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no. 2-0020

# Corning Microarray Technologies

Greg Brown, general manager of Corning Microarray Technologies (CMT), finished delivering the bad news to his team. Through the first half of 2001, demand had plunged in the telecommunications sector, which accounted for 73% of Corning's revenue. As a result, Corning could not sustain funding for the nascent CMT venture. He instructed the group that they would have to identify options for keeping the program alive with half or less of its current budget.

Mr. Brown knew that few situations strained the cohesiveness of a management team like formulating plans for severe budget cuts. Still, the team had strengthened dramatically since he had inherited the venture, rife with conflict, in November 1999. Because he had commitments to travel for the following two weeks, he left them to work on their own, expecting detailed proposals upon his return.

## Opportunity: Meeting the Needs of Genetic Researchers

In June 2000, the scientific community reached a momentous milestone, the complete mapping of the human genome. But even before this breakthrough, molecular biologists conducted new genetic experiments. They started with organisms with simpler genetic codes, such as yeast, and worked towards more complex genomes and partial strands of human DNA.

Once scientists had completely mapped the human genome, literally millions of new tests were possible. There was no scientific field ready to grow as explosively as genomics. Researchers sought new knowledge about the genetic basis of life, and in particular, genetic markers for diseases. They anticipated advancing to experiments with specific subsets of genes known to be related to a particular disease. They foresaw a revolution in medical therapies.

Genetic experiments involved measuring the magnitude of DNA interactions. Measurements were always comparative, between an experimental sample and a control sample. Due to the complexity of genetics and the imperfect nature of the laboratory apparatus, experiments were run multiple times, and conclusions drawn on statistical inference. The high standards of proof expected in the physical sciences

This case was written by Professor Chris Trimble and Gautam Bellur (T'03) of the Tuck School of Business at Dartmouth. This research was sponsored by the William F. Achtmeyer Center for Global Leadership. It was written for class discussion and not to illustrate effective or ineffective management practices. Version: 4/11/03.



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were not possible in genetic research. Experimentation generated tremendous volumes of data, and was computationally intensive.

To increase the speed and efficiency of genetic experimentation, researchers used equipment that facilitated batch testing. One such piece of equipment was the DNA *microarray*, a glass slide that contained thousands of microscopic DNA samples. An entire genomics system included robots for "printing" DNA onto the microarrays, optical scanners, which measured light emitted from reactions, and specialized computers. As of the late 1990s, much of the technology was still new and not completely reliable.

Affymetrix, a startup launched in 1992, supplied complete systems, including the microarrays, and was the market leader. Affymetrix' sold *closed systems* (you bought all or nothing) which were not necessarily interoperable with other equipment on the market. There was no other company selling complete, closed systems.

Many laboratories chose to "self-print," that is, to assemble their own systems by buying components from other suppliers. They cited the high price of Affymetrix' products, mentioned that their in-house approach was at least as reliable, and complained that because some of the inner workings of the Affymetrix system were not disclosed, they did not have the flexibility and control they desired.

But self-printing was also less than ideal. In part, doing so was likely to infringe on Affymetrix' patents, and the company had a large legal staff to aggressively litigate. Self-printers sometimes had to pay royalties to Affymetrix, and this was a significant revenue source for the company. Dr. William Hall, a Corning molecular biologist, commented on another disadvantage of self-printing:

> "Researchers do not have the time or patience to run a facility dedicated to printing microarrays. It is not what they are paid to do. They don't want to be constantly assembling genes, or managing the enzymes that are needed for printing. That's generally technician level work. Unfortunately it's a precise process. You have to put your best researchers on it."

Printing microarrays was expensive and time consuming. Simply preparing the DNA could occupy 20% of a researcher's time.

## Corning Life Sciences and Interest in Microarrays

For several decades, Corning's Life Sciences division had manufactured laboratory glassware, including beakers, bottles, filters, flasks, tubes, traps, cylinders, stopcocks, vessels and valve assemblies. Growth of these products was typically four to eight

percent per year. In 1993, Corning Life Sciences accounted for roughly two percent of Corning's total revenues.

That summer, to revitalize growth in the life sciences division and gain a presence in the higher-growth molecular biology products needed by the burgeoning biotech industry, Corning acquired Costar. A startup in the Boston area, Costar manufactured a variety of products used in advanced life sciences laboratories, and they had a reputation for innovation.

Rather than moving Costar's management team to Corning's headquarters in Corning, NY, Edward Huntington, the general manager of Corning's life science division, and several members of his staff moved to the Boston area. Nonetheless, the acquisition was a difficult one. There never was a full integration of the two cultures. Many Costar employees felt that their innovative spirit was threatened. They did not want to be "gobbled up" by a large company, and they did not want to be "Corningized." Because of the difficulties, corporate executives at Corning sometimes argued that the life sciences businesses should be divested, since "it wasn't really our business."

In 1997, Corning commissioned a team of consultants to identify and evaluate growth opportunities across all divisions. Along with seven other possibilities, the consultants encouraged Corning Life Sciences to investigate the genomics market.

Samuel King, a researcher formerly with Costar, had already been trying to generate some momentum for such a project. Although he had become frustrated in his efforts to get executives in Corning, NY excited, he had succeeded in engaging both business development and research staff at Corning's Fontainebleau Research Center (FRC) in France, and had obtained FRC funding to support further investigation. The FRC had had a substantial role in developing optical fiber, and was now trying to revitalize its importance within Corning.

The next year, in 1998, a second consulting study painted a much more detailed picture of the genetics opportunity, identifying value propositions and proposing initial business plans for three possible product lines. The first was *microplates*, a plastic plate with a microscopic well for tests involving single cells. Corning Life Sciences had already launched this business in a limited way – the study confirmed its potential. The second was the DNA microarray, to which Corning subsequently made an increased financial commitment. The third, products to support a genomics process known as Direct Binding Analysis, was deferred.

In evaluating the microarray opportunity, the consultants and executives at Corning concluded that they had a skill set that would give them a unique competitive advantage. The existing suppliers were life sciences experts – in fact, almost the entire management team at Affymetrix had PhDs in molecular biology. But based on

Corning's conversations with researchers, mastering the printing process was the most challenging aspect of the microarray business.

Printing appeared to be a manufacturing process ideally suited to Corning's abilities. They had unmatched expertise in specialty glass manufacturing. And in other business lines, they had developed expertise in three areas critical to microarray production – applying unusual coatings to glass, controlling liquid flows on microscopic scales, and continuously improving microscopic manufacturing processes. (Printing microarrays involved precisely attaching thousands of tiny liquid DNA samples to glass with a special adhesive coating.)

The value proposition was simple. Corning would mass produce reliable microarrays at low cost. In fact, Corning believed that they could develop technology that would enable printing microarrays as much as ten times faster than Affymetrix. And, they believed that they could develop printing processes of sufficient quality that variability in genomics experiments would be reduced substantially. The consultants conducted thorough interviews with genomics researchers in the pharmaceutical industry, and concluded that the value proposition was indeed very powerful.

In the process, they expected to revitalize the life sciences division, and maybe even create the next "big win," that is, a success on the order of magnitude of Corning's optical fiber business. The genomics market was projected to grow to several billion dollars within a decade. Realizing that the total funding they could allocate to new ventures was limited, Corning cancelled a venture in the energy sector that was projected to have a longer-term payback.

Before continuing with how Corning built a business group to pursue the microarray opportunity starting in 1998, it is important to understand a bit about Corning's history, its organization, and its general approach to innovation.

## Corning: From 1851 to 2001

For Corning to consider entering an entirely new market such as genomics was not unusual. The company had reinvented itself numerous times, and by doing so had survived much longer than the average corporation.

Innovation – specifically, regularly introducing new products based on cutting-edge research in glass and ceramics – was central to Corning's strategy. Many of Corning's innovations simply improved existing products, or introduced new products to existing markets. However, through its history, Corning had succeeded in creating entirely new platforms for vigorous growth every two decades or so.

For example, in the 1870s, Corning entered the emerging market for light bulbs, and by 1908, light bulbs accounted for more than half of Corning's revenues. The glassware technology developed in the 1920s by Corning Life Sciences, under the

Pyrex® brand name, ultimately became a platform for a launch into consumer products – cookware. And, in the 1970s, following clean air regulation in the United States, Corning created the first ceramic substrates used in catalytic converters (which purify automotive emissions).

Corning tended to divest mature divisions. In 2002 it was no longer manufacturing light bulbs or cookware.

In the 1980s, Corning introduced fiber-optic cable, the backbone of modern telecommunications and computer networks. This was Corning's "next big revolution." By the mid-1990s, sales of fiber created rapid appreciation in Corning's stock price. By 2000, revenues from the telecommunications division accounted for an astonishing 73% of Corning's revenues and 69% of net income from continuing operations. (See Corning financial summary, Figure 1.)

The success in fiber-optics led to a significant organizational change. Corning's non-telecommunications divisions were reconstituted as a separate "sector" in Corning's organization, known as Corning Technologies. (See organization chart, Figure 2.) Most of the businesses in this sector supplied manufacturers in the automotive and energy sectors, or manufacturers of computer monitors. These businesses did not have the explosive growth potential of the fiber optics market, but were reasonably predictable. Corning Life Sciences was also part of Corning Technologies.

Martin Ford, President of Corning Technologies described the sector's strategy:

> "We have a very simple business model here. We are usually in technical oligopolies, supplying an OEM with a component that we developed first. We are usually a first-tier supplier, and where we are not we are treated like one. We have very strong intellectual property. We continue innovating to meet changing customer needs. Then we look for offshoots of the technologies we develop to serve other markets. That's what we do."

Corning protected a reputation for high quality, and the R&D staff understood the importance of getting a product right the first time, a bias reinforced by a quality initiative in the 1980s. Threats to Corning businesses were usually indirect, from substitute technologies or technological advances that made their products unnecessary. For example, better internal combustion engine technology may someday render catalytic converters unnecessary. Changes in government regulations also occasionally threatened Corning businesses.

Corning had been managed by the Houghton family for most of its history. Corning, New York was a company town. The Corning Museum of Glass was perhaps the most notable tourist attraction. The staff at local restaurants knew Corning executives by name.

Some employees described Corning's corporate culture as paternalistic. Careers at Corning tended to be very long, and senior managers were expected to carefully manage the career paths of their subordinates. Employees emphasized high-trust, high-touch relationships, and the value of face-to-face, one-on-one meetings. Mid-career hires from the outside were rare. Though such hires were becoming more common by the late 1990s, they created discomfort. Employees expecting promotion resented outsiders that filled positions they aspired to. At the same time, some outside hires, even after a few years, suspected that power revolved around an "insider's group" at Corning.

Corning's scientists and engineers competed to be assigned to the riskiest, most innovative projects, but that hadn't always been the case. A downturn in the early 70s had resulted in layoffs in the research and development staff, and, for as long as a decade, many technologists avoided cutting-edge projects to protect their job security. There was some fear that the telecommunications downturn in 2001 had the potential to do the same.

Markets for telecommunications capital equipment, such as fiber, were the most vulnerable to the technology bust that began late in 2000. New orders for Corning fiber dropped precipitously in the first two quarters of 2001, and many standing orders were cancelled. Corning eliminated 4,300 positions by April 2001, including both hourly and salaried employees representing 11% of the workforce. In addition, Corning viewed goodwill and other intangible assets from earlier telecommunications acquisitions as unrecoverable, and took a $4.8B charge in the 2$^{nd}$ quarter. Corning's share price fell from a high of $109 per share in September 2000 to $17 at the end of the June 2001.

## Managing Innovation at Corning

Over the years, Corning developed and refined a standardized five-stage process for managing innovation. The process was designed to create smooth and efficient transitions from Corning's research facilities, to product development groups, and finally to business divisions. Each stage included market-related, technology-related, and manufacturing-related milestones. (See Figure 3.) Scientists in the research group transferred responsibility to engineers in the development group at roughly the point when a working prototype was created. The development group worked out the bugs. Business units established manufacturability and launched the product.

Corning's research and development heads reported directly to senior management, as did the general mangers that ran the business divisions. This structure resulted in dual leadership roles during certain stages of the innovation process. For example, an executive in the development group and a general manager slated to inherit the business co-led the innovation process over a certain time period.

Fred Allen, the Technology Delivery Officer responsible for all development projects within Corning Technologies, who had been at Corning since 1966, was a strong advocate of the structured innovation process, but was less convinced that dual leadership was a good idea:

> "I personally prefer single leadership with clear role definition. I have seen large programs in Corning, notably in fiber, run with dual leadership. There's a technical leader and a commercial leader. So I won't say it can't be done, but I don't personally favor it."

Mr. Allen had endeavored to create a more formal career path for "program managers." He believed that program management was worthy of Corning's most talented general managers. A program manager, in his view, understood the discipline of markets and also could be an effective leader of scientists and engineers. The greater the risk and ambiguity associated with a given program, the higher the demands on the program manager, because the innovation process itself became less predictable and less linear. Mr. Allen elaborated:

> "Program management is about managing ambiguity. Let's say you have a scientist who thinks he has the greatest thing since white bread. The program manager must figure out: What's the value proposition? Can we make money in this? Do we understand the competitive reaction? Do we understand the manufacturing difficulties? If you look at the innovation processes, you've got manufacturing, commercial and technical aspects. Program managers must be able to deal with the interrelationships of all three."

Mr. Allen distinguished the program manager, who could only be evaluated on the quality of decision-making, with a project manager, who achieved short-term milestones embedded within the innovation process, and whose performance could be measured in terms of time and money spent.

Corning's senior management team endeavored to create an environment that attracted talented general managers to new business units. Success could be a fast-track to running a major new division, and could also lead to increased compensation. Nonetheless, general managers were sometimes reluctant because of a perceived career risk.

The philosophy of the senior management team was that innovations were difficult, and required patience. As the general manager of a risky venture, if you started with a strong track record, carefully documented your decisions, kept the senior team informed, and tried to learn as much as possible from the experience, then your career could tolerate one or even multiple failures. In fact, it was not uncommon for general managers at Corning to lead efforts to bring new products to market more than once.

Ideas for new ventures at Corning had come from many places, including the R&D staff, the business units, customers, and consultants. Initial evaluations often simply involved technologists and businesspeople within R&D deciding if an idea merited more resources. As ideas gained promise, more formal evaluations took place within the context of Corning's annual planning cycle. Outside consultants were often used for validation and initial planning.

After that, the planning process for new ventures mirrored that of mature divisions, albeit with greater attention from senior managers. The process started with long-term (5 year) cash flow planning in the spring, to establish constraints. It continued with strategic reviews in the summer, and budgeting in the fall.

In the budgeting process, financial models for mature businesses tended to use historical results to project future trends. For new ventures, because there was little history and no stability, planners built financial models that were much more abstract and reliant upon questionable assumptions. Comparatively little time was spent reviewing the past. According to Scott Lewis, the controller in the life sciences division:

> "It's hard to look retrospectively when planning new products. It is sort of like being a defensive back in football. You have to have a short memory because you know that you are going to fail a lot."

## Assembling the Microarray Team

Following the decision in 1998 to allocate capital to the microarray opportunity, the senior management team at Corning began to reassign personnel. Key figures on the senior team whose responsibilities included the new venture were Mr. Huntington, general manager of Corning Life Sciences, and John Keller, who preceded Mr. Allen as head of the development group. Both reported to Colin Gilbert, who preceded Mr. Ford as president of Corning Technologies. (Refer to organization chart, Figure 2.)

Stephen Woodbury, who had been involved in other product development efforts and at the time was a plant manager, was selected to manage the microarray business, reporting to Mr. Huntington. Catherine Hamel, a long-time Corning engineer, was appointed to head up the development effort, reporting to Mr. Keller.

Dr. Mark Fraser led the research group working on microarray technology, and reported to Ronald Smith, Corning's Chief Technology Officer. Dr. Fraser had a built a career in scientific research at Allied Signal and Corning. He had spent most of his career working on advanced materials, and despite being uninvolved with the life sciences for many years, he had more knowledge of biology than others at his level on the research staff.

In turn, Mr. Woodbury, Ms. Hamel, and Dr. Fraser, all of whom worked out of Corning, NY, began assembling the necessary staff. To make the venture successful, the leaders needed skills and resources from several existing groups at Corning, including FRC, the life sciences teams in the Boston area that evolved from the Costar acquisition (they now managed the microplates product line), and the massive, multi-business-line research and development facility in Corning, NY. In addition, each of the three recognized that they would soon need to hire experts in molecular biology.

Dr. Fraser built a molecular biology research group, starting by hiring Dr. Ralph Hansen, a veteran of the field in both academia and industry who had already worked on printing microarrays. Dr. Hansen was well known around the world, had contacts in several major research sites, and routinely spoke at genomics conferences. Dr. Fraser described how he and Mr. Smith formulated an early hiring plan:

> "We needed experts in everything form the chemistry of the substrate to the handling of DNA materials, a total of five or six different technical areas. We needed a critical mass, at least five people, in each. It was important, since we felt that we were behind, to spend the money and get the people on board. We could afford to do it, so we did."

Ultimately, Dr. Fraser hired a staff of approximately twenty five, counting both external hires and internal transfers. Dr. Brian Chase, a veteran in Corning's research organization who had been involved in the initial evaluation of the venture, identified and assembled the team of experts in Corning's traditional scientific fields. Ms. Hamel and Mr. Woodbury also built staffs of similar magnitude for the development and commercialization teams, also hiring outsiders with molecular biology expertise.

Expectations were high, and because they had been validated by the outside consulting study, they were rigid. In staffing the venture, the senior management team bypassed people who suggested that the projections were unrealistic. They wanted to involve people who believed in the project. Revenues of $100M were expected within five years. And in the excitement of the telecommunications boom, expectations rose to $250M in the following planning cycle. Mr. Lewis recalled the environment:

> "Expectations felt aggressive, but not terribly aggressive. The excitement around fiber made it seem as though everything was growing at 70% per year. So if you didn't project $250M in five years, you heard 'Guys...not enough zeros.' It hadn't always been that way – just in the past four or five years."

Mr. Woodbury felt that it was critical to get to market quickly. The market was evolving, and there were rumors that other corporations such as Agilent and Motorola were pursuing the same opportunity.

The research and development teams began working on a proprietary system for manufacturing microarrays. Because developing such a system was expected to take two years, the management team decided to pursue a quicker path using existing printing robots available commercially – i.e. the same printing robots that Corning's potential customers were using in their own laboratories. The logic for doing so was twofold: (1) Corning could still do a better job than their potential customers because they would mass-produce and had the manufacturing process improvement skills to perfect production, and (2) close contact with multiple customers during development of the proprietary system would lead to faster and better results.

The Corning staff began to refer to this approach as Generation One ("Gen 1") and to the proprietary system as "Gen 2." The latter was to be a unique approach, and the team believed it would enable an unbeatable cost structure by utilizing proprietary Corning technologies. In partnership with the staff in Corning, the research staff at FRC was dedicated exclusively to Gen 2. The development teams in New York and Massachusetts focused on getting Gen 1 products into the market.

An early success was the launch of an unprinted coated glass slide in 1999. Mr. Woodbury's colleagues had been nervous about the launch, fearing potential competitors would discover some of Corning's proprietary science. However, Mr. Woodbury decided that it was more important to begin building relationships with customers. Although Mr. Woodbury never dedicated significant resources to the product – it was not the big prize – the slide was welcomed by the market. Users described it as far superior and far more reliable than any alternative.

Four different standards for microarray equipment were in place internationally. The marketing team focused on encouraging adoption of a single open standard. Kevin Adler, who led the sales and marketing team under Mr. Woodbury, described the objective:

> "I had one marketer that did nothing but ensure superior *system level* solutions. We wanted to be neutral – we didn't want to get married, we wanted to date everybody. We went through a lot of engineering to ensure that we were compatible up and down the value chain."

Meanwhile, the team endeavored to get the Gen 1 system working. They did not foresee difficulties. Corning had mastered the process of applying a liquid coating to a glass surface. It was a common element of many Corning products. The one difference – which appeared minor at the time – was that the liquid included DNA.

The team struggled. They had trouble effectively mixing sufficiently large batches of DNA. Plus, supplies of DNA were of inconsistent quality from one vendor to the next. As a result, consistently matching the DNA fluid to a glass coating to which it would adhere was tricky. One vendor wreaked new frustration when it switched to a

new method of cleaning the DNA in order to meet Corning's order – the largest it had ever filled. The new cleaning chemicals disrupted the printing process.

Corning's methods for identifying and correcting manufacturing problems were confounded by unexpected inconsistencies inherent in handling DNA. Monday, the printing process appeared to be working fine, Tuesday mysterious problems arose.

Tensions mounted between the physical scientists and life scientists on the team. The biologists were accustomed to phenomenon being inconsistent and imperfectly understood – that was the nature of their science. But the physical scientists fixated on achieving perfection – which translated to extremely low error rates in manufacturing processes. Biologists eventually complained that they could not find an audience for their viewpoints. Dr. Chase recalled the tensions:

> "The biologists disagreed with our methodical approach. They wanted to get to market. Corning focuses on quality – on making things work right. We would say 'We shouldn't have this variability. This batch is bad.' The biologists would say 'You don't understand what is needed.' We would say 'You don't understand how good we can get.' They would say 'Humans have perhaps 100,000 genes. As of today we only know 7,000 or so. 10% wrong in our world is not a big deal.'"

As milestones in the development process were missed, other tensions initially buried in the excitement of launching a new business rose to the surface. The staff at FRC and the team in Corning were not working together effectively. Development staff in Massachusetts began to assert their independence, believing they could accomplish more on their own than in partnership with the team in New York. Interaction between the development and commercialization staffs was unproductive – the life sciences unit had much less experience developing and launching new products than other Corning business units.

Furthermore, tensions arose between the staff of the core life sciences business and the advanced molecular biology product lines – microplates and microarrays. Mr. Huntington recalled one incident:

> "I was traveling with one of our sales reps, and a customer was interested in microplates. And the rep said 'Well, you're going to have to contact Carol, because I don't handle microplates.' I just about died. There was synergy in approaching customers – we did well in some places and less well in others."

The sales operations were not easy to integrate because the customer buying processes were very different. The core life sciences products were inexpensive, and administrative staff made routine purchases several times per year. By contrast,

senior managers were involved in the system-level decisions associated with microarray purchases, and deliberated for long time periods. Longer, in fact, than had been anticipated in the business plan.

Augmenting these tensions, the microarray commercialization team had assumed what Mr. Adler described as a rather elitist attitude. Blaming himself, he recalled telling the microarray sales reps that they were selected because they were the best, because this venture was the future. They were successful in getting resources whenever they needed them, while the core business struggled to do so. One Corning executive observed that the same dynamics disrupted cooperation between the telecommunications group and Corning Technologies.

The leadership group was also struggling to get along. Relationships between Mr. Woodbury and Mr. Huntington, and also between Mr. Woodbury and Ms. Hamel, foundered. They had frequent awkward meetings, and failed to achieve a consensus on many decisions.

By late 1999, despite a budget that had risen to roughly $30M per year, the Gen 1 printing process was still not working. The Gen 2 process was way behind its development schedule. Most of the people involved in the venture had lost confidence. Their expectations had been dashed.

## Diagnosing the Problems with the Venture

Mr. Ford, having succeeded Mr. Gilbert as the President of Corning Technologies, was concerned about the prospects for a turnaround, as was Mr. Allen, who by then had replaced Mr. Keller as head of the development group. (Refer to organization chart, Figure 2.)

The two agreed that the venture's organizational approach appeared unwieldy, and because of Corning's focus on fiber-optics, Corning's best leaders had not been selected to manage an important but highly risky venture. They also observed that the team managing the venture lacked cohesion. Worse, the various groups involved in the project were not sharing information, and were sometimes fighting.

Finally, Mr. Ford and Mr. Allen noted that giving the same general manager (Mr. Huntington) responsibility for both mature and new product lines created too many conflicting pressures. The life sciences unit was trying to sustain profitability while the microarrays venture rapidly consumed cash.

Based on these observations, Mr. Ford and Mr. Allen decided to make some significant changes.

In 2002, with the benefit of hindsight, Corning executives made several additional observations about what had transpired through late 1999. Dr. Fraser observed that

in the effort to get Gen 1 products to market, resource allocation decisions had been ineffective. He described the problem:

> "When we hit problems, we would attempt to solve them by saying 'Look, there are five aspects to this problem. I need a couple of people to work on each.' An expert, on the other hand, would say 'There are five aspects to this problem, but based on my knowledge and experience I know that three are very minor and have almost no impact on what we are trying to do. We only need a couple of people each for the other two.'"

In addition, the leadership struggled on occasion in matching problems to the people with the right expertise. This created dissension among the staff, as some questioned why others were spending so much time working on problems that seemed unimportant. Dr. Fraser also observed that the venture had attracted resources very quickly – perhaps so quickly that the assets for the venture had been assembled without time for sufficient thought, or without sufficient information.

Despite these issues, Dr. Fraser felt that the technical progress had been significant. Corning had created a large base of talented scientists, constructed new laboratories, established some new intellectual property, created some incredible inventions, and built the basic Gen 2 printing machinery (which still needed to be perfected):

> "The early technical teams did incredible jobs even in the face of the disagreements, the overly optimistic market entry timings, and the lack of management experience in life sciences. Many of our technological accomplishments are paying off in other products today."

Furthermore, Mr. Adler observed that in an effort to get the product launched in the expected timeframe, Ms. Hamel and Mr. Woodbury, who in fairness had insufficient power to reduce expectations, became very intent on advancing the project smartly through the five stage innovation process:

> "We'd make a lot of decisions to get back to plan. The same way you would in an operating business. In the venture capital world, where you know you have a certain amount of cash, you focus much more on your burn rate."

Mr. Allen reflected that they needed to allow more flexibility to iterate through stages – there were many ambiguities to resolve, and marching down a single path was an unlikely route to success. Problems could not always be resolved with simple, expedient solutions. While the team acted as though it was in Stage 3 or Stage 4 in the innovation process, a more reasonable assessment indicated that they were still in Stage 2.

## Reconstituting the Microarrays Business Team

Mr. Ford and Mr. Allen had developed Greg Brown's career over many years. They regarded him as one of Corning's most talented general managers. Like most of his colleagues, he had little exposure to life sciences businesses. But he had worked on development projects in the past, and had demonstrated an ability to get scientists, engineers, and businesspeople all working together.

In November, 1999, they selected him to replace Mr. Woodbury. Mr. Brown felt some reluctance, but Mr. Ford and Mr. Allen knew him to be a "good soldier" and left him little choice in the matter.

Mr. Allen viewed Mr. Brown as the program manager, meaning that he had singular responsibility for the venture. Mr. Ford wanted to be more involved in the venture, so Mr. Brown communicated with both Mr. Ford and Mr. Allen frequently. Mr. Brown and Mr. Huntington had little experience working together, and each went out of their way to gain trust by communicating decisions and sharing information.

As part of the effort to reshape the business, Mr. Ford, Mr. Allen and Mr. Huntington agreed to move all of the staff working on the project in Massachusetts to Corning, NY, in order to help build more productive working relationships. Roughly half of the staff resigned in the process, including some key scientists such as Samuel King, who appeared to have never overcome his resentment of Corning since its acquisition of Costar.

One of Mr. Brown's early concerns was gaining sufficient cooperation from Mr. Woodbury to ensure a smooth transition. However, Mr. Woodbury proved to be extremely helpful, and later confided that he was relieved to put the venture behind him.

Mr. Brown's mandate was to diagnose any problems, and then decide whether or not the venture should go forward or not. But he never explicitly considered exiting, once he saw the business potential and the technology fit:

> "I just dove in. The possibilities were intriguing, and the challenge of overcoming technical hurdles was something I always liked."

Mr. Brown had learned to avoid momentous changes early in a new position:

> "I don't believe you should go in and start mixing things up until you know what is going on. Things are the way they are for a reason."

However, the atmosphere was so charged that Mr. Brown felt compelled to act immediately:

> "I will never forget this. On Monday I started to talk with the team. By Tuesday afternoon, I called everyone together because I was just so

> shocked. I said 'We have got to talk. This ridiculousness has got to stop. We are all accountable. We are all leaders. This thing will self-destruct if we don't do something fast.'"

He went on to insist that conflicts could no longer be buried, that all frustrations must be aired. Some of the staff later let Mr. Brown know that the meeting was much-needed, and long overdue. Brian Chase, a close colleague of Mr. Brown's, emerged as both a senior technical advisor and the steady "voice of reason" that helped keep the research and development teams together.

The change in leadership reset expectations. The venture had a fresh start. The past was forgotten. While revenue expectations remained in the hundreds of millions of dollars, development milestones were pushed back roughly one year. The market opportunity still looked attractive.

In the first quarter of 2000, however, the venture suffered a significant disappointment. The team had set expectations in the press and with customers that they were very close to launching a yeast DNA microarray (based on the Gen 1 manufacturing process.) But they discovered that their first large batch was contaminated. The team seemed to expect a harsh reaction from Mr. Brown, but none came. There were no blatant operational mistakes. The team had worked hard, following their best understanding of the manufacturing process. Mr. Brown accepted the problem, and set the team to diagnosing and fixing it.

Later, however, Mr. Brown made additional changes to the organization. He placed Andrew Roberts, a Corning veteran who was at a natural transition point in his career, in charge of manufacturing. In addition, Mr. Brown and Mr. Allen agreed that Ms. Hamel needed to be replaced by someone with more familiarity with life sciences. On a customer visit to Smith Kline Beecham, Mr. Allen met William Hall, one of the first customers that bought Corning's unprinted coated glass slides. Dr. Hall had a PhD in molecular biology, was well published, held several patents, and had spent the previous seven years managing the high throughput microarray facility at SmithKline Beecham.

Mr. Allen hired Dr. Hall in May, 2000 to replace Ms. Hamel. Officially Dr. Hall reported to Mr. Allen, but Mr. Allen made it clear that Mr. Brown led the venture. The new business team was in place.

## Working Towards Product Launch

Through the summer of 2000, the team worked to fix the Gen 1 manufacturing line while continuing development of the Gen 2 process. The team solved problems with DNA supply by hiring a full time molecular biology expert to work with vendors to

train suppliers and establish new standards for the industry. As a result, CMT launched the Gen 1 yeast microarray product in September.

But the market had shifted by then. Few researchers were running experiments on yeast DNA because progress on the mapping of the human genome enabled more enticing experiments using human DNA. While sales of the product were disappointing, customers gave outstanding feedback. According to Mr. Huntington, the product was a "home run" from a technical standpoint. The feedback was a confidence boost for the CMT team. Internal perceptions of the venture's performance were rising.

Around this time, Mr. Ford acted to eliminate the conflicting pressures on Mr. Huntington, created by the demands of simultaneously managing a nascent venture and a mature business. He made the microarray venture its own independent division, dubbed Corning Microarray Technologies (CMT). The microplates product line was merged with the life science unit under Mr. Huntington. Mr. Brown now reported directly to Mr. Ford.

Meanwhile, progress on the development of the Gen 2 process was disappointing. The relationship between the FRC and Corning had improved. Still, cultural differences and the physical distance resulted in incomplete and occasionally inaccurate transfer of technology from the point of development (FRC) to the point of manufacture (Corning, NY). Mr. Roberts described his role:

> "I was to lead the transition from development to manufacturing. But the job ended up being more development. And it changed dramatically over the next year and a half. We had demonstrated feasibility, but were having difficulty with replicability."

Mr. Roberts endeavored to quicken the pace of learning by eliminating delays involved in experimentation. For example, he shortened the total time for testing new nozzles for the printing robots (a process that had steps in both France and New York) from a few months to a few weeks. He also eliminated the delays in information flows associated with a quality control process from several weeks to several days.

Despite these improvements, the team continued to miss milestones. But in Mr. Lewis's observation, the milestones were more tangible under Mr. Brown, and the team was more successful in overcoming the difficulties in diagnosing what was going wrong. Things that the team did *not* know became increasingly identifiable and evident. Several key decisions made early in the development process were revisited.

Despite some struggles over staff assignments with the telecommunications group, delays could not be blamed on a lack of resources. In fact, based on an aggressive

revenue forecast to which the CMT team had committed, Mr. Roberts built a large manufacturing staff many months before the product was ready.

By December 2000, the team felt that launch with a Gen 2 product was imminent, and built some anticipation with customers directly and through the press. But another difficult setback followed.

Meanwhile, Affymetrix continued to reiterate long-standing warnings that they suspected Corning's Gen 2 system infringed on their patents, and that they intended to litigate. The technical team believed that the Affymetrix patents could be worked around, or would eventually crumble under legal challenges from elsewhere in the industry. Nonetheless, Mr. Brown and Mr. Ford had researched the problem and had begun pursuing conversations with Affymetrix about licensing certain aspects of their printing technology over one year earlier. Negotiations were tense.

## Sudden Cutbacks

By the middle of 2001, the development team had overcome many hurdles, and Gen 2 product launch once again seemed imminent. The team successfully produced a unique human DNA product, and manufacturing yields approached 80%. Confidence and excitement continued to build, though Corning employees outside of CMT may only have noticed that the Gen 2 product still hadn't been launched. (The team had also successfully produced a human DNA product using the Gen 1 system and was also preparing it for launch.) The market still appeared promising – roughly 30% of the microarrays were still self-printed by potential customers, while another 44% used the expensive Affymetrix system.[1]

Meanwhile, orders for Corning's fiber optic cable were unexpectedly plummeting. Mr. Ford was in a bind. He anticipated that the annual budgeting cycle for 2002 would result in severe, corporate-wide budget cuts in October, and best-case forecasts for CMT still showed a $30M loss. He asked Mr. Brown for options for keeping the venture alive with half or less of its current budget.

Upon return from his two weeks of travel, the CMT team presented Mr. Brown with a plan for a $15M per year budget. The plan allowed the venture to continue to make progress, albeit at a slower rate. Mr. Brown was pleased with the plan and with the team, which had proven able to make consensus decisions involving sacrifice. (Dr. Fraser, who was involved in formulating the plan, later reflected that the fact that the process wasn't much more contentious only indicated that the budget was too big to begin with.) Shortly thereafter, Mr. Brown reached agreement with Affymetrix on a framework for an expensive licensing agreement.

[1] Source: Mercer Management Consulting

Meanwhile, Mr. Ford had commissioned another consulting study to review a wide range of growth options for Corning, including taking another look at CMT. The consultants encouraged a system-level view of the genomics market. They forecast that profitability in the industry would eventually shift to *bioinformatics* – computer systems, software, and services for managing the information generated by genetic experimentation. They recommended that Corning acquire the bioinformatics capability rather than try to build it themselves. If Corning did so, the consultants argued, they would certainly have sufficient influence in the industry to set standards. It was unclear just how expensive the acquisition would be.

A bioinformatics industry was in fact developing. But some scientists at Corning dismissed the consulting recommendation because they were aware of customers that readily handled the data collection and analysis aspects of their work on spreadsheets. Plus, they argued, laboratories protected their valuable results and would hesitate to let outsiders manage them.

The telecom market weakened further, so much so that September 2001 became known as the "September from hell." Mr. Ford decided to stop funding CMT entirely. Mr. Brown, Mr. Allen, and Dr. Fraser, who wrote a forty-page white paper on how CMT could still succeed following a new approach, all endeavored to change his mind—but to no avail. Mr. Brown recalled some of Mr. Ford comments:

> "I know you believe in the business Greg. But to be honest, I just don't know. I don't know the customers, and can't justify continued investment."

Others at the corporate level were unable to be supportive, too busy dealing with the fiber market to give much attention. Mr. Ford cited a number of reasons for the decision (in no particular order): 1) scarce capital, 2) lack of control over intellectual property and aggressive Affymetrix posturing, 3) uncertainty over how the industry would evolve, including ambiguity regarding the necessity to buy into the bioinformatics market, 4) repeated missed deadlines, 5) no revenue streams beyond roughly $5M per year for unprinted slides, 6) several potential competitors appeared to have spent far more even than Corning to develop a microarray product line (see Figure 4), and 7) personal discomfort and unfamiliarity with the business – a feeling shared by the rest of the corporate management team.

In late 2001, the decision was made to stop the program. When all was said and done, half of the sales staff and most of the manufacturing staff was outplaced or laid off. Cutbacks were not as severe within R&D – positions were identified on other projects inside Corning. All efforts to print microarrays were halted. All of the yeast microarrays were sold at bargain prices, and supplies of human DNA were written off.

Figure 5 is a timeline that highlights the key events in the evolution of Corning's microarray venture.

## The Next Year

Over the following twelve months, the telecommunications market showed little sign of recovery. Corning eliminated 12,000 of 40,300 jobs worldwide. They announced closure of seven major manufacturing plants, reduced capital spending from $2.5 billion to $1.8 billion, and stopped all expansion projects in the telecommunications segment. In order to pay for remaining expenses, Corning discontinued dividend payments in July 2001, issued new shares to raise $225 million in August 2001, and issued convertible debt to raise $665 million in November 2001.

Year-end results for 2001 showed that telecommunications revenues dropped 14% to $4.5 billion, compared to a 74% increase between 1999 and 2000. Corporate-wide, revenues dropped 12% to $6.3 billion, and Corning suffered a net loss of $5.5 billion (including the $4.8 billion write-off). Long-term debt as a percentage of total capital increased to 45% from 27%. Late in 2001, Standard and Poor downgraded Corning's debt rating from A to BBB and maintained a negative outlook. Moody and Fitch followed with similar downgrades. In April, 2002, CEO Matt Dickenson stepped down, just 16 months after his appointment.

Mr. Brown was evaluated positively on his performance in managing CMT, and was assigned another new venture related to diesel technologies. Mr. Ford believed this project had a higher probability of success, and anticipated that Mr. Brown would soon be running a major new division.

Dr. Hall continued to work for Corning in the life sciences area. A great deal of scientific and engineering know-how was retained, and Corning continued to evaluate possible new products in the life sciences market. In fact, they had expanded their offering of unprinted slides and offered kits which included the slides plus reagents used in the printing process.

As of the autumn of 2002, genetics researchers still had no compelling alternative to the Affymetrix system other than printing their own microarrays.

## For Discussion:

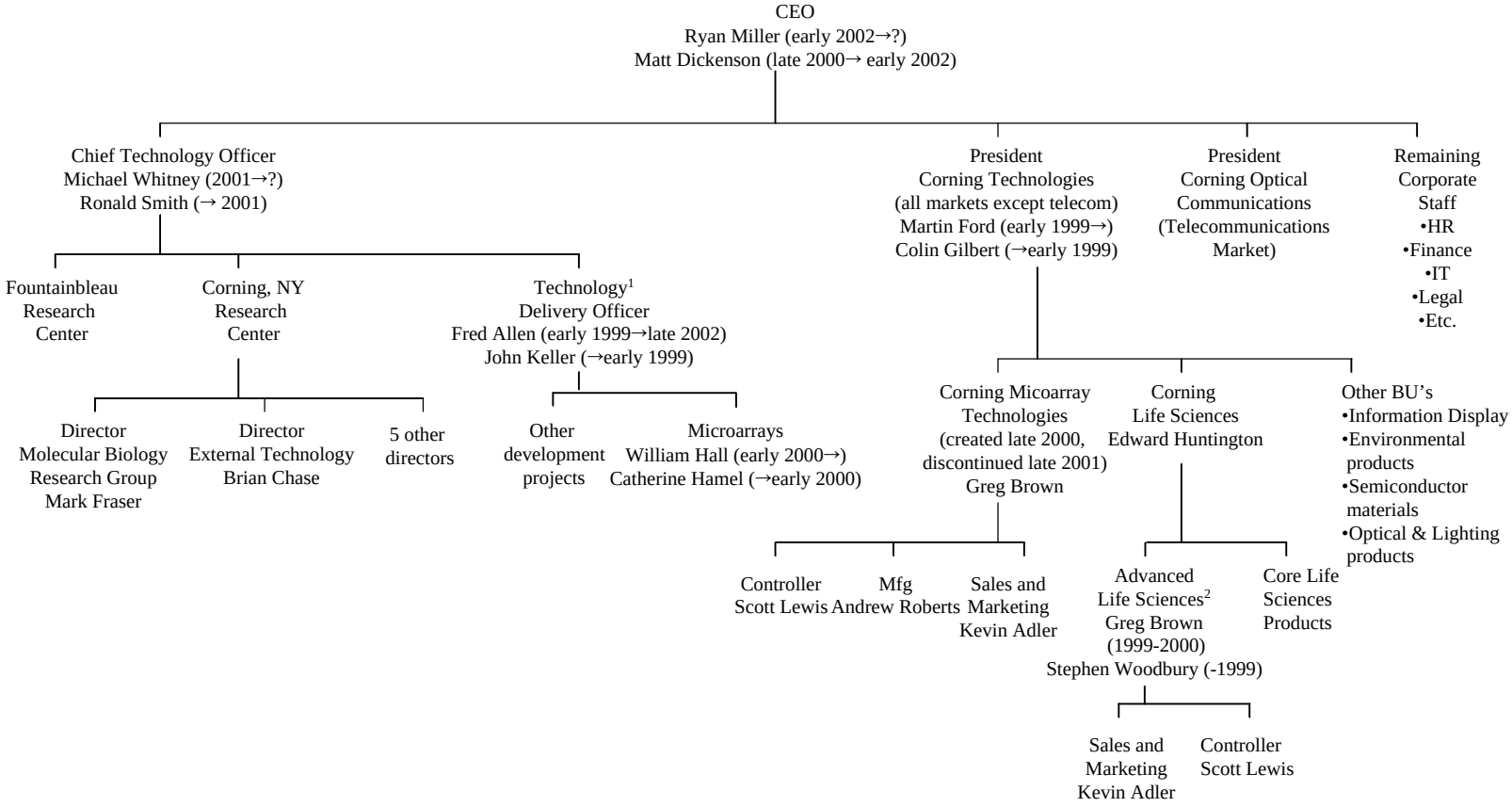
1. Was DNA Microarrays a sensible growth opportunity for Corning to pursue?
2. What are the differences between the CMT business model and the general business model for Corning Technologies?
3. Did Corning build an adequate level of expertise in molecular biology? Explain.
4. Why did the initial microarray leadership team falter?
5. Evaluate Greg Brown's priorities upon taking over the newly created CMT division.
6. How was the microarray venture affected by the buildup and subsequent sudden decline of the telecommunications business?
7. On a graph over time, trace perceptions of how the microarray venture was performing. On what basis did these perceptions form? Change? Evaluate.
8. In 2002, how secure do you suspect was Affymetrix position in the microarray market? Explain.

## Exhibit 1 Corning Financial Summary ($ in Millions)

| | Life Sciences | Corning Technologies | | | Telecommunications | | | Corning Total * | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Sales | Sales | R&D | Net Income | Sales | R&D | Net Income | Sales | R&D | Net Income |
| 1999 | $267 | $1,726 | $116 | $200 | $2,987 | $262 | $322 | $4,741 | $378 | $516 |
| 2000 | $248 | $1,915 | $145 | $312 | $5,186 | $395 | $696 | $7,127 | $540 | $422 |
| 2001 | $263 | $1,793 | $160 | $195 | $4,458 | $474 | ($81) | $6,272 | $631 | ($5,498) |

* Totals include corporate charges such as acquisition related charges and restructuring charges. In 2001, such charges amounted to $5.7B, of which $4.8B was associated with write-offs of intangible assets, including a $3.2B impairment of goodwill resulting from the acquisition of a single company, Pirelli, an optical components and devices company.

## Exhibit 2




[1] Responsible for product development, for managing the process of getting technologies from the lab to the market.

[2] Discontinued in late 1999. Microarrays became its own division. Microplates were merged with the rest of life sciences unit.

## Exhibit 3

| | Stage 1<br>Build Knowledge | Stage 2<br>Determine Feasibility | Stage 3<br>Test Practicality | Stage 4<br>Prove Profitability | Stage 5<br>Manage Life Cycle |
|---|---|---|---|---|---|
| Sample Milestones: | | | | | |
| Market | Search emerging markets for opportunities | Define specific products. Gather competitive data. | Judge customer needs vs. actual capabilities vs. competitor capabilities | Pilot Launch | Ongoing monitoring, analysis, planning |
| Technology | Identify commercial possibilities | Patent search, build prototype and have customers evaluate | Finalize patent position | Finalize product specifications | Develop next generation technology |
| Manufacturing | Create "wish list" of manufacturing capabilities | Define one or a few manufacturing processes | Demonstrate process reliability | Firm up cost/ performance estimates | Continuous improvement: cost, quality, service |
| Planning Goal: | Concept Plan | Development Plan | Profitability Plan | Commercialization Plan | Life Cycle Plan |

Source: Corning, Inc.

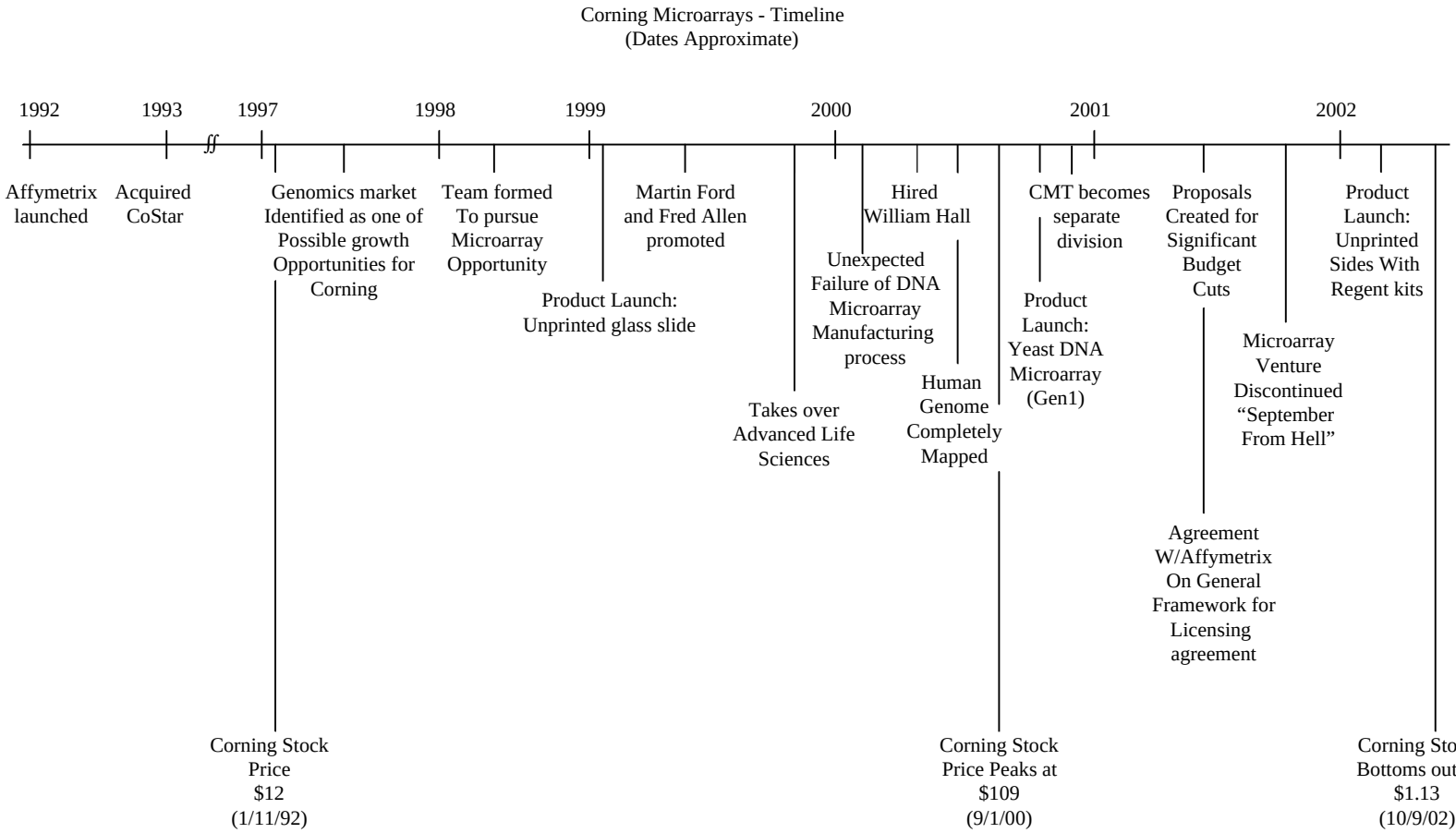
## Exhibit 4

**Total Microarray Development Spending Estimates ($M)**

| | |
|---|---|
| Affymetrics | $595 |
| Motorola | $500 |
| Incyte | $380 |
| Agilent | $245 |
| Corning | $100 |

Source: Mercer Management Consulting

## Exhibit 5


Corning Microarrays - Timeline
(Dates Approximate)
1992
1993
1997
1998
1999
2000
2001
2002
Affymetrix launched
Acquired CoStar
Genomics market Identified as one of Possible growth Opportunities for Corning
Team formed To pursue Microarray Opportunity
Martin Ford and Fred Allen promoted
Product Launch: Unprinted glass slide
Takes over Advanced Life Sciences
Unexpected Failure of DNA Microarray Manufacturing process
Hired William Hall
Human Genome Completely Mapped
Product Launch: Yeast DNA Microarray (Gen1)
CMT becomes separate division
Proposals Created for Significant Budget Cuts
Agreement W/Affymetrix On General Framework for Licensing agreement
Microarray Venture Discontinued "September From Hell"
Product Launch: Unprinted Sides With Regent kits
Corning Stock Price $12 (1/11/92)
Corning Stock Price Peaks at $109 (9/1/00)
Corning Stock Bottoms out at $1.13 (10/9/02)