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So, You Have a Game-Changing Discovery… Congratulations!

Vision without execution is hallucination.

—Thomas Edison

Some of the best days in the life of a researcher are those where you get the data back from a key experiment to find that you have proven your hypothesis, met your design objective, or just flat out made a new discovery. That excitement and sense of fulfillment is, in part, what drives academic faculty. The discovery and the dissemination of those important findings are the well-deserved products of tenacious research endeavors.

There may be a day when you realize that your discovery has real promise outside of the lab—it could be a game changer. But what's the best way to get this discovery from the lab to commercialization? Academics are trained in graduate school and during our postdocs in how to run a lab, design experiments and write grants, analyze data, write papers, present scientific findings, and teach. To date, the academic community has not used this same apprenticeship model for systematic training in aspects of entrepreneurship, especially academic entrepreneurship and all of the steps and decisions that need to be made to "translate" your discovery to commercialization (Figure 1.1), where it can become a product or service to meet a need in our society.

And yet, many academics roll up their sleeves and try anyway. Without training and often with little guidance, academics make their way through intellectual property (IP) law (United States and international), market assessment, value propositions, licensing agreements, negotiating business relationships, finding a good corporate partner, and starting and financing a new company. This book is intended to provide a process that will allow a step-by-step approach to evaluate and realize commercial potential of your research findings. To supplement the methods, there are summaries of

Academic Entrepreneurship: How to Bring Your Scientific Discovery to a Successful Commercial Product, First Edition. Michele Marcolongo.

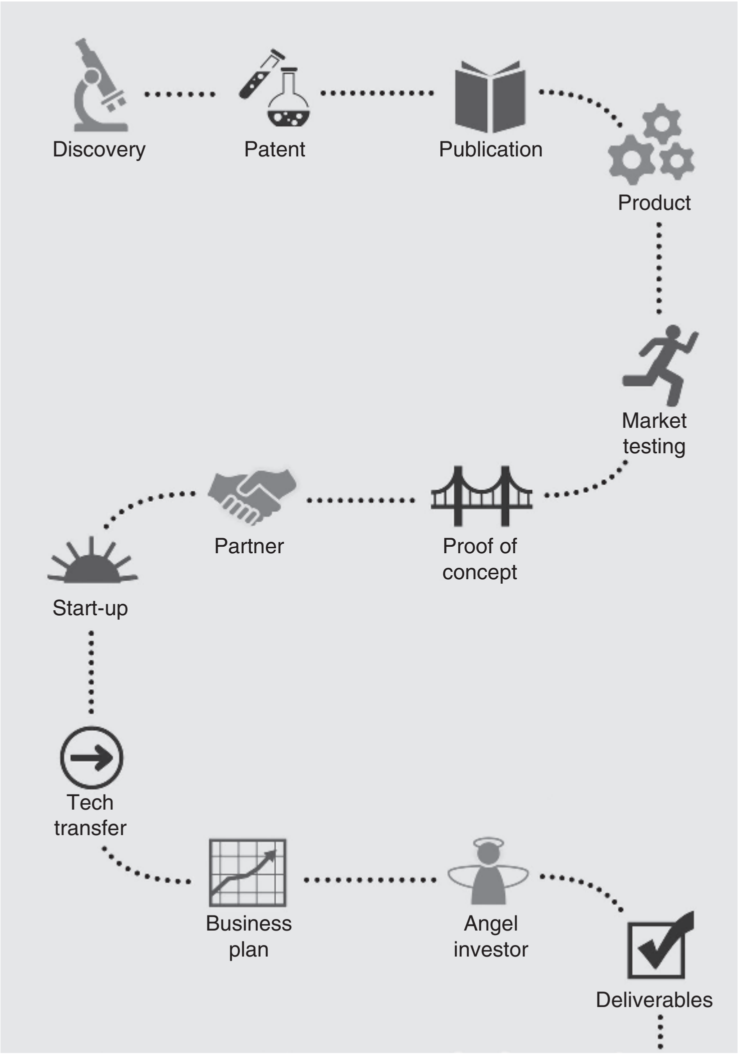

Figure 1.1 Start of the path toward commercialization of an academic discovery.

interviews with notable members of the academic entrepreneurship ecosystem including investors, heads of proof-of-concept centers, incubator directors, and numerous academic entrepreneurs themselves. To get started on your path to entrepreneurship, please go to Chapter 2. For a very brief history of how we got to this point in academic entrepreneurship, continue through the rest of this chapter.

Brief Review of Academic Entrepreneurship

How did we get to the point of academic research turning into commercial products and services? Some academics are not interested in commercializing a research finding (but probably not many of those reading this book). They're driven solely by the probing of new knowledge and not by bringing the fruits of that knowledge back to society in ways other than the traditional methods of publishing findings and training students. Indeed, if universities don't provide a place for fundamental research, where will it be done? With notable exceptions, corporations that used to have major internal research centers have cut those back dramatically with a preference for outsourcing or acquiring early-stage research. Early-stage research and discovery is a concept that is critical to the advancement of basic knowledge, but expensive to support with the constraints and impatience of real-world corporations today. The Bureau of Economic Analysis (BEA, 2014) cites a decrease in research and development (R&D) growth from 7% in 1965 to 2% in 2013, with a 50-year average of 4.6%. From 2007 to 2013, the average was 1.1%. This corresponds with, but may not be causal to, a reduction in the number of corporations that publish in scientific journals, which have gone from 17.7% in 1980 to 6.1% in 2007 (Fortune, 2015). A tremendous source of research is our national labs whose members contribute research, but with a focus that is primarily mission driven, potentially limiting the breadth of basic research questions. Along with teaching and service, research is a primary mission of an academic faculty member who then disseminates those findings openly to the scientific community. Can we maintain this "purity" while extending our definition of dissemination of findings to include translating discoveries toward commercialization where they can more directly address societal and technological challenges?

In the book *Open Innovation*, Henry Chesbrough summarizes the evolution of research within the government, universities, and corporations (Chesbrough, 2006). From the turn of the twentieth century until World War II, the US government was generally uninterested in supporting university research. The government's few scientific interests were in understanding gunpowder as well as in developing a system of weights and measures. For corporate protection, the US patent system was initiated. During this same period, basic science was in an amazing state of discovery in universities across the world. This was the time of Einstein, Bohr, Roentgen, Maxwell, Curie, Pasteur, and Plank. These were "pure" scientists. However, pre-World War II universities lacked funds to conduct significant experiments themselves. During this time period, Thomas Edison invented the phonograph and electric light bulb. Edison, however, was considered by the university scientific community to be a "tinkerer" of "lesser ability," who had compromised himself and corrupted the process of scientific discovery. Thomas Edison held 1093 patents.

Corporations during this time needed to work toward innovative products, so they began internal R&D within the companies. They were able to hire top scientists with jobs for life, creating academically stimulating corporate environments. Corporate scientists performed basic research that in some cases also led to product development. The centralized R&D organizations were critical to growth and business opportunities for the high-growth corporations. At that time there was little connection among government, university, and corporate research (each being mostly closed systems).

After World War II and through the 1970s, the US government's interest in supporting research was greatly enhanced. President Franklin D. Roosevelt realized that the United States needed to import much of its scientific knowledge and technology from Europe for weapons development during World War II. Roosevelt charged Vannevar Bush to study ways that the United States could increase the number of its own trained scientists. He wanted to simultaneously aid research activities in the public and private sector and increase federal funding of basic research in universities. Roosevelt envisioned a strong and independent scientific reservoir in the United States, in part as a defense strategy. To satisfy these needs, the National Science Foundation (NSF) was formed to coordinate efforts between government, universities, the military, and industry. The GI Bill of Rights was also enacted to fund tuition for veterans returning from war. As universities found themselves with a new influx of research funding from NSF, academic science was elevated to more equal partner with the government and industry. The government was now funding basic research in universities whose faculty, through open publication, were expanding the pool of knowledge available to society and industry.

After World War II, colleges and universities trained many new undergraduates and graduate students. This decentralization of knowledge enabled industry to increase internal R&D. There was expansion in Bell Labs, GE, and DuPont in addition to the formation of Watson Labs at IBM, Sarnoff Labs at RCA, and then others at HP and Xerox. Employees from Bell Labs and IBM received Nobel Prizes, and those at DuPont discovered new chemical fibers and materials. Chesbrough summarizes that this was the "golden age for internal R&D." The United States enjoyed growth of the postwar industry for over two decades. But the corporate closed innovation system was soon to come to an end.

Consider the US economy during the 1970s. The Japanese and German markets were taking off, and it looked as if the United States would lose the high-tech industry, while the economy was experiencing double-digit inflation and unemployment (AUTM, 2012). The federal government had a policy of taking all federally funded university inventions and licensing them to companies nonexclusively. With the lack of IP protection against competition (because of the nonexclusivity of the license agreements), companies were not actively pursuing the university inventions. The federal government held 28 000 patents with fewer than 5% licensed to industry (GAO, 1986). While numerous scientific advances were being made, it was felt that the great investment in university research from the American taxpayers, then billions of dollars, was not significantly making its way back to those taxpayers to advance the standard of living and economic viability of the United States.

In 1980, two US senators got together and formed legislation that again changed the innovation paradigm for the United States. The Bayh–Dole Act (1980) was motivated by widely held belief in the late 1970s that the United States would no longer be industrially competitive. Senators Birch Bayh (Indiana) and Bob Dole (Kansas) initiated a law that created a uniform patent policy for federal agencies that support research. The major focus of this law was to enable small businesses and nonprofit organizations (universities) to retain title to inventions made under federally funded research programs (http://www.autm.net/Bayh_Dole_Act1.htm).

Bayh–Dole Act led to new provisions to universities that are funded by federal agencies:

- Nonprofits, including universities, and small businesses may elect to retain title to innovations developed under federally funded research programs.
- Universities are encouraged to collaborate with commercial concerns to promote the utilization of inventions arising from federal funding.
- Universities are expected to file patents on inventions they elect to own.
- Universities are expected to give licensing preference to small businesses.
- The government retains a nonexclusive license to practice the patent throughout the world.
- The government retains march-in rights.

Now and for the past thirty-plus years, universities no longer provide free-of-charge, federally funded research findings to companies to advance industry. With the advent of Bayh–Dole, the universities themselves can protect the IP of their findings, and even though the research will still be published and knowledge shared openly, industry is no longer legally permitted to take the protected ideas of universities and use them to advance their products and profits. This primary change set a new dynamic for innovation that has undergone many iterations to bring us to present-day university policies. Corporations are able to license IP (exclusively or nonexclusively) directly from universities or national labs if they would like to commercialize discoveries from federally funded research. This option is extended to faculty members who are able to license university-owned IP through the vehicle of a start-up company.

State of University Technology Transfer

The Association of University Technology Managers (AUTM) was founded in 1974. In 2016, the organization had 3200 members from 300 universities. The mission of the organization is the support and advance technology transfer globally. AUTM has summarized the statistical productivity of university research toward innovation and economic development with citations from "The Gathering Storm," the 2006 report of the National Academy of Sciences. To summarize, since the initiation of the 1980 Bayh–Dole Act, university research helped create whole new industries, such as biotechnology. In addition,

- More than 5000 companies formed around university research resulted, many nearby the universities where the original research was performed.
- University patents in 2005 totaled 3278 up from only 495 in 1980.
- In 2005 alone, universities helped introduce 527 new products to the marketplace. Between 1998 and 2005, 3641 new products were created.
- University technology transfer creates billions of dollars of direct benefits to the US economy every year.

According to the former president of the NASDAQ Stock Market, an estimated 30% of its value is rooted in university-based, federally funded research results, which might never have been commercialized had it not been for the Bayh–Dole Act (AUTM, 2012). All the while, researchers in the United States led the world in the volume of articles published and in the frequency with which these papers are cited by others. US-based authors were listed in one-third of all scientific articles worldwide in 2001 (Committee on Science, Engineering, and Public Policy, 2007).

AUTM (2012) reports the following metrics:

- 22 150 total US patent applications filed
- 14 224 new patent applications filed
- 5145 issued US patents
- 5130 licenses executed
- 1242 options executed
- 483 executed licenses containing equity
- Total license income: $2.6 billion
- 705 start-up companies formed
- 4002 start-ups still operating as of the end of FY2012

There are some interesting inferences that can be drawn from this data. First, in consideration of the amount of federal research dollars spent in the United States in 2012 ($40 billion), there were 22 150 patent applications filed and 5 145 patents issued. Broadly, there is approximately 1 patent filed for every $7.7 million in federal research dollars spent. The long lag between patent filing and review makes the issued patents a lagging indication of productivity. The resulting licenses were 5130. There were 705 start-up companies formed, and these employed approximately 15 000 people. The data showing that 80% of licensed patents went to existing companies indicates that academia is still supporting corporate industrial growth in the

United States and that companies in some industries are interested in licensing directly from universities. The 20% of licenses that went to start-ups is interesting in that this segment is a significant portion of the licenses. This can be compared with 2002 data that showed 14% of university licenses went to start-ups (Shane, 2004). Pro and con Bayh–Dole advocates have fairly strong opinions of the consequences to this law, which was summarized in a quote by James Pooley who says, "At the end of the day, what we've learned from Bayh-Dole is that by harnessing the capitalistic system, we get a lot more technologies out to market and, arguably, a lot more spread into other areas as well" (Slind-Flor, 2006). Academic entrepreneurs now make up a growing and significant part of the industry that translates knowledge from universities toward commercialization. Because this is an important market phenomenon, academics in another part of the university, the B-school, have become interested in studying this population to learn about academic start-ups.

Study of Academic Entrepreneurship

Business school academics have developed an independent discipline that studies and analyzes academic entrepreneurship. The academic entrepreneurship literature is rich with insights of some key areas: characteristics of an academic entrepreneur, which universities are best adapted to successfully support academic entrepreneurship, organization, and policies of the technology transfer office and environmental context network of innovation, social networks, and relational capital. The motivation for understanding these drivers is clear: policymakers, universities, and business leaders desire a clearer knowledge of the characteristics of academic entrepreneurs and the policies and practices that promote them. Some characteristics of an academic entrepreneur and the likelihood of an academic becoming an entrepreneur have also been investigated.

The characteristics typical of an entrepreneur:

- Ability to take risks (but not excessive risks)
- Innovative
- Knowledge of how the market functions
- Manufacturing know-how
- Marketing skills
- Business management skills
- Ability to cooperate
- Good nose for business
- Ability to correct errors effectively
- Ability to grasp profitable opportunities

For 1780 academics examined for participating in technology transfer, "individual attributes, while important, are conditioned by the local work environment" (Bercovitz and Feldman, 2008).

Academics were more likely to become academic entrepreneurs if:

- They were trained in institutions that had accepted technology transfer.
- They were closer to their graduate training (those farther away from graduate training had less participation).
- Their department head was active in technology transfer.
- Respected members of their academic community were participating in technology transfer (sometimes known as the "Porsche effect").

If, instead, academics find the social norm of the department or the community is not supportive of technology transfer, even if they received training in entrepreneurship, they will conform to local norms rather than prior experience.

Tenure/tenure-track faculty taking on entrepreneurship were also affected by the standard by which their contributions are measured for tenure and promotion. Assessment for tenure and promotion for STEM faculty are scholarly output (typically analyzed by the amount of externally funded research support, scholarly papers and other scholarly work, training of doctoral students, and academic reputation) in addition to teaching and service accomplishments. Academic entrepreneurship is not included in the performance reviews of most academic faculty members, although several universities have recently adapted entrepreneurship activities into the tenure and promotion metrics. Therefore, especially during the critical pre-tenure years, as well as at the associate professor level, academics are indirectly discouraged from pursuing academic entrepreneurship by not being rewarded for these endeavors. As universities are becoming more interested in the advancement of their research innovations to commercialization, policy change will surely be necessary to facilitate this activity in a major way without penalty for the faculty member in tenure and promotion (Stevens *et al.*, 2011). For those who decide to pursue academic entrepreneurship anyway, there are some interesting findings of how start-ups from academics differ from other high-tech start-ups.

Academic Start-Ups Are "Early Stage"

Because university start-ups often initiate from a discovery and not necessarily from a clearly defined product and market need, university start-ups can take a great deal of additional R&D before they can become a viable businesses according to Lubynsky (2013). This is often a frustration to the academic inventor who has worked, perhaps many years already on the initial invention, only to hear repeatedly that the technology is really "early stage" by investors and the broader business community. Lubynsky studied 10 start-ups out of MIT, most of which were led by graduate students with concepts developed in collaboration with their faculty mentor during the course of their doctoral work. Even in MIT's entrepreneurial community with substantial resources and support for academic entrepreneurship, out of 10 start-ups, 2 failed after about 10 years, 2 were acquired after 8 and 10 years, and the remaining 6 were still in business with duration ranging from 0.5 to 10 years at the conclusion of his analysis. Regardless of the outcome, the research phase of the start-up lasted between 3 and 10 years. Lubynsky concludes that academic ventures are different. Many academic entrepreneurs believed that the only effective path to advance the technology was to form their own start-up. Another interesting finding of the study relates to the importance of students (graduate students and postdoctoral researchers) in academic entrepreneurship with students being major contributors to the academic start-ups. While the students were critical to the start-ups that were successful, they also found challenges in the companies that were studied. Two common conflicts for the student entrepreneurs were with their faculty advisors and with business student partners in business plan competitions. Part of the challenge for all of the academic entrepreneurs was the transition from well-developed academic networks to networks in the entrepreneurial community.

Robert Langer, Ph.D.
David H. Koch Institute Professor
Department of Chemical Engineering
MIT

Only a few more and MIT's Bob Langer will have more patents than Thomas Edison (1093), not to mention 1250 journal articles. Wow.

Bob's accomplishments for the scientific world are impressive by any standards, and he has been recognized with numerous prestigious awards. But what might be most notable is Bob's dream to "use his background in chemistry and chemical engineering to improve people's lives." Founder of 28 companies to date, Bob's academic entrepreneurial efforts have fulfilled this dream over and over again.

An entire book should be dedicated to understanding the brilliance and tenacity of Bob Langer. Here we'll focus on some of Bob's observations about academic start-ups.

An article on The Langer Lab by Harvard Business School (Bowen *et al*., 2005) summarizes Bob's own process of the "four elements of an ideal research project" and notes the "symbiotic relationship between science and science-based business":

1) *A huge idea* conceived by recognizing a critical societal need that could be met by inventing a platform product
2) *A seminal paper* based on research to establish the science underlying the product concept and its efficacy
3) *A blocking patent* derived from patent disclosures written in parallel with the research process, the goal being to have patents filed before the research paper's publication
4) *Preliminary in vivo studies* in animals that demonstrated the efficacy of the research

Some academics are lucky enough to hit on these four elements a couple of times in a career, but Bob and his lab have the creativity, intellect, and drive to do this almost annually. The resulting companies have given Bob tremendous insights into the academic start-up process.

When discussing what he wished he had known before embarking as an academic entrepreneur, Bob had a ready reply: "1. How to find good investors; 2. How to find a good CEO; and 3. How important it is to have a really good plan before you do lots of research."

Bob has had a business partner for each of his companies. Now, he doesn't have any trouble finding a good CEO, but in the early days it was more difficult. "It's hard to know when you have a great CEO, but easy to know when you have a poor one."

With his broad experiences in start-up companies, Bob can offer many perspectives, but perhaps most unique is his vast experience with exits. Most academics with start-ups may have an exit opportunity one, two or maybe three times…Bob could do a statistical study on his!

Many founders have trouble letting go of control of their company with a sale. How does Bob approach exits? By the time there is a decision of an exit, he feels it's a joint decision. Aside from IPO's (to bring resources into the company), there are two reasons why exits occur: The first is financial interest. If a preemptive offer is extended (2–3X), then investors are interested in the deal. The second may be unique to the medical sector where the commercialization and sales process is complicated and a lot of capital is needed to do the work. Sometimes before the product is launched, another company will buy the start-up and put in the investment to take the product to the clinic. With mergers you lose control, but gain resources to advance the technology.

When you transition your start-up to a larger company, there still are challenges. Financially, "milestone-based payments are bad," especially when you don't have control over the budget or work any longer. Some companies do a good job of taking on technology, but others may have priorities that are not aligned to those of the start-up. What forces them to do a good job is the contractual arrangement. These terms can vary widely, but in general they are intended to cover what happens if there is a lack of progress after the sale, for example, additional payments are to be made or technology is to be given to the start-up.

There is "no particular answer for a company and many variables." Exits depend on whether the technology is a one-trick pony or platform. For a platform, Bob wouldn't want to sell quickly because you have more "shots on goal." "Developing the technology across lots of product spaces is a good thing."

Does Bob like all of the financials and board meetings that go with the company management? Not really. He prefers more creative endeavors. However, Bob recommends that the founders have a representative on the board of the start-up. It's the best way to "really know what's going on, including understanding the financials."

How has Bob managed his tremendous success in translating his research findings to commercialized products to help people? I've had "lots of good students, lots of opportunities and made lots of mistakes."

All of our mistakes should be so fruitful.

Social capital describes the resources you use to execute your objectives through your network. There are differences in the networks that are necessary for academic research and academic start-ups. Social capital evolves from your network and helps you best complete your work (De Carolis and Saparito, 2006). For a faculty member, the social capital may be the dean, department head, the research office administrator, the registrar, program director, purchasing representative, students, and fellow professors, among others. For an entrepreneur, this network may include quite a different circle, such as the patent and contract attorneys, business entrepreneurs in your sector, accountants, local economic development administrators, technology transfer officers, corporate players in target sector, angel investors, and venture capitalists (Figure 1.2). The intersection of these networks of social capital is divergent for the most part with little overlap. A university system that provides a faculty member with the opportunity to develop social capital in the entrepreneurship ecosystem may more efficiently drive commercialization.

The current state of academic entrepreneurship is in different stages of maturity among the different research institutions across the country. Challenges include creating a supportive ecosystem, methods for navigating the university processes and policies, and moving a start-up forward while maintaining an active research lab. The National Academies Press has published a report (2013)

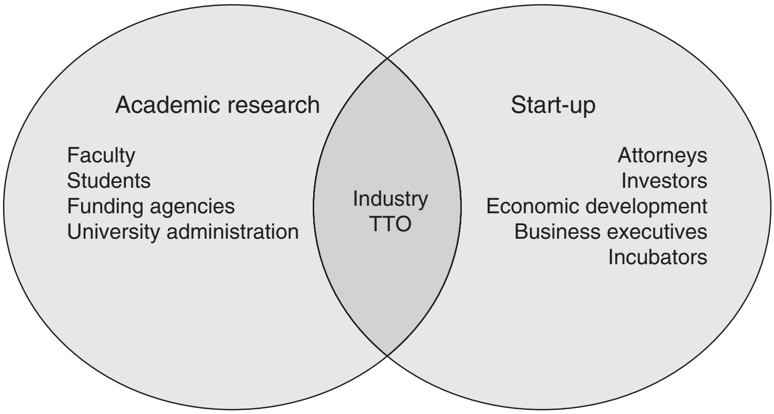

Figure 1.2 The social capital needed for academic research and translation of that research into a commercial product or service can be very diverse.

that discusses trends in the innovation ecosystem through a collaboration between the Academies of Sciences and Engineering and the Institute of Medicine. Their analysis summarizes the state of national universities toward supporting innovation (Olson and Dahlberg, 2013):

- The knowledge and experience of individuals are the primary drivers of innovation.
- Science and technology expertise alone is not enough to ensure innovation; the skills of finance, business development, production, and management are useful.
- Innovation is stimulated by the movement and interaction of individuals from different sectors.
- The culture of a region and its institutions shapes the nature of these interactions.
- Openness to new ideas and a tolerance for failure are important.
- Culture is not easily changed, and creating clones of Silicon Valley might be the wrong strategy.
- Innovation is a contact sport and might be facilitated by a concentration of talent that increases the rate of interaction.
- General principles do not explain everything. Significant differences exist among institutions, regions, industries, and sectors.

Among the most interesting observation by the members who collaborated on this report is that "general principles do not explain everything." It is interesting that while there is an overall process for translating research to commercialization, there is not a governing path to ensure success. The process is multifaceted, and each component of the business development has its associated risks that need to be managed uniquely for each case. This being said, there is a general process that can be put forth as a framework to take a scientific discovery on the journey to commercialization.

Overview of the Process

The challenge with creating value from a scientific discovery revolves around limiting the risk associated with the business proposition to secure investment and then executing on a well-considered plan using those resources. The types of risks may include technical risk of the product or service working, being scalable and cost effective; marketing risk so that there is a buyer when you are ready to sell; team risk, which may be the most important of all to investors, having a talented, coachable team that can deliver on promises; and for some industries regulatory or reimbursement risk. While the chapters of the book are laid out serially, the process is iterative. Constant analysis and associated minor adjustments or major pivots may be necessary throughout the process, iterative toward convergence. The first step begins in the university lab (Figure 1.3).

The first step toward value creation is the protection of your discovery and is discussed in Chapter 2. After deciding the mechanism of protection (patent,

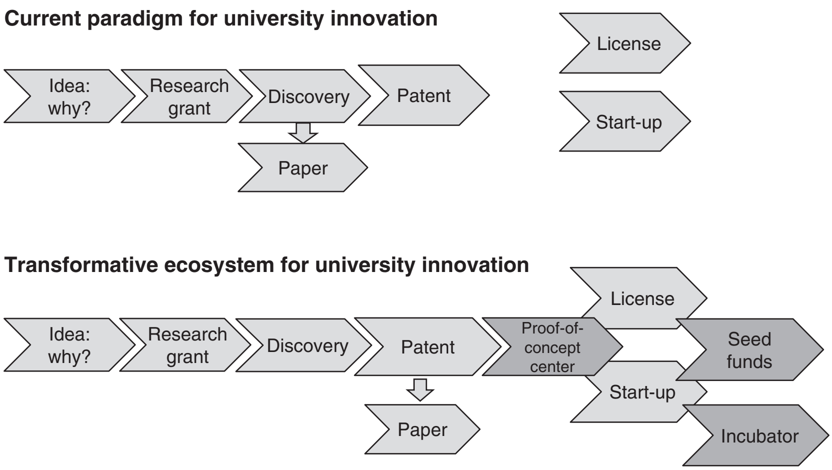

Figure 1.3 Research and dissemination of research findings typically follow the path (top) where there is a disconnect between the university flow to commercialization of the discovery as a product or service. To facilitate translation of research findings, a few key components to the process may be added to the university system, such as a proof-of-concept center, seed funds, and an incubator or accelerator in the region.

trademark, copyright, or trade secret), you will need to work with your tech transfer officer to disclose the IP, go through the university decision process for filing the IP, and work with a patent attorney to write the IP application in a smart way that will differentiate you from others. The protection of your IP needs to be addressed prior to disclosure of your invention external to your university in order for the patent to be valid. The concept will need to be described in the context of prior art, such as all pertinent previously published patents or patent applications, journal articles, abstracts, presentations, website descriptions, or the like. For a patent application, the description will have to be deemed novel and non-obvious by the patent examiner to be granted. You will need to make filing decisions on provisional or non-provisional follow-up with a Patent Cooperation Treaty and international filing. You may have more than one patent application for the work, so a portfolio of patents may be collated around the discovery. The protection of the discovery legally excludes others from making, using, selling, or importing the invention. This carves out the space for a business to operate by preventing competition from copying your invention (although it doesn't necessarily allow you freedom to operate, that separate analysis can be made of the patent landscape in your area). Once the patent application or patent has been filed, you can then publish your findings and discuss them publically (outside of the university or outside of a nondisclosure agreement) without risk of compromising the patent prosecution. At this time you are ready to move into a market analysis of your proposed product or service. Chapter 2 also discusses splits of inventorship among co-inventors, which may be unique to academic patent filing where potential rewards of a successful commercialization can be based on percentage contribution of the IP. With the IP protected, you are ready to explore the application of the discovery in the marketplace.

To take a deep dive into the market viability for your envisioned product or service, secondary and primary marketing analysis is needed. Secondary marketing data is compiled market analysis that tells of the overall size of a sector and then your niche within that sector. These analyses will give broad strokes to the market size and divisions to see if it is a fifty million or a billion plus dollar market. It may also tell the major competitors in the marketplace and their market share and growth. Secondary marketing data is typically sourced by companies that compile marketing research and sell it to customers like you. After framing the potential value of the market, primary marketing research is used to assess the need and value of your specific proposed product or service that may be derived from your discovery. This is a critical piece to the de-risking of your technology (market risk). Direct conversations with numerous (maybe 100) potential customers with targeted questions about the need for your product or service as well as the value will inform the market potential of your product or service. Feedback from potential customers, even at this early stage of development, is critical for examining the market need and willingness to pay for what you are offering. Feedback from the primary market research can be tabulated (scale of 1–10 type questions) and analyzed, and hypotheses can be tested. Results of the marketing research can tell you if you need to adjust the product (add features or simplify) and continue toward commercialization. The results can also tell you if your concept is interesting, but not commercially viable. This is a key step in the go-no-go decision process that you will make as you consider the development of your innovation toward commercialization. If you decide to go forward, the next step may be licensing the technology from the technology transfer office to an established company or to your own start-up.

The IP (application or granted) can be licensed from the university, who is the assignee. The university can choose to license the IP to an existing corporation or to a start-up company. While 80% of the IP is licensed to existing companies, more and more start-ups are spinning out of universities. An exclusive license of your IP to an existing company is the most straightforward way to transition your innovation toward commercialization. The license agreement is typically made in exchange for any combination of recovered patent fees, royalties, and up-front payment. There may be terms specifying the participation of the faculty member in the development of the technology through a sponsored research agreement and/or a consulting agreement. There is typically little conflict between the faculty member and the university around a direct licensing agreement. Sometimes, however, direct licensing is not desired either by the existing corporations or by the university. If the technology is "too early," sometimes major corporations prefer not to license. Some companies do not like to do business with universities because of a cumbersome negotiating and approval process within the universities. Other times the university does not have the resources to adequately market the technology. If a promising technology does not fit the model of licensing to an existing corporation, it may be suitable for a start-up company. If the faculty inventor is a founder (an equity holder) in a start-up and also eligible for a percentage of the share of the university in the license to the start-up, there is a conflict of interest to be managed. Centered in the middle of the conflict is the faculty inventor. This situation is another component of commercialization that is unique to university settings. In Chapter 4, negotiating with the technology transfer office and managing potential conflicts of interest are discussed. In addition, licensing agreements with existing corporations and how to manage that process as a faculty inventor are described, including how the match is made between the university and the existing corporations that might be interested in your IP and how to manage negotiations with "early-stage" technology.

One way to de-risk the technology behind your proposed product or service to transition out from the "early stage" is to do a proof-of-concept experiment. This experiment is not necessarily aimed at furthering basic scientific knowledge. Instead, it is a targeted analysis of the feasibility of your proposed product or service. This might be launch of a minimally viable product or a key animal model that conclusively shows that your proposed solution works. Chapter 5 describes proof-of-concept strategies. If you have strong proof of concept, investors are more likely to commit because you have begun to address the key technological risk in your business. Some universities have their own proof-of-concept centers like UCSD and MIT who were among the earliest academic proof-of-concept centers started in the early 2000s. It has been shown that proof-of-concept centers assist in technology commercialization and are a valuable part of the university entrepreneurial ecosystem. Even if your university does not have a proof-of-concept center, federal Small Business Innovation Research and Small Business Technology Transfer programs offered through numerous agencies can provide financial assistance by way of a grant (not investment) to further de-risk the technology. While these experiments may not be publishable, when designed correctly, they can answer key risk questions that will enable investment in a start-up or convince an existing corporation that the technology is robust enough for them to license.

If you decide to follow the start-up route toward commercialization of your university technology, you must assemble a group of people that will be able to drive the invention toward a product, define and test a viable market, and secure investment to provide the resources necessary to sustain the effort and communication among every member of the organization and its stakeholders. In Chapter 6, strategies are outlined for you as the founder to set up your company and to select key people who will help you execute your vision. You will have the opportunity to manage the company yourself and/or partner with a student (graduate student or postdoctoral researcher), technical colleague, or business partner. Considerations for how to select your partners are described. The team may consist of you as the founder, your business partner, students, or others who may join the start-up as employees, advisors, consultants, subcontractors, corporate partners, investors, and a board of directors. Discussion of structuring a bricks-and-mortar company versus a virtual company will allow you to think about strategy and associated financing needed to realize your business. Incentives for partners and employees will need to be considered. With a start-up on a tight budget, you may be limited in salary but can offer a share of a successful future with equity. Unique to academic start-ups is the business partnership with a graduate or postdoctoral student. Considerations of conflict and managing through this new type of relationship between advisor and student, now founder and employee, or founder and CEO are significant for the success of the start-up.

From the graduate student or postdoctoral student perspective, there are numerous considerations in joining a university start-up. In addition to the relationship with their academic advisor-turned business partner or employer, participating in a start-up after years of academic preparation will need to be weighed versus potential lost opportunity in pursuing a faculty position or industry or other position after graduation. Most (more than three quarters) of university start-ups have a student in a key role in the business. Chapter 7 explores university start-ups from the graduate and postdoctoral student perspective including potential conflicts with academic advisors, starting position in the company, negotiating compensation, evolving roles over progression and growth of the business, and furthering education in finance and management. For a student, choosing to launch a career with a start-up can be either an additional experience before returning to research or the beginning of an entirely new career path.

After securing your IP, negotiating a license to your start-up, doing a proof of concept, and assembling your team (not necessarily in that order and not without iteration), it will soon come time to move out of the university lab and into independent space for the start-up. Chapter 8 examines your options with incubators and accelerators. Incubators are generally nonprofit organizations that rent office and/or lab space to start-up companies. They are often associated with universities. The earliest incubators began around 1959. Typical time for a start-up in an incubator is 1–5 years. Accelerators are most often for-profit entities that select start-ups to join a cohort of companies that go through a three-month on-site program where the start-ups are developed to the point of succeeding or failing fast. In exchange for being in the program, the start-up receives some funding in exchange for equity in the company. The result of the accelerator is demo day, where the start-ups present their businesses to a group of investors. Ideally, this would serve as a jumping-off point for the company. Starting in an accelerator does not preclude a start-up from later using an incubator. Either way, accelerators and incubators are ways to transition from the lab to becoming an independent company.

From the very first day that a start-up is incorporated (and probably even before), the founders start to strategize about investment. Those who invest in start-ups are mavericks in the investor world, taking a major risk on a business that has no product and no sales. To convince an investor to put their money into your university start-up, you must put together an outstanding business plan. From our initial discussion, the objective of the plan is to lay a strategy for the business to build value. The value is built as the risks are addressed. Chapter 9 summarizes the components of a strong business plan and then describes strategies for securing investors in your start-up. Investment can be from friends, family, incubators/accelerators, economic development organizations, individual angels, angel investor groups, corporate partners, crowdfunding, and venture capital. Each investment comes with obligations and some money "costs more" than others. Dilution of the founder is a very real challenge in an academic start-up in particular. Because the technology is early stage at the time of incorporation and depending on the product or service, there can be an expensive and long timeline until a return is made to investors. Investment usually comes in rounds that build value with incremental infusions of investment. As each investor brings additional resources, the trade-off is equity, which can come from the founder's initial equity position. Numerous faculty members have started successful companies, but have not achieved financial reward themselves due to their negotiations through this process. Understanding the expectations with investment may help you to maximize your financial reward while still driving the business to a successful and viable company, getting your laboratory discovery into the hands of those who can directly benefit from it.

History affords us the ability to learn from others who have traveled the road before us. As it turns out, there are summaries of reasons why start-ups, both nonacademic and academic, have failed in their journey to sustain viable businesses. Interestingly, there is considerable overlap between the two categories of start-up pitfalls, although there are some particular challenges that are unique to academic start-ups. Equally important to analysis of the cause of failures is the study of what made a start-up succeed. A detailed study of great start-ups turned viable businesses allows us to see the exciting yet sometimes quite painful paths that companies who made it experienced.

The result of your reading of this book will be the understanding of the logical path to commercialization for your discovery. In a step-by-step introduction to the methods, lingo, considerations and points of potential conflict, you will be able to navigate the road, hopefully avoiding the biggest potholes.

Summary

Academic entrepreneurship is on the rise. The current US economy and society may greatly benefit from the potential products and industries across every sector initiated by an academic discovery. Universities that create instructive, supporting, and encouraging environments for academics to commercialize technologies are likely to have more successes in this domain. Academics who educate themselves in entrepreneurship and who expand their social capital to include the innovation ecosystem will have a necessary foundation for success.

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