>
<th>decade</th>
<th>No.</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910s</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1920s</td>
<td>5</td>
<td>Polystyrene</td>
</tr>
<tr>
<td>1930s</td>
<td>6</td>
<td>Low Density Polyethylene</td>
</tr>
<tr>
<td>1940s</td>
<td>5</td>
<td>Nylon, ABS</td>
</tr>
<tr>
<td>1950s</td>
<td>9</td>
<td>High Density Polyethylene, Polypropylene</td>
</tr>
<tr>
<td>1960s</td>
<td>9</td>
<td>Polycarbonate</td>
</tr>
<tr>
<td>1970s</td>
<td>6</td>
<td>PET</td>
</tr>
<tr>
<td>1980s</td>
<td>2</td>
<td>Liquid crystal polymers</td>
</tr>
<tr>
<td>1990s</td>
<td>4</td>
<td>Bio-degradables</td>
</tr>
</tbody>
</table>

Products that have achieved sales of over 1m ton/year in the U.S.
Source: McKinsey and others
Bio-based materials and processes:

On April 11, 2000, Du Pont announced to name a new polymer platform “Sorona™.” Sorona™ not only provides superior quality when applied to fabric use, but also has a unique characteristic; that this polymer platform can be produced through bio-catalytic process from glucose, a natural renewable source. Du Pont plans to start a pilot plant for corn starch-based production of Sorona™ later in 2000 and to operate commercial facility within three years.

This process has been implemented through genetic modification technology to combine genes from two different organisms into one microorganism. Du Pont, in collaboration with a R&D partner Genencor International, invented a bacterium that can produce an intermediate for Sorona™ more efficiently and inexpensively than traditional chemical process using fuel ethanol and ethylene glycol.

Sorona™ is one of Du Pont’s early success stories in integrating biotechnology and chemistry. The company attempts to go further into research areas including:

1) Use of green plants as manufacturing plants to make useful chemicals and polymers,
2) Use of microbes as programmable manufacturing factories to make chemicals and polymers, and
3) Exploration of market opportunities by applying biotechnology to new or improved product functionality.

This research activity should be matched by engineering process that is commercially viable. And the company has to find economic solutions before its competitions.
The biggest challenge at this biotechnology/chemistry interface could be about relationships among the people required to work across very disparate disciplines. Du Pont has to overcome “Not invented here” syndrome not only at the border between inside and outside the company, but also within the company.

The 5 years Du Pont-MIT research alliance is also intended to shed a light on the above issue.

----Research is expected to strongly emphasize team-based approaches rather than individual investigators working in isolation; for example, shared students/postdocs and joint publications/patents should be the norm rather than the exception. (Du Pont-MIT Alliance: Guiding Principles)

**Bio-related businesses:**

After the U.S. chemical industry experienced a significant decline in 1970s, due to technological maturity, the energy crisis, and overcapacity, diversification into pharmaceutical and biotechnology products as well as specialty chemicals became a general trend. They include not only drugs but also agricultural chemicals and new types of products based on advances in biotechnology. However, most of these areas were already dominated by specialized firms. Especially, big drug companies were already established in pharmaceuticals industry. The major route to entry, therefore, was through acquisition.

After recombinant DNA attracted a great deal of attention in the U.S. scientific and business communities, genetic engineering became a burgeoning field of science and
technology. It is also said that growth in biotechnology knowledge is increasing ten-folds every five years. This rate exceeds the rate of computing power growth, which is traditionally defined by Moore’s Law that computing power would double every 18 months.

As was shown in the previous part, Du Pont had been somewhat hesitant to enter this business area until the beginning of 1980s. However, once the company realized the opportunity and, at the same time, the need to increase the commitment to biotechnology, it did exactly what it needed. So far, mainly through acquisitions, some human pharmaceutical products have been successfully commercialized.

We should also note that there are a variety of anti-GM (genetic modification) public sentiments, part of which are represented by organizations such as Greenpeace International. Du Pont is aware of this issue and sets its own standards for the use of biotechnology as follows.

1. Highest Ethical Standards
2. Informed Consumer Choice
3. Protection of the Natural Environment
4. Product Safety
Chapter 4. Conclusion

As we analyzed in the last chapter, Du Pont seeks its future growth in biotechnology and integration of biotechnology and chemistry. For this purpose, the company keeps traditional chemical materials business as a good source of cash, and has divested energy business to earn one-time cash.

In our observation, the company’s three key words on the cover of its 1999 annual report can be used to describe Du Pont’s long-term strategies in the way shown below. (See Figure 4.)

(Figure 4) Du Pont’s Technology Innovation Curves
Goals of the company’s long-term strategy are clear. However, it is also clear that the way to achieve them is tough. A century ago, when Du Pont transformed from a gun powder company to a science-based chemical company, the company was a forerunner of the industry and technology innovations were not so rapid as today. Du Pont could spend 17 years in a cycle of technology innovation. This time, however, the company is a latecomer and innovation is accelerated by computer and network technologies. If the company was ever to really achieve its goals, there is no time to waste.

Du Pont has to make a true commitment for integrated science. It has to use its time and money wisely through acquisition and strategic alliances. It is also very challenging to form an organization, where totally different sciences interact to each other and create a new product or a new process.

In terms of existing chemical businesses, the company has to be good at selecting right products and ensure sound cash flow. Sometimes the company may have to decide on harvesting or divesting less profitable products.