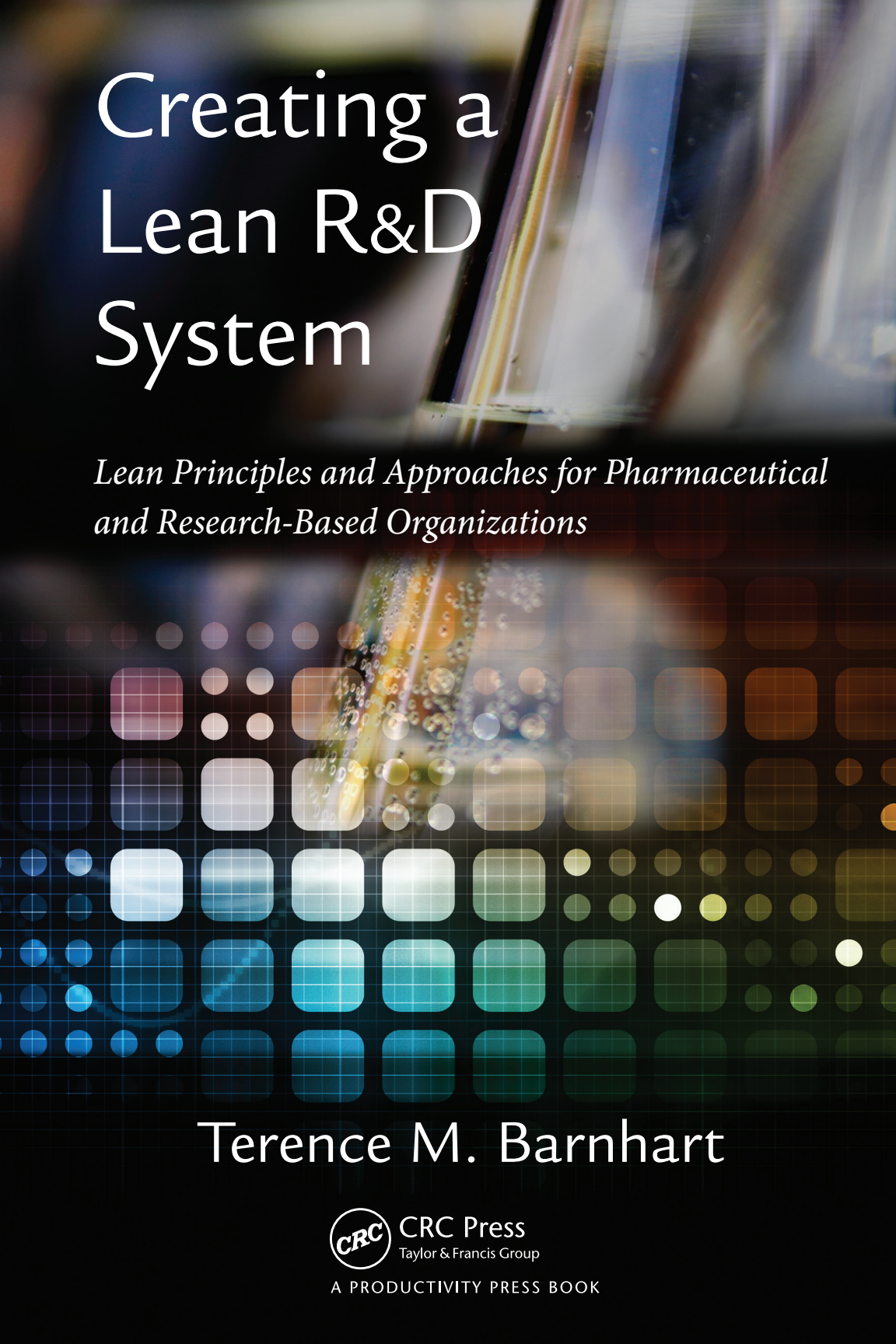
Creating a Lean R&D System
Lean Principles and Approaches for Pharmaceutical and Research-Based Organizations
Terence M. Barnhart
CRC Press
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A PRODUCTIVITY PRESS BOOK

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To Helen and Fiona and generations to come.

In loving memory of Dr. Leona Mae Barnhart.

Contents

List of Figures

Preface

Lean has a long and rich history of innovation and expansion. From some early efforts to improve a machine shop at Toyota, Lean's ability grew to where it could improve full production lines. Further effort enabled Lean to tackle the improvement of entire plant operations, and extended its value stream further and further back to its suppliers. Beyond production, Lean learned to improve strategy; to improve execution, technology, product development, and design; and to integrate these efforts into the growing learning capabilities of Toyota. From this expansion, it is clear that Lean is a learning, evolving platform—a research project whose goal is to explore the how and why of work and to devise ever-increasing capabilities to change work for the better.

I am very lucky to have been involved in the great research project known as "Lean." When I began my Lean experience in research and development (R&D), I was blessed with a new frontier to explore. There were, of course, and there remain, vast numbers of people engaged in improving technology, developing science, and pushing the frontiers of knowledge to create new products, technologies, processes, and capabilities. But at the time I began working in Lean, there were scant few people working to understand how to improve R&D, writ large, in a scientific and systematic way.

At that time, people were much more likely to imagine improving R&D productivity by giving it more (or less) money, organizing it into (or out of) functional or project teams, changing its location, scaling it up or atomizing it through outsourcing, or by changing the amount or timing of input from various functions. There were far fewer engaged in studying the thinking processes of R&D, the causes of R&D successes and failures, and the philosophies and assumptions about R&D, and in creating experiments to test, assess, and improve them. Yet there was, and remains, a need to answer fundamental questions that affect the capability of R&D in delivering valuable innovation. Can you learn to create "eureka!" moments that drive leaps in innovation, and if so, can you teach it? What are the barriers to innovation, and how can we remove them? In some areas, a key recurring question is: How can scientists better motivate themselves and each other to overcome

the crushing odds against their eventual success? And always, R&D requires the synthesis of knowledge. We build on knowledge of past scientists; we collaborate with current scientists; and we share—through documents, objects, and so on—with other researchers, including those of our future. So how can we increase the quality and rate of integration of historic and emerging ideas so that knowledge can build more quickly into marketable innovations?

While there has been research into those and other critical R&D questions, most of these are philosophical or retrospective analyses without follow-on experimentation to prove their validity in changing R&D capability. Only a handful of people were actually doing experiments at scale to test new ideas in R&D and to prove and adapt them to enable real improvement. It has been my great joy to have worked with a number of these people, and to have had the opportunity to be involved in the research, testing, and implementation to prove (and disprove) and synthesize (and deconstruct) some of their ideas and my own into a coherent path to R&D improvement.

Along the way, it should not surprise you that Lean manufacturing tools cannot always transfer directly into other fields, for example, research biology. Some of the ideas presented will not feel like Lean, especially to those who have not spent time reading and exploring the history and works of the key Lean architects (in particular, Ohno[*] and Shingo[†]). Ohno, in an interview, stated that the pursuit of improved manufacturing productivity stalled in the 1930s, but that Toyota continued on in the spirit of Henry Ford, innovating in manufacturing efficiency.[‡] These works stress the importance of thinking, the importance of experimentation, and the importance of learning to the development of Lean. Through these works, you can see the outcomes of this experimental endeavor, and what emerges is the strong impression of Lean as a decades-long and currently active research project.

Another, perhaps more subtle, message in these early works on Lean is the emphasis on people and community within the work environment.

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[*] Taiichi Ohno and Norman Bodek, *Toyota Production System: Beyond Large-Scale Production* (Portland, OR: Productivity Press, 1988). Taiichi Ohno and John Miller, *Taiichi Ohno's Workplace Management* (Mukiteo, WA: Gemba Press, 2007).

[†] Shigeo Shingo and Andrew P. Dillon, *A Study of the Toyota Production System* (Portland, OR: Productivity Press, 1989). Shigeo Shingo, *A Revolution in Manufacturing: The SMED System* (Portland, OR: Productivity Press, 1985). Shigeo Shingo, *Zero Quality Control: Source Inspection and the Poka Yoke System* (Portland, OR: Productivity Press, 1986).

[‡] Koichi Shimokawa and Takahiro Fujimoto, eds., *The Birth of Lean*, translated by Brian Miller with John Shook (Cambridge, MA: The Lean Enterprise Institute, 2009), 1, 13–14.

People at Toyota are expected to not only understand their jobs, but to experiment to improve their jobs. This is not merely true of managers of their employees, but of all employees at all levels. In this, there is a sense of community that is crucial to the existence (and in my view, the building) of Lean into the fabric of an organization. Realization of this connection to community came late to us, which is unfortunate, because the sense of community that is crucial *over the long term* in the production world is a necessary *precursor* for Lean in the innovation world. For this reason, it is presented front and center here.

Small improvements around the edges of R&D can be made by the application of Lean "tools" to the small number of manufacturing-like processes that exist within R&D. In contrast, by creating a sense of community purpose and research alignment and by building not merely an individual's ability to learn, but a community's ability to learn, an R&D organization can create leaps of innovation within its core responsibility of creating new products and processes. It can deliver nearly unimaginable improvements in R&D capability, perhaps as much as an order of magnitude or two.* Out of this community, new Lean tools, processes, and thoughts will emerge, just as they have done for decades in the manufacturing sphere, but it is important always to note that tools are not the answer in R&D any more than they were for Ohno in manufacturing. Just as in manufacturing, better thinking, better integration, and better community consistently deliver unexpectedly valuable results. It is into this realm that I invite you.

Finally, this book is but one more chapter in the research project that is Lean. Many other researchers will take alternative paths, some will build on this work, and others will find its flaws. Each case will expand Lean science beyond where it is today, and that is a good thing, for the more we explore, the greater is our ability to improve. I look forward to seeing where you take Lean on your journey.

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* Those who doubt this should recall that Ford achieved a four- to tenfold improvement in labor productivity by introducing assembly line work (David Hounshell, *From the American System to Mass Production, 1800–1932* [Baltimore: Johns Hopkins Press, 1984], chap. 6, 217–261). Meanwhile, Toyota increased its *manufacturing* productivity tenfold in the decade from 1946 to 1955 (Koichi Shimokawa and Takahiro Fujimoto, eds., *The Birth of Lean*, translated by Brian Miller with John Shook [Cambridge, MA: The Lean Enterprise Institute, 2009], 13) and has obviously made significant progress since then.

Acknowledgments

I have far too many people to thank than I can list here. There are literally thousands of Pfizer colleagues whose work, experiments, and improvements have led to the thoughts embodied in this text (and none of them, by the way, are to blame). The number of colleagues who have directly redesigned their work as a result of projects I have supported is significantly more than 2,000. The number of colleagues who have implemented at least some of those changes in the wider organization must be close to 5,000. Each of you has my respect and thanks. It has been a joy to work with you every day.

Beyond the wisdom of my colleagues, I have been influenced by several individuals over the course of my time in Lean. Jim Luckman got me started on my journey with his excellent course in Lean product development. His subsequent coaching and thought partnership led to many of the "discoveries" that we developed into our own Lean practice at Pfizer. His colleague, Beau Keyte, provided the most breathtakingly important coaching moment of my Lean career when he mentored me to bring my first workshop back on the rails. We have continued to collaborate and to share methods and experiments as well as our lifelong love of Michigan football.

Jim introduced me to Bob Burdick, a former Lexmark/IBM engineer, whose research into physics, Taoism, Buddhism, and his dialogues about "have-do-be" (and nearly everything under the sun) created within me the ability to explore thinking in a way I'd never have imagined possible.

Monica Schroder worked with me in Agile R&D (Lean) and opened new pathways in thinking on an almost constant basis. Not just small diversions, these paths were big, wide highways of thought. She introduced me to Gary Hamel's work on radically different paradigms in business management. Not to be outdone, Adrienne Motion brought the personal touch to Agile R&D, creating a warm approach that negated the cold, calculated, tool-centric thought process that characterized its beginning. Similarly, Diana Galer introduced ideas like Nancy Kline's "time to think," which enabled us to build deeper reflection into our facilitation work, and thereby led us to much, much greater improvements.

Finally, Andrew Seddon was a part of nearly every project, every strategy session, every emerging development and experiment; and he had a special love and talent for creating, supporting, and engaging improvement in the most basic research in the company. Adrienne, Monica, Diana, and Andrew were a breathtaking group to behold in action, and I both honor and revere their capabilities and contributions.

I owe a large debt to the "Boyd" community and to the U.S. Marine Corps for supporting and nurturing that community. John R. Boyd was a fighter pilot, engineer, aircraft designer, and, most important, researcher into strategy, learning, community, innovation, and winning and losing. Although he purposely refrained from writing a text, his slide decks and briefings (many thanks to Chet Richards for presenting and explaining these and for being a mentor and friend for several years now) provide tremendous and unfolding insight. Jim Luckman's slide on learning loops led me to Robert Coram's biography of Boyd, which led me to Boyd's "Disciples." Chet Richards, who gives the authorized version of Boyd's briefings live, deepened and expanded my view of Boyd and his work and gave me direction. Frans Osinga's work gave me so much more depth and background into Boyd's thinking. The entire Boyd community continues to populate new ideas and insights. Boyd's work inspired much of the experimentation in community and fast learning, and provided early thought into what became the "wildfire" strategy. Within this community, several people stand out as mentors, co-creators, and inspirations, including Stan Coerr, its host; Scott Shipman, my friend and intellectual mentor; Michael Moore, a uniquely creative light; Marcus Mainz, the next generation; and Fred Leland, the relentless Lieutenant of Walpole, who tries and succeeds at delivering fast learning to communities near you.

In addition to the great colleagues across Pfizer, special kudos go to Pfizer's Strategic Management Group, which gave me the space not only to create thought pieces in Lean, but to actually test them in the real world of pharma R&D, and then to grow those experiments into a fully operating Lean R&D transformation group (Agile R&D).

Finally, I want to thank my family for their support through the always turbulent waters of personal and professional growth.

Introduction

MORE THAN MEETS THE EYE

People often ask what Lean looks like in research and development (R&D), or ask to see a site that is operating in a Lean way. This gives me pause because Lean in R&D doesn't necessarily *look* different than any other R&D environment, but it does *feel* different, and its operations might as well be on different planets for all of the similarities they share.

That said, I am left with the unenviable task of describing a feeling. Luckily, nearly every human has experienced this feeling and, therefore, we just need to link ourselves to it through analogy. For most of us, there was a time in our lives when we were a part of a group, perhaps a sports team, perhaps a choral or jazz ensemble, perhaps just a group of very close-knit friends, who achieved this state or feeling. Eventually, your group had worked together, been together, practiced together, performed together, and, perhaps, gotten into and out of trouble together long enough that each member felt he or she had intimate knowledge of what the other group members would do in a given circumstance. You just knew, without speaking, signing, or even looking at each other what would come next. Any emerging circumstance will fit seamlessly, naturally into the group's ongoing activities. The jazz band that pulls a yell out of the audience and distills it into a trumpet solo that then passes to the brass and on to the rhythm section has felt this. The hockey team that flows to the puck, passes without looking, adjusts to the greatest and least effort of its opponent, and scores seemingly without effort has experienced this. The friends who *just know* that, because it is Tuesday and the sun is out, Frisbee in the park is on (and bring extra water because someone will bring a new friend to join the group) has this feeling.

The feeling is an intimate sense of community, of belonging, combined with an indescribable but intensely energizing feeling of being "on." It involves trust and shared experience, a common purpose, and a sense of

place. It involves a sense of personal commitment to others, and a group commitment to the person, but it neither involves nor requires a hierarchy, only shared capability, knowledge, direction, and common bonds.

Those grand words may strain credulity, and yet I watched teams at Pfizer build just such trust and confidence, collaboration, and capability, and do so in short order. Moreover, the same values that accrued to our group of friends, our sports teams, and our musical ensembles, when they reached that level of connection, accrued to these R&D teams. Their performance jumps to an almost ridiculous level. Following one example, a team's speed of scientific discovery increased by a factor of six; their newly developed scientific approach invalidated several disease hypotheses being actively pursued in the laboratory and, much more expensively, in the clinical trials of many global pharmaceutical companies. That same science identified likely causal pathways that no one had yet identified, creating uncharted opportunity for the team to pursue.

Other levels of performance changed just as dramatically. Scientific milestones were *never* missed. Progress was made on previously intractable problems. New paradigms of research, testing, and data manipulation emerged. New paradigms of project and scientific management were created, freeing up as much as 50 percent of management's time to invest in creating even more effective environments in which people and innovation could thrive. The whole *atmosphere* within the work area changed. It was noticeably calmer, happier, and more energized than other work spaces in the company. Conservatively, the level of performance increased a good two orders of magnitude in just five months.

That said, concrete outward signs of change were difficult to quantify, since, fundamentally, the differences between Lean and non-Lean R&D arise from different assumptions about how the universe works and how people work, interact, and flourish in that universe, as well as about how best to construct an environment in which people can create and deliver valuable innovations within that universe. These different assumptions have no outward physical component. The same people still read scientific literature, still design and execute experiments in the same laboratories with the same equipment they always did; they just think about their work in a radically different way, and that makes all the difference.

Author

Terence M. Barnhart, PhD, has worked as an academic and industrial research scientist, a strategy consultant, a plant engineer, and a project manager for some of the largest and best-known companies in the world, including Pfizer, McKinsey and Company, and General Electric. His professional passion is researching, developing, and implementing strategies to help people create environments in which they and others can flourish.

Dr. Barnhart received his PhD in inorganic chemistry from the University of Wisconsin and a bachelor of science degree and post-doctoral fellowship in chemistry from the University of Michigan.

1

Seeing and Removing Barriers in the R&D Environment

As I look out the front window of my house, I tend to absorb the beauty of the scene. There is a beautiful oak tree out there next to the dock. The dock juts out into a cove. If it is summer, there is a swim platform floating fifty or so feet across the inlet, and if it is daytime, people, especially children, can be found playing in the water. To the left, the inlet opens onto the river, a shallow half-mile-wide estuary with clamming and moored boats, posts with osprey nests, and navigational signs and buoys.

Depending on the day, it may be dreary or blindingly brilliant. I may see a sunrise that catches my breath, or snow and sleet. I may see violent weather that only wind, wave, and my own vulnerability can reveal, or depths of peaceful tranquility that only calmness and water seem to inspire within me. I will be annoyed when the geese come (their facility for turning green plants into fertilizer is somewhat frustrating), and I will be joyful when the swans appear, marveling at their beauty and the facility with which they run the geese out of town.

I am not a fisherman, but my neighbor is. He sees everything that I do, but he also sees that the bait fish are (or are not) running. He sees the waterway not merely as a place to swim or paddle, or to observe beauty, but also as a right-of-way to the ocean and the trophy bass that it may yield in future expeditions. The neighbor behind me, a retired commercial fisherman, sees the same channels as a source of employment, seeing the water—haven to many different species—by its seasons of harvest.

At the same time, none of us is a navigational engineer, so we do not see the changing depth of the channel and the consequent need to dredge, place markers, or remove obstacles. None of us is a biologist, who might