Manufacturing Pharmaceuticals: Eli Lilly and Company, 1876-1948

James H. Madison[1]
Indiana University

In the first quarter century after its beginning in 1876 Eli Lilly and Company was like dozens, probably hundreds, of other pharmaceutical concerns. It made and sold sugar-coated pills, fluid extracts, elixirs, and syrups in Indianapolis and surrounding communities. Plants provided much of the raw material, and hand work constituted the primary method of production. Hand-rolled pills, for example, came in many sizes and shapes, none uniform. More important, the efficacy of the pills and elixirs remained unproved despite claims to the contrary. Although the Indianapolis firm was more careful in making and promoting drugs than the patent medicine men of the era, the company remained ambivalent about scientific research. One of its best sellers at the turn of the century was Succus Alterans. Produced from a secret formula, purportedly derived from Creek Indians, Succus Alterans was sold primarily as a "blood purifier" and treatment for "syphilitic afflictions" but also was recommended for "certain types of rheumatism and especially skin diseases like eczema, psoriasis, etc." [3].

Like most of its competitors, Eli Lilly and Company at the turn of the century was family owned and managed. The founder, a Civil War veteran usually known as Colonel Eli Lilly, died in 1898. His son, J.K. Lilly, Sr., managed the business, keeping close watch over every phase, using a method of supervision, one employee later remembered, that "was a personal thing performed by word of mouth" [19, p. 4].

Here then was a company more traditional than modern, closer to a nineteenth-century Indiana grist mill than such exemplars of big business as U.S. Steel or Standard Oil [5]. Change came rapidly in the years just before and after World War I. By 1930 Eli Lilly and Company was a modern industrial corporation, leading the way in bringing revolutionary changes to the pharmaceutical industry. At the center of these changes was Eli Lilly, grandson of the founder.

Born in 1885, young Lilly entered the company in 1907, just after his graduation from the Philadelphia College of Pharmacy. For the first two years he roamed through the plant seeking ways to improve production and cut costs. In the company's machine shop he developed new gadgets, including a bottle filling machine that adjusted for bottles of different sizes and saved $7,500 a year in spillage. His precise quantitative studies in the Fluid Extract

---

[1]This paper is modified from parts of Chapters 2, 3, and 5 of my *Eli Lilly: A Life, 1885-1977* (Indianapolis, 1989). Full documentation is provided in the notes of that book. I would like to thank especially Anita Martin, archivist, Eli Lilly and Company, for her assistance in my research and the Indiana Historical Society and the American Institute of the History of Pharmacy for fellowship support.

BUSINESS AND ECONOMIC HISTORY, Second Series, Volume Eighteen, 1989.
 ISSN 0849-6825.

Department demonstrated that wooden barrels caused a loss through absorption of several pounds of alcohol. Lilly installed copper-lined barrels, effecting a savings of $15,000 a year. He also began to investigate the general processes of production, leading to his system of blueprinted manufacturing tickets, whereby the formula for a drug was typewritten on transparent paper and multiple copies were made by a blueprinting process. Used to check each drug as it moved through the several departments, these blueprint tickets replaced verbal instructions, handwritten notes, and individually-typed orders.

After two years of this kind of roving efficiency work, Eli's father informed him that he was ready to assume the superintendency of the manufacturing division. The new superintendent had the zeal of youth and a personality that a later generation might label "type A" or "workaholic." Above all he was determined to succeed, to show his father and others in the company that he could make his own contribution.

As superintendent Eli Lilly continued his attention to the mechanical side of production. One of his first challenges came in manufacture of gelatine capsules, a tedious process of hand labor that often produced capsules that stuck together or shattered. Lilly effected some improvements by installing instruments to determine the temperature and specific gravity of the gelatin solution rather than rely on the workers' rule of thumb, but demand continued to exceed the company's means to produce capsules. In 1909 Lilly oversaw installation of ten Colton automatic capsule making machines. Four years later he moved these machines to a newly-constructed capsule plant and soon had in place a systematic layout of fifty Colton machines. A writer for *Scientific American* visited Indianapolis in 1917 and proclaimed the wonders of "the largest capsule factory in the world," capable of producing 2.5 million capsules a day-- all without the touch of a human hand [14]. Production soon exceeded the company's needs, leading to sales to others in the trade and to abortive arrangements to sell to Russia and Germany just prior to the opening guns of August 1914.

Although Lilly never lost his interest in machinery, he soon was devoting his largest attention to the process rather than the mechanics of production. His principal concern, he later wrote, "was with the time required for a given factory or laboratory operation. We wanted to perform the individual operation in less time" [9]. In early 1911 he brought a stopwatch to the McCarty Street plant to study systematically the many and varied tasks in the manufacture of pharmaceuticals. He began to set methods and standards of output to reward efficient workers with bonuses rather than piece rates. He achieved his largest success in the Gelatin Coating Department, where his time studies and bonus system resulted in increasing workers' pay by 40 percent and their output by 90 percent.

Lilly, of course, had been bitten by the scientific management bug, reading avidly the works of Henry L. Gantt, Frank B. Gilbreth, and Frederick W. Taylor. And while he had made progress on his own, he decided in 1913 that outside assessment and advice would speed that progress. He called in Harrington Emerson, one of the most popular scientific management consultants. Emerson's experts visited Indianapolis in 1913 and produced a 369-page report, praising especially the system of blueprinted manufacturing

tickets and the bonus system in the Gelatin Department, urging its expansion through the company. The experts returned for another visit at the end of 1913, staying for six months to help expand the new methods and standards.

Lilly's driving attention to speeding up production and cutting costs led also to addressing problems of seasonality in the pharmaceutical business. Demand was highest in March and October. In the month or two prior to this high demand the company hired new workers and then released them when peak sales passed. Lilly initiated a plan of producing ahead of demand by determining those drugs that were low in material costs and less burdensome in inventory. Production of these items during slow seasons enabled the company gradually to move toward a more stable and experienced labor force. At the same time Lilly attacked the problem of determining the most economical lot sizes for each product. High inventory costs argued for small lot sizes, while lower unit costs resulted from manufacture in large lots. Lilly and his assistants devised for each class of product a formula that balanced these variables and enabled a rapid and accurate determination of the most economical lots. These formula guided production decisions for decades to come. Other improvements came after a new accounting and inventory system was installed following a study done in 1916 by Ernst and Ernst. Soon thereafter the company purchased Hollerith sorting and tabulating machines to meet the needs of more detailed record keeping and analysis.

In pushing for more rapid flow of product through the plant and lower unit costs Lilly insisted on careful planning, intense supervision, meticulous record keeping, and standard, uniform procedures. A typically curt memorandum sent all supervisors in 1914 indicates his thinking: "No changes in details of manufacture or packaging shall be made except by written memoranda. No written memoranda seeking to effect changes in details of manufacture or packaging shall be authority for such changes unless it bears the following stamp" [8]. Formal, routinized methods replaced informal, rule of thumb methods.

The Indianapolis company grew rapidly in size and profits in the second decade of the twentieth century. In 1919 the Lillys decided on an ambitious program of plant expansion, with Eli Lilly serving as head of the project. His crowning achievement was Building 22, an example of what Alfred D. Chandler labels "the critical entrepreneurial act" -- "the construction of the plant of minimum efficient size required to exploit fully the economies of scale and scope" [4]. When completed in 1926 this new factory enabled raw materials to enter one end and exit the other as finished drugs, moving through the production process in a near straight line by means of an elaborate system of conveyors, lifts, pipes, and chutes. It was probably the most sophisticated production system in the American pharmaceutical industry. Lilly worked hard to design the layout for this straight-line system so as to meet his dictum that "The less time required in applying motion to material, all things being equal, the more profitable the business" [9]. Increasing the speed of flow and reducing human handling by means of conveyor transfer of materials had long fascinated Lilly. As early as 1907 he had investigated the use of mechanical conveyors, sustaining this interest with a tour of Ford's River Rouge plant just after World War I.

The introduction of conveyors was only the most obvious illustration of the new straight-line production system at Building 22. More important and difficult to achieve was the detailed planning necessary to make the system work efficiently. Unlike the builders of the automobile assembly lines, Lilly had to plan for the production of approximately 2,800 different products in Building 22. A myriad of pills, tablets, ointments, elixirs, and syrups, derived from all manner of raw materials, had to be produced, bottled, and packaged in many forms and quantities. Through the early 1920s Lilly labored over the details of setting up this complex new system so as "to permit the logical flow of work from operation to operation with the minimum of handling" [17, p. 81]. By 1926 Lilly and his associates had meticulously laid out the five floors of production. An editor from *Chemical & Metallurgical Engineering* concluded after a visit to McCarty Street that "those engaged in other process industries in which the diversity factor is assuming difficult proportions, will do well to examine the Lilly system and adapt its features to the solution of their own problems" [17, p. 83]. With great pride Lilly wrote an article for the business periodical *System*. Titled "We Find Out How to Speed-Up Production 50%," the piece claimed that "the majority of the departments of our business are putting material through the processes from raw material to finished, bottled product in half the old standard time" [9, pp. 598, 600].

By the late 1920s, then, Lilly had created a company culture in which a zealous employee used the word "efficiency" four times in one sentence and a Methods and Standards Department Manual advised workers that "Both hands should be busy; if they are not, surely some change can be made to keep them busy all the time" [15, 16]. But speed and efficiency were not Lilly's only goals. Indeed, though necessary to success, speed and efficiency alone were no longer sufficient conditions for survival in a rapidly changing pharmaceutical market.

By the second decade of the twentieth century graduates of America's expanding medical schools were warning their growing numbers of patients against the many dubious medicinals on the market. Such warnings were sound, for the 1905 revision of the *United States Pharmacopeia* contained, by a modern estimate, only a handful of efficacious drugs. Most of the work done in American pharmaceutical company laboratories was of a routine nature, focusing on quality control and standardization. Such work was difficult and important, especially with the rise of mass production, but it did not lead directly to basic research or efficacious new drugs [6, 18, 20]. Indeed, so unproductive were pharmaceutical company laboratories, according to physicians and university scientists, that the American Medical Association warned in 1915 that "it is only from laboratories free from any relation with manufacturers that real [pharmaceutical] advances can be expected" [23, p. 5]. World War I drew increased attention to the problem, as it cut off the supply of German pharmaceuticals and the scientific expertise behind them.

Eli Lilly and his father were very much aware of this changing environment. They knew that for old sales leaders such as Succus Alterans the days were numbered. And, J.K. Lilly admitted in 1919, "the development of new specialties of large possibilities by this house is extremely unsatisfactory" [11]. What was required, the senior Lilly reported, was the

creation of a new "department of Experimental Medicine ... on 'result getting' lines" [10]. J.K. and Eli Lilly made their first and most important move in the direction of scientific research by hiring in 1919 George Henry Alexander Clowes, an Englishman with a German university Ph.D. and one of the most respected biochemists in America. And they gave Clowes, at least during his early years with the company, the financial and intellectual freedom this brilliant but egotistical and independent-minded scientist needed.

Among the research initiatives Clowes brought to the Indianapolis company was an extensive contact with university scientists. It was one such contact, with scientists at the University of Toronto in 1921, that led to insulin. Historians Michael Bliss and John Swann have told the insulin story in full and compelling detail [1, 21]. Suffice it to note here that it was a genuine partnership between science and industry. The Toronto researchers produced a pancreatic extract that had near miraculous effect on diabetes patients. But they were unable to produce their insulin in any but very small quantities and at times not at all. The Lilly Company's contribution to the partnership was to develop methods of moving from small-scale laboratory production to large-scale manufacture, a task that proved extremely difficult but that was finally completed in the spring of 1923. This university-industry partnership was filled with friction, not only on scientific matters but on such questions as trade names, patents, licenses, and prices. There were few precedents or models, for as Swann notes, this was "the first long-term, large-scale case of biomedical collaborative research between a North American university and a pharmaceutical firm" [22, p. 73].

The results of the Lilly-Toronto partnership were salutary for both parties. To the Toronto scientists came the Nobel Prize in 1923. To the Indianapolis company came record profits from insulin sales. Long after September 1923, when other companies were allowed to enter the insulin market, Eli Lilly and Company continued to dominate sales of the hormone. Even more important, the insulin success attracted worldwide attention and certified the company's position as a first-rank, research-based pharmaceutical manufacturer. "We are now flooded by propositions from scientists both in this country and abroad to cooperate with them to develop their new item," J.K. Lilly proudly wrote in 1924 [12]. The days of Creek Indian remedies were gone, replaced by an expertise and a confidence that encouraged aggressive searching for sophisticated and efficacious new drugs and new ways to manufacture them. One employee later remembered, "we got our first pair of long pants in 1922" [2].

The scientific enthusiasms and the profits from insulin contributed significantly to creation of a university fellowship program and to construction of a new research laboratory in 1934. Four hundred university scientists attended the dedication ceremonies, marveling at the bright showcase for the company's achievement and promise in its own laboratories and in laboratories of cooperating university scientists.

Insulin was the most important drug in the history of Eli Lilly and Company, doing more than any other to make the firm one of the major pharmaceutical manufacturers in the world. But insulin alone did not bring this change. The research initiative begun in 1919 and marked by the hiring

of Clowes was essential. Also essential was the new sophistication in production that flowed from Lilly's long, hard push toward systematic management and mass production. "It was," he later recalled, "as if we had rushed ourselves to a point of readiness just to participate in this momentous event" [7, p. 9].

There were other challenges after insulin. Eli Lilly, who replaced his father as president in 1932, devoted major attention in the 1930s to employee relations, becoming as enthralled by the work of Elton Mayo and Fritz Roethlisberger as he had been by Galbraith and Taylor. Concerns about employee relations increased as the company grew in size. So did questions of administration and of family management. By the time he stepped down from active management in 1948 Eli Lilly had initiated a major plant expansion in Indianapolis, entry to overseas markets and production, and an extensive administrative reorganization that brought more middle managers to McCarty Street and prepared the way for the inevitable shift from family management. And he had kept the company in its leadership position in research, including development of the antibiotics that revolutionized health care in the postwar era.

Eli Lilly and Company thus became one of the handful of major pharmaceutical companies that dominated the industry, claiming on its fiftieth anniversary in 1926 that it was the third largest pharmaceutical manufacturer in the world. There is no single event, year, or individual the historian can point to as primary cause for such a momentous change. But central to the shift was the work of the young Eli Lilly in the 1910s and 1920s, energetically introducing improved methods of production and encouraging development of new products. Although little is known of other pharmaceutical companies, a few appear to have been engaged in similar efforts, including Merck, Squibb, Abbott, and Parke-Davis. Hundreds of others did not gain the economies of scale in production and the "first-mover" advantages in biomedical research. They fell by the wayside. Even J.K. Lilly, Sr., who sometimes resisted his son's enthusiasms, understood this new truth in the pharmaceutical industry: "any manufacturer," he wrote in 1925, "who does not follow the modern trend is simply going to be out of business" [13].

References

1. Michael Bliss, *The Discovery of Insulin* (Chicago, 1982).
2. Austin H. Brown, "Address before Twenty-Five Year Group," typescript, May 10, 1949, Company History Files, Eli Lilly and Company Archives, Indianapolis.
3. *Budget* [Eli Lilly and Company], 5 (May 15, 1909).
4. Alfred D. Chandler, Jr., *Scale and Scope* (Cambridge, Mass., forthcoming).
5. _____, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, Mass., 1977).
6. Jonathan Liebenau, *Medical Science and Medical Industry: The Formation of the American Pharmaceutical Industry* (Baltimore, 1987).
7. Eli Lilly and Company, *The First One Hundred Years* (Indianapolis, 1976).
8. Eli Lilly to S.O. Sharp, January 8, 1914, Memorandum-Misc., 1912-1929, XPDc, Lilly Archives.

9. Eli Lilly, "We Find Out How to Speed-Up Production 50%," *System*, 48 (November, 1925).
10. J.K. Lilly, Sr., "A Plan for Promoting the Affairs of Eli Lilly & Company during the Years 1920-21-22-23," October 26, 1919, XCAe, Lilly Archives.
11. _____ to Board of Directors, February 20, 1920, XCAc, Lilly Archives.
12. _____ to John Uri Lloyd, August 13, 1924, Insulin Folder, Company History Files, Lilly Archives.
13. _____ to R.A. Whidden, March 18, 1925, Lilly Letters, XCAc, Lilly Archives.
14. Harmon W. Marsh, "Glue Jackets for Disagreeable Medicines: How Gelatin Capsules Are Manufactured," *Scientific American*, 117 (September 15, 1917).
15. George Meihaus to Mr. Taylor, November 14, 1928, Manufacturing Tickets, Planning Department, XPDv, Lilly Archives.
16. Methods and Standards Department Manual, typescript, 1929, XIRe, Lilly Archives.
17. Theodore R. Olive, "Applying Mass Production Methods in a Pharmaceutical Plant," *Chemical & Metallurgical Engineering*, 35 (February, 1928).
18. John Parascandola, "Industrial Research Comes of Age: The American Pharmaceutical Industry, 1920-1940," *Pharmacy in History*, 27 (1985).
19. R.M. Reahard, "Forty-Three Years in Retrospect," *SuperVision* [Eli Lilly and Company], 3 (October 1948).
20. Glenn Sonnedecker, "The Rise of Drug Manufacture in America," *Emory University Quarterly*, 21 (Summer 1965).
21. John P. Swann, *Academic Scientists and the Pharmaceutical Industry: Cooperative Research in Twentieth-Century America* (Baltimore, 1988).
22. _____, "Insulin: A Case Study in the Emergence of Collaborative Pharmacomedical Research: Part II," *Pharmacy in History*, 28 (1986).
23. James Harvey Young, "Public Policy and Drug Innovation," *Pharmacy in History*, 24 (1982).

Eli Lilly & Co. discovers, develops, manufactures and sells pharmaceutical products. The company operates through two segments: Human Pharmaceutical Products and Animal health business segment. The Human Pharmaceutical products segment includes the discovery, development, manufacturing, marketing, and sales of human pharmaceutical products worldwide in the following therapeutic areas: neuroscience, endocrinology, oncology, cardiovascular, and other. The Animal health business segment operating through the Elanco Animal Health division, develops, manufactures, and markets products for both Eli Lilly and Company, Indianapolis, Indiana. 199K likes. Lilly unites caring with discovery to create medicines that make life better for people around...Â Eli Lilly and Company strives to create informative and engaging online communities that share infor See More. CommunitySee All. 199,148 people like this. 200,299 people follow this. 14,030 check-ins. AboutSee All. ELI LILLY & COMPANY (B) 1 Founded in 1876, Eli Lilly and Company (LLY) discovers, develops, manufactures and sells pharmaceutical products. The Company manufactures and distributes products through owned or leased facilities in the United States, Puerto Rico and 22 other countries.Â The company also has an animal health business segment that conducts research to find products to treat diseases in animals and to increase the efficiency of animal food production. Its products include Cymbalta for major depressive disorder, Humalog for type 1 and type 2 diabetes; Cialis for erectile dysfunction; Zyprexa for schizophrenia and bipolar mania; and Gemzar for small-cell lung, pancreatic, bladder, and metastatic breast cancers.