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Do-It-Yourself Biology: Analysis of an Emerging Organizational Form

Senesac, Lauren G.

Princeton, NJ : Princeton University

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DO-IT-YOURSELF BIOLOGY LABS: ANALYSIS OF AN EMERGING ORGANIZATIONAL FORM

Lauren G. Senesac

A DISSERTATION

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Abstract

Processes of emergence for new organizational forms have developed along three lines: processes that emphasize identity (Fiol and Romanelli 2012), processes that focus on organizational context (Ruef 2000) or network changes (Padgett and Powell 2012), and processes that emphasize recombinations of existing features (Powell and Sandholtz 2012a). In this dissertation, I use data from the fifteen community biology labs in the United States to examine how these processes work for organizations with an emerging form. The data comes from interviews, forum discussions, Meetup.com data, founding documents, and organization websites.

I construct the most complete analysis of the earliest stage of emergence possible by examining all of the instances of an emerging organizational form. I highlight relevant factors shaping the emergence of community labs in the United States and help develop an understanding of the mechanisms at work as a new organizational form emerges. I argue that the very earliest stage of a nascent organizational form is characterized by a struggle to structure the organizations in ways that meet a variety of stakeholder goals while also making the organizations sustainable. Members of community labs draw on models of organizing from adjacent fields as they select features to structure the labs. The organizations then undergo changes to these initial structures based on outside pressures and failures within the organizations.

I examine the nascent community lab form from three different angles. I first describe the founding of community labs and the factors that shape the organizations during founding, including how the founding team coalesces and the resources available at founding. I then

examine the variety of structures that community labs adopt, the factors that shape which features are adopted, and the ways in which a struggle between participation and successful administration influence ongoing structuring of the organizations. Finally, I examine how community labs and their members interact with other organizations in four adjacent fields: professional biology, education, technology, and art. I argue that the labs develop niches that take advantage of gaps that they perceive in each field and examine the narratives members create around their participation in the labs.

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Any dissertation is an enormous undertaking, and mine would not have been possible without the guidance, support, and participation of a number of people, who I would like to thank. First, I want to thank all of the community lab members and affiliates who graciously gave me their time. I was surprised and delighted to have such enthusiastic subjects. I offer particular thanks to the people who offered documents, follow up information, additional interviews, and lab tours, and the lab members who painstakingly record and make publicly available data about the goings-on at various labs – your commitment to openness and transparency is appreciated. I hope that the dissertation accurately reflects their experiences and provides them some fodder for their ongoing attempts to produce sustainable organizations.

My committee has been invaluable. My advisor, Paul DiMaggio, has given me enough feedback on this work to fill multiple binders. I will never understand where he finds the time. I am forever in his debt for shaping not just the dissertation, but also my intellectual trajectory. Paul's support has been plentiful and happily bestowed (as far as I can tell), and I am forever grateful. I would like to thank the remainder of my committee – Paul Starr, Janet Vertesi, and Matt Salganik – for thoughtful and incredibly swift feedback. This work has benefitted from their very different but pleasingly complementary feedback. I could not have asked for a better committee.

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I feel very fortunate to have been surrounded by a number of peers and mentors who provided feedback, inspiration, and emotional support during the dissertation process. Susan Munkres and Michael Ian Borer provided the inspiration through their teaching during my undergraduate years that got me interested in sociology in the first place, and they continue to provide advice and encouragement. I am lucky to have found such caring mentors as an undergraduate. I also am grateful for engaging and supportive peers. Adam Murphree and Karen Levy both provided feedback in the planning stage of the dissertation that shaped its ultimate outcome. I also thank Erin Johnston, Kerstin Gentsch, and Joanne Golann for moral support, writing parties, and advice – without peers like them, the work would have taken far longer. Jason Windawi let me take over his desk for the last great writing push and I cannot thank him enough.

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Chapter 1: Community Biology Labs as an Emerging Form

One Monday evening in July 2012, I press the buzzer to be let into a nondescript building in a large city on the eastern coast of the United States. The building houses mostly artists spaces, but I am here for the once monthly outreach event for a community biology lab. One of the lab members comes to the front door and escorts me through the bicycle strewn front hall, up an elevator, and to the top floor, which is divided by a community kitchen. Half of the floor is devoted to an artist's studio. The other half houses the various pieces of equipment necessary for a biology lab. I sit at the large marble table with mismatched chairs that takes up the main space. The walls are lined with cluttered bookshelves. To one side, there is a glass-enclosed clean room housing bench space and supplies.

I am joined by a man who works as an administrator in a music distribution agency and his female companion, both of whom have attended lectures previously hosted at the lab. The lectures, usually open to the public for a very small suggested donation, range in topic from bioart to the human microbiome to forensics to biotechnology innovations. This couple has become interested in food engineering.

A male graduate student in a local computational biology program is in the space for the first time, drawn in by excitement over proposed projects and visions of do-it-yourself style biology discussed in the Google groups he has been participating in online. Several of the original cofounders of the lab met in these same Google groups, which are devoted to discussing ways for people to do synthetic biology projects in their home labs. Soon, they started a regular local meeting using Meetup.com. One of the cofounders hosted the early meetings in her own

house, but eventually they sought out this space so that members could have access to ongoing projects.

The fifth attendee of the Meetup is a female blogger who also writes cookbooks and freelances for magazines and newspapers. She is here because she's heard about the lab's favorite educational demonstration – the making of DNA cocktails, which use pineapple juice and Bacardi to extract DNA from strawberries. If executed properly, participants can see the DNA floating in the cocktail. The demonstration is particularly popular at Maker Faires, festivals of do-it-yourself enthusiasts in science and engineering, at which the lab often sets up a booth. When children are present, they use rubbing alcohol instead of Bacardi and do not drink them afterward. Two members recount to me, with much amusement, how they once led a large group of FBI and CIA agents through this process when asked to do a demonstration at a security conference.

Besides the five of us who are here to check out the place, three of the lab cofounders are here to host us (at this point, the lab has about 20 members). Susan and Max are both PhD trained scientists who work part time teaching at local colleges but also spend a significant amount of time doing work at the lab. Susan does a lot of the administrative work, including filing the lab's 501(c)(3) nonprofit paperwork, serving as the executive director of the space, coordinating outreach, communicating and networking with outside entities, and fundraising. Max has a few small projects going, including building biological sensors and a collaboration with a designer through which he has a small grant, and he also spends time advising others who work in the lab. Adi is an artist who worked with time-based media (like live performances, sometimes over the internet) and technology before she became interested in bioart, an emerging art form that uses biological processes to create art. Besides these members, the lab hosts a range

of other enthusiasts from art backgrounds and engineering backgrounds, a few students, and assorted others. The members tend to range in age from their early 20s to their early 50s.

The five guests are gathered here to try out DNA extraction and replication through PCR[1] techniques. It is part of the community lab's attempts to interact with the public and potentially gain new members. We spend the next two hours going through the process of extracting DNA from a leaf that I have brought from my yard at Princeton. This involves multiple steps using chemicals, micropipettes, and a centrifuge. Though the experienced lab members are there, they give us the protocol (found on a website) and let us guide ourselves through the processes. Occasionally they give feedback, like how to avoid drawing the chemicals too far into the micropipette, which would lead to contamination of the instrument. While we wait on a process to take place, we find a video on YouTube to describe the process that is actually happening. We also end up making the DNA cocktails.

PCR is just one simple technique that is part of doing biology experiments, and demonstrations of this technique (or, perhaps more accurately, providing access to the public for an evening so that they can attempt these techniques) is just a very small part of what goes on in this lab. They also periodically offer one day workshops and multiday classes for people to learn the basics of synthetic biology, how to engineer a gene, basic forensic science for kids, neuroscience, biotechnology and more. Members of the lab also serve as mentors for students competing in a synthetic biology competition though the International Genetically Engineered Machine Foundation (iGEM), every year. These students work on their project in the lab space under guidance of the members. Though educational and learning opportunities are part of the lab, the lab is also intended to serve as a space for doing individual scientific explorations and

[1] Polymerase chain reaction, a process used to copy a DNA sequence, often the first step in other processes.

research. Various members have conducted projects like cataloging the genes of plants in the local ecosystem, designing biofuel batteries, creating art using bacteria, and studying microbiomes.

Originally founded at the end of 2010, the lab incorporated as a nonprofit public charity (501(c)(3)) in 2012[2], with in income that year of around $100,000 and $14,500 in assets. About half of that income came from program revenue, such as revenue from the classes and lectures: $20,000 came from memberships, at $100 per month for each individual, and the rest came from event revenue, class revenue, donations, and grants. All but $10,000 of this revenue went toward compensation for employees (such as the members who taught classes), professional fees, printing, rent and utilities, and other operating expenses. The organization is largely volunteer run, although a few key members, like the president, did receive some compensation for work.

For the most part, at this point, the community lab is a labor of love with a few scattered goals. Education and science engagement are important goals for some members. "Categorically, I'm a person who's interested in DIY because I believe that the way to learn how to master something is to do it yourself. You can learn from books and having people tell you about the subject…but eventually you have to do it. So I'm a big fan of skipping over the whole reading a book and someone how to tell you to do it in a classroom and going straight to doing it," one member explains.

For others, the lab is about access to a biology lab and the possibility of innovation that comes with it. "If people are interested enough to want to do science, I don't think that they should be turned away," I am told. Another member adds, "There's room for imagination – to access people's imaginations of what could be, you know, in ways that a smaller population

[2] Though the lab actually had its nonprofit status revoked in 2013 for failure to file the necessary paperwork then subsequently had the nonprofit status reinstated.

wouldn't be as possible. So it grows exponentially, the possibilities of advancement, of discoveries, grow exponentially with that larger population that have access. And something like a microbiology lab – it's really about access. There are very few people who really have access."

For still others, the lab is a space to get science work done in a different environment. "There is this backlog of people wanting to work on biotech projects that just don't have a space, and you'd think that wouldn't be the case, but it is!" A member, who is also a professional scientist, tells me. Some professors or other professionals are looking for a different space to pursue their own work. "They find the intellectual property issues at their schools can be too onerous, and they'd just kind of like a neutral ground to do science and to do entrepreneurship".

As the experimentation winds down and the evening turns to talking about the lab and the science in the space, I note that, though organizational struggles certainly seem to be taking a lot of their time, enthusiasm for science is an overwhelmingly shared motivation that ties these members together. "The reason that I got involved was really more, from a scientist's point of view, it was really disturbing, particularly during the Bush administration, how unscientific the American public has become. I grew up in the 60's and at that point, science was really everything. I mean, people were so in awe of what science could do. I mean, we put a man on the moon. We were gonna cure cancer. It was like this worship of science at the time," a community member explains. Out of this passion for sharing excitement about science comes the lab's tagline: "Remember when science was fun? At [our lab] it still is."

I. Introduction

The community biology lab described above is one of fifteen community biology labs that were founded in the United States between 2009 and June of 2015. Each of the community labs is different from the last. They have different funding models, different authority structures,

different motivators, different pressures and networks from surrounding organizations, different core activities, and more. They are not, as yet, the same organizational form – but neither do they take the form of any existing organizations. Instead, I argue that they are at the very earliest stage of an emerging organizational form, characterized by experimentation toward similar goals and with a common shared identity. The form is nascent or inchoate – at the beginning stages of emerging and not guaranteed to succeed.

In this chapter, I describe the literature on emerging organizational forms. Briefly, my contribution is an examination of an inchoate form from an unprecedentedly early stage using interview and ethnographic methods rarely used to examine emerging forms. I focus on the emerging form from three angles: how circumstances of founding and founding conditions affect the new organizations, the factors that shape recombination of features from existing forms into the new form, and the larger organizational environment's influence on the new form. I outline factors that shape the various instances of the nascent form from many different angles, giving an unusually complete picture of how the organizations emerge. In addition, I have collected data on eleven of the fifteen community labs, which gives the analysis a broad view of the field of community labs as a whole.

The chapter proceeds first with additional background about community labs and the traditions from which they have emerged. I provide brief vignettes about two additional labs in order to provide a fuller picture of the variation in community labs. I then review perspectives on the definition of organizational forms and three strains of thought on the emergence of organizational forms. Finally, I detail the methods used in the dissertation and summarize the contributions of the subsequent chapters.

II. Public Participation in the Sciences

Community labs are part of a larger set of activities and organizations that involve the participation of the public in science. Many of the founders of community labs drew inspiration from a larger quasi-movement called Do-It-Yourself Biology (also commonly referred to as DIYbio), which emerged in 2008 in Boston (Delfanti and Soderberg 2012). Do-it-yourself biologists draw inspiration in turn from two pre-existing communities – the citizen science community and the maker community. In this section, I give additional background on these communities and on DIYbio community labs, and start to articulate why community labs are an intriguing site for studying emerging forms.

Citizen Science

Community labs are part of a subset of public activities in the sciences that are categorized as citizen science. Citizen science has been defined in a few ways. Though some definitions focus on volunteers as "field assistants" to scientific studies (Cohn 2008:193), most cast a wider definition of citizen scientists as members of the public who participate in organized scientific endeavors (Dickinson and Bonney 2012). The sorts of tasks citizen scientists undertake vary from ecological counts and astronomical observations to building scientific equipment and conducting experiments (for a typology of citizen science, see Wiggins and Crowston 2011). Projects typically fall into two general categories: those that are organized by professional scientists, who allow volunteers to help collect data but then who do the analysis themselves, and projects that are run by the public enthusiasts who may either pursue their own individual projects or who may organize others toward a common project goal.

Citizen science projects that are led by professional scientists and funded by agencies like the NSF are sometimes seen as educational outreach to the public even more so than they are

valued for their scientific contribution (Cohn 2008). Public outreach is intended to increase public understanding of science, potentially improving civic engagement with the sciences and increasing public support for science funding. In addition, many professionally run research and monitoring projects that require a large number of field researchers would be cost prohibitive to conduct without volunteers contributing their labor (Cohn 2008). Proponents of professionally led citizen science emphasize public engagement and the power of harnessing the masses for data collection and problem solving.

Many project that involve citizen scientists are not led by professional scientists. Like the professionally led projects, these projects can also include data collection attempts with large numbers of people. Some projects enable people to collect data on themselves, like Quantified Self (Anon 2012). However, other projects focus on the creation of original scientific findings or the building of new biotechnology. For instance, the crowdfunded company OpenPCR produces polymerase chain reaction (PCR) technology necessary to make copies of DNA for experiments at a fraction of the cost of traditional technologies (Anon 2015). Though PCR machines can cost tens of thousands of dollars, OpenPCR sells a PCR machine kit for $649 or provides fabrication design documents to anyone free of charge under a GNU GPLv3.[3] In this way, citizen scientists, even without professionals involved, can make meaningful contributions to the biology community.

Citizen science is not new. The National Audubon Society bird count began using citizen volunteers to collect data in 1900 (Cohn 2008) and early botany, in the 1800s, was conducted entirely by amateurs (Keeney 1992). However, in the last few decades, the Internet has afforded

[3] This is version three of GNU's general public license, which promotes "copyleft" instead of copyright. It gives users the right to modify and distribute the work, with the caveat that users must also allow subsequent users of their work to modify and distribute it (see GNU.org 2015).

dramatically easier ways of organizing among citizens – including finding people with similar interests, coordinating data collection across a large geographic area, and forming cheap, sustainable forums for people to interact about their scientific endeavors. Moreover, the Internet has afforded significantly greater access to resources, such as scientific knowledge for learning endeavors, help with troubleshooting particular project issues, places to acquire specialized equipment and supplies (like eBay), and platforms for crowdfunding laypeople's scientific undertakings. Overall, changes like these can be expected to enable larger scale coordination for projects and lower the entry barriers to a larger range of scientific endeavors.

While the Internet has afforded uses that make doing citizen science easier, enthusiasm for citizen science has also been growing. Many citizen science projects (often led by professional scientists) have been able to gain federal sponsorship (see Bowser and Shanley 2013 for a summary of seventeen case studies of funded citizen science projects). Many community labs have also benefitted from the public enthusiasm for citizen science by using crowdfunding platforms to raise funds to found their labs and to acquire donated materials. More importantly, perhaps, the growth of interest in citizen science has helped mobilize potential members. The people at community labs are often also familiar with a range of citizen science projects outside of their labs, such as local data collection projects, Quantified Self (a movement in which individuals collect data about themselves, including diet, exercise, weight, body oxygen levels, or other metrics of interest), FoldIt (a game in which members of the public attempt to fold DNA sequences, ultimately with the hope of contributing to scientific knowledge), and others.

A number of visions are expressed by citizen science enthusiasts. One is the idea that collaboration among individuals with diverse backgrounds and specialties will yield substantial innovation (Nielsen 2013). The idea is that people from different backgrounds bring different

ways of problem solving to projects – so people with different backgrounds in collaboration are thought to solve problems more effectively. A second common idea in citizen science is that the public can be best educated in areas of science by participating in science (Cohn 2008; Mueller, Tippins, and Bryan 2012). A third commonly cited vision is that the participation of larger numbers of people through the democratization of science is a way to accomplish new and important science (see case study of FoldIt, a DNA folding game through which citizen have been able to contribute real knowledge about the mechanics of proteins, in Chapter 7 of Nielsen 2013). With so many more eyes on a problem, citizen scientists believe, someone is more likely to figure out how to solve it. Each of these ideas about the value of public participation has also been adopted in the DIYbio community.

Maker Movement

The maker ethos, which emphasizes the value of hands-on involvement and invention, also permeates the DIYbio community. The Whole Earth Catalog, founded in the late 1960s, linked the counterculture and technology communities, fostering a do-it-yourself spirit in technology tinged with countercultural values that emphasized technology as personal (Turner 2006). Following in this tradition (O'Reilly 2006), *MAKE* magazine, founded in 2005, conjures an image of American grassroots innovation and self-sufficiency through at-home manufacturing (Tocchetti 2012). *MAKE*'s Maker Faires, festivals thrown in large cities worldwide that emphasize the do-it-yourself attitude, began in 2006. These publications and gatherings and their values are key elements of the modern DIY movement. *MAKE* and Maker Faires provided early venues for DIYbio endeavors to do community outreach, find project inspiration (through magazine issues) and technologies that could apply to DIYbio (like 3D printers and cheap open-

source electronic controllers called arduinos), and publish information about their projects and results.

Since its inception, DIYbio has drawn inspiration from the do-it-yourself, grassroots image of the maker community. Among my research subjects, it was common to hear vision statements about the value of getting one's hands dirty and fond recollections of various ways in which lab members had hacked together solutions to experiment or equipment problems using everyday items and ingenuity. This embrace of self-sufficiency and creativity parallels the maker ethos.

Do-It-Yourself Biology

Though most makers do not contribute to scientific knowledge and many citizen scientists do not make physical objects, citizen science and making meet in the do-it-yourself biology community. DIYers in biology do everything from collect data to create their own scientific experiments to invent new biotechnology. DIYbio enthusiasts tend to participate in the community through three different avenues: as members of DIYbio devoted forums, as members of Meetup groups, and as members of community labs. Each of these ways of participating affords different sorts of activities and requires different sorts of commitments from participants.

Google Groups

Many DIYbio enthusiasts are members of one or more Google groups devoted to DIYbio. The international group (which is also the only nationwide group in the United States) was founded by the original members of the Boston group, including Mac Cowell and Jason Bobe, who coined the term "DIYbio." It has over 4000 members with over 5000 forum topics, many of which have multiple replies. The forum often has multiple new threads a day, sometimes as many as 10, and many replies to previous threads each day. Similar (though often less active)

forums exist on more local levels – sometimes for regions and sometimes devoted to particular cities or particular community labs. Google groups are used to solicit feedback on project ideas, procedures, equipment acquisition, experiment troubleshooting, legal issues, good web resources, and more. The groups also are used to advertise new projects, get out awareness for crowdfunding campaigns for biology projects, solicit interest in gatherings, and generally share news. Local Google groups also share event announcements, meeting minutes for Meetups or labs, founding documents for organizations, and are used to coordinate gatherings and socialize.

Google groups are often composed of people who do not get together in person. In part, this is because some groups contain members who are not geographically co-located. Others prefer to work in their own home lab. Indeed, a major contributor to multiple Google groups who I interviewed over email was actually against getting together in person. "So, I never really wanted a physical meetup group. I think the idea of meeting with others about diybio is sort of silly, and I dislike the idea of community labs. I think that's somewhat not diybio. People don't seem to be happy with diybioers just having their own home labs. Pretty strange."

Meetup Groups

However, a subset of these DIYbio enthusiasts do meet in person. They often coordinate through Meetup.com, a platform that provides tools to help coordinate meetings, which sometimes run parallel to local Google groups. Sometimes DIYbio enthusiasts coordinate entirely within Google groups. Meeting in person requires more coordination, time, and group commitment than participating in a forum. Some Meetup groups are founded but never are able to coordinate an actual meeting. Many more meet sporadically for a while and then eventually disband. Other Meetup groups enjoy more long-term success.

Meetups, like forums, are useful for exchanging ideas and expertise and collaborating on problem solving. They are often hosted in local coffee houses or sometimes hacker or maker spaces. Meetings can include idle chatting, talks, projects, or whatever else members might prefer. Though interaction in forums is certainly social and members develop relationships, meeting in person is likely to make the social element more central to the endeavor. People who attend meet ups are either not content to or not able to do DIYbio alone in their homes.

Community Labs

The most involved and least common way to participate in a DIYbio community is by founding or joining a community biology lab. Community labs require the most sustained time commitment. Aldrich and Ruef (2006:1) observe "through organizations, people pursue activities too broad in scope to be accomplished by individuals or families acting on their own. Accordingly, organizations mediate the influence of individuals on the larger society." Community biology labs are a way for DIYers to band together and accumulate resources that individual members would be unable to amass in their garage labs. These organizations also provide a base for organizing community events, such as biology classes, fundraisers, and lectures, which have value for many members of the community and beyond. Community labs often organize group projects, as well, that help amateurs gain more expertise and allow people with different skills to bring themselves into dialogue on the same project.

Since 2009, fifteen community biology labs have been founded in the United States. Like the lab described in the opening, these organizations are volunteer run. Though some are for profit, most are nonprofits. All of them collect monthly dues that vary from $50 to $600, though most tend to be closer to $100. Labs typically have 8 to 10 members, though the largest lab has

around 50.[4] In addition to membership, members of the public engage with these labs through offered courses, public lectures, open houses, regular meetings and Meetups open to the public, and on the labs' online forums. The membership fees, membership requirements, authority structures, and finances of each of these institutions varies. Chapter 2 details the variation in lab structures and practices.

Though they may differ somewhat in how they organize, community biology labs were all founded under a similar set of motivations: a small group of highly motivated individuals wished to pool resources and form a community dedicated to providing access to biology education and lab work to a wider public. By pooling resources, biology enthusiasts can buy more equipment and disposables than they could individually, and by pooling expertise and sharing a common space, they can help each other problem solve and learn about biology.

Community labs attract a wide array of members – though some are professionally trained scientists in biology-related fields, many are amateur biologists whose careers are in art, engineering, computer science, or technology entrepreneurship. Most members participate in the labs in their free time while working other jobs, but some members are entrepreneurs working full-time toward a project goal or unemployed scientists who are doing work at the lab that they hope to parlay into a job. The activities in the lab reflect the multitude of interests of the members; they include classes and workshops, lectures, art, community projects, and bench work. Members participate in whichever of these suit their needs.

[4] There is no centralized list of members and organizations gave me only estimates of the number of members that they have. I estimate that there are 130 to 150 community lab members in the United States.

The Importance of DIYbio and Community Labs

Do-it-yourself biology is just one small corner of citizen science, and citizen science endeavors are at the fringe of other science endeavors in the United States. However, projects such as these are potentially of growing importance to science. Science, and biology in particular, is at a crossroad that makes community lab endeavors particularly relevant for sociological study. This crossroad stems from two main factors: the oversupply of professionally trained scientists and the cheapening and proliferation of biological technology.

Our science systems encourage the training of scientists at higher than their replacement numbers – a strategy that worked well as long as science funding was increasing and the sector was growing but which became less tenable as science funding stopped doubling in 2003 and then began being reduced after the recession in 2008 (Alberts et al. 2014). The resulting oversupply of trained scientists leads to 1) hypercompetition that "suppresses creativity, cooperation, risk-taking, and original thinking required to make fundamental discoveries," 2) extended time spent in training limbo and excessive stress on the job market, and 3) a surplus of people unable to find jobs (Alberts et al. 2014: 5774).[5] Now, trained biologists find fewer options on the traditional job market. Community labs are able to benefit from this oversupply of scientists because some of them are drawn to work in the labs, where they can help provide expertise to less trained enthusiasts. At the same time, the labs benefit the scientists by giving them alternative places to work as they try to find jobs (see Chapter 4 for additional analysis). Many scientists who do some work at the labs cite the relief of being able to pursue whatever

[5] Funding for biology has begun to recover. The NIH budget was increased by $1 billion in 2016 (Office of Budget (OB) 2015), which may help alleviate some of the job market strain experienced by professional biologists. While the increases are a step toward recovery of the biology field, when accounting for inflation and increased costs of research, the NIH budget is far from recovered to its 2003 peak (Federation of American Societies for Experimental Biology 2015).

endeavors they desire, superior creative license, and relief of job market woes.[6] As the science training system continues to turn out more scientists than can be employed, alternative routes may become increasingly important as outlets for surplus scientists. At the same time, if more scientists enter these community labs to pursue less traditional research opportunities, these labs may become increasingly legitimized and produce the sorts of knowledge that would make them competitive with existing science institutions.[7]

While an oversupply of scientists is reshaping the science system, biology research is becoming ever cheaper to undertake. This cheapening lowers the barriers to dabbling in biology outside of science institutions. In fact, members of community labs constantly drew parallels between the current circumstances in biology and the electronics revolution that took place in garages in decades past. The way the members see it, biology will soon be something that members of the public will be able to experiment with and drive innovation in, just as they did with electronics. The keys are the cheapening of the technology, which continues to be driven by these communities that are trying to work outside of professional spaces (Grushkin, Kuiken, and Millet 2013), and the blackboxing of technologies that is currently underway. Blackboxing is a term used in the programming and hardware community to describe a process by which the inner workings of a piece of hardware or a chunk of code are hidden from the users. Users, then, need only understand the inputs and outputs of the technology and not the way that it functions in order to use it. In the years leading up to the personal computer, electronic components like the microprocessor and transistors were designed that allowed computing enthusiasts without individual expertise on these interior components to combine them together to create new machines. Computer operating systems are another type of blackboxed technology. Programmers

[6] Though these may not be realistic; see Chapter 4.
[7] Though the scale of these contributions is likely to remain small, at least for the time being.

who write applications do not need to know the entire workings of the system in order to write for them (indeed, such information is usually proprietary). Instead, the programmers need specific information about how to interact with the operating system. Those in the DIYbio community want to develop similar components that can help compartmentalize expertise in biology. One organization leading the charge to build a set of building blocks of biological parts is iGEM, which runs a yearly competition of high schoolers, college students, and community labs. They also hold a registry of biological parts meant to help the community coordinate in an open source fashion, to share knowledge and to establish standard biological parts to streamline innovation in the community (iGEM 2015) (see Chapter 4 for more discussion).

The compartmentalization of parts and cheapening of participation are just two ways in which biology is becoming easier for amateurs to participate. As discussed previously, the Internet has also increased the ability for amateurs to network with each other, share knowledge, raise funds, acquire equipment, and acquire and share expertise in biology. As trust in the cultural authority of scientists has been declining among conservatives in the United States and as science has become more politicized (Gauchat 2012), participation of amateurs may be an additional destabilizing factor. The cultural authority of the sciences rests in public trust that scientists have a specialized knowledge that allows them to understand the complexity of the world in a unique way. The participation of amateurs in creating scientific knowledge could serve to further undermine the cultural authority of science. Indeed, many of my subjects see community labs as a way for untrained scientists to push innovation and go beyond what scientists are doing at professional institutions.

On the other hand, many scientists and members of the community labs actually see these labs as an important place of contact between scientists and the public (Grushkin et al. 2013).

Community biology labs are one important way in which members of the public can engage in science on their own terms. The labs can fill a gap in education by engaging people who otherwise would not be able to participate in science. In this way, the labs promote science as important and increase interest in biology and biology research. Additionally, many amateur participants note that they have increasing respect for the difficulty of designing and conducting a biological experiment after attempting such things for themselves.

Community biology labs provide a case that allows us to examine the interaction of science and the public at a moment that could be transformative. Biologists and amateurs believe that biology will be the next site of technological revolution, and now could be the early phase of an era of personal biology. From an organizational standpoint, the case is important because these organizations sit at the interstices of several very well established institutions in science, education, and government regulation that make organizing particularly challenging. The potential consequences of "getting it right" could be large, if the organizations can survive. Organizers face a variety of internal and external stakeholder pressures that they have to navigate as they imagine and re-imagine what a community lab might be. This case study provides a view of the beginnings of the emergence of an organizational form as it negotiates its place in the currently complicated scientific field.

III. Organizational Forms

Community labs are experimenting with organizational form as they attempt to create sustainable citizen science organizations in biology. An organizational form is a way of conceptualizing the commonalities of a set of organizations as a kind of ideal type. We might say that the community college is a form of organization for higher education – one that is different from the form that large state universities take. These two forms of higher education

organizations vary in the kinds of relationships they have with other organizations, the kinds of organizations with which they have relationships, their goals, the consumers that they attract or audiences with which they wish to interact, the forms of authority that act at the schools, the core technologies (such as physical technologies in the classrooms, pedagogical approaches to different sized classes with different skill levels, skill of the members, or infrastructure), the sense of identity that the institutions have, and the way these two forms of higher education are perceived by the public. Though they are both a means of higher education, community colleges and state universities have organizational features that set them apart from each other. Though organizations such as these intuitively have different forms, the definition of an organizational form has not been settled upon in the sociological literature. Typically, it has been approached in three different ways.

Structural Equivalence

The first approach emphasizes that organizations that share an organizational form are positioned similarly in networks of other institutions with which they interact (DiMaggio and Powell 1983; Polos, Hannan, and Carroll 2002). An organizational form might be constituted by organizations that occupy similar places in an organizational field, or that have structural equivalence and thus have similar roles to play relative to other organizations. Indeed, DiMaggio and Powell (1983) illustrate how organizations within a field come to look more like each other as a means of managing uncertainty and constraints. This approach draws attention to how organizations fit with other actors in their organizational field, particularly their suppliers, resource and product consumers, and regulatory agencies, and not just the other organizations that are similar to them.

Core Features

The second approach to organizational forms concentrates on the core features or core competencies of the organizations (Hannan and Freeman 1984; Polos et al. 2002). Hannan and Freeman (1984) outline four core features which, when taken together, distinguish between one organizational form and another. These include: 1) the goals of the organization, 2) the forms of authority within the organization, 3) the core technologies integral to the organizations such as capital investment, infrastructure and skills of the members, and 4) the marketing strategy, which refers to the kinds of clients, customers, and audiences that the organization targets or from which it obtains resources. New organizational forms are those that vary on one or more of these core features from organizations that came before. The core features approach deemphasizes the external environment for an organizational form, and instead focuses on competencies and features of the organizations themselves.

Identity

The final approach to defining an organizational form emphasizes the shared common identity of members of an organizational form (Aldrich and Ruef 2006; Fiol and Romanelli 2012; Polos et al. 2002). While feature based approaches allow researchers to do technical analysis, Polos et al. (2002) emphasize that distinctions between organizational forms are often reflections of the social processes of boundary creation, which would direct researcher attention toward a different set of phenomena: social network ties, closed flows of personnel among a set of organizations, technological discontinuities, and social movements that articulate the interests of a particular set of organizations. These processes of boundary creation lead toward a common identity for organizations of similar form. Two types of identity are relevant in defining an organizational form: a shared identity among members of the organizations as well as a shared

external identity by which people outside of the organization can recognized organizations that are of that form.

Fiol and Romanelli (2012) suggest that collective identity development among organizations promotes the formation of "similarity clusters" of organizations, which then audiences can use to identify certain organizations as similar and distinguish them from other organizations. Others emphasize that organizational identities are bound by social codes, or sets of rules, that outline the sorts of features that an organization should have – and that audiences evaluate more favorably organizations that conform to these codes (Polos et al. 2002). As individual organizations come to look more like each other, audiences come to code them together as a form (Hsu and Hannan 2005). This perspective emphasizes the external understanding of identity as a key feature of an organizational form.

Combining Definitions

The structural equivalence approach, the core features approach, and the identity approach to defining organizational forms emphasize rather different phenomena and processes associated with organizational forms. There is no consensus in sociology about which definition to use. Each has its own strengths in approaching the issue of emergence of a new form. The structural equivalence approach draws important attention to how organizations are included within a larger field, which must influence the shape the forms take. The core features approach draws attention to the amount of variation possible in the running of the organizations themselves. The identity approach emphasizes the importance of boundary making, internal understandings of how the organizations are related to other organizations, and the ways in which external audiences and their ability to classify organizations is relevant to the form. Each of these approaches yields different sorts of insight.

Forms that are in the very first stages of emerging have not undergone the sorts of processes necessary to help them conform to a single form. Each organization negotiates its own place in its organizational environment. Each organization adopts different core features to try out. The organizations do not necessarily share a single identity. At the earliest stages of a nascent form, uncertainty and variation are prevalent. In this dissertation, I examine an array of community labs, combining elements from all of the definitions of form in order to understand how the organizations are shaped at earliest stages of emergence of an organizational form.

IV. The Early Stage of a Form

As Fiol and Romanelli (2012) note, many studies concentrate on new forms that have already emerged, missing the variety and tensions that are important in the early evolution of the would-be form. Much of the literature that concentrates on the emergence of new forms marks that emergence through something easily measureable like the emergence of regulation of organizations with that form or the first mentions of the form in the media (Ruef 2000). While this approach is certainly useful for examining things like selection and survival of new forms in a population of organizations, it does not tell us much about the early lives of new or potential new forms. The early stages are avoided for good reason – it is often difficult to know when first a new form is emerging – to identify the first moments of conception, when ideas about a new organization diverge from those that are already out there. The earliest stages of potential emerging forms are bound to be disorganized, with vague boundaries and understandings of the form. Still, this nascent phase is a vital time in the life of an organizational form because it is when the boundaries around the form emerge, when the identity becomes solidified, when would-be organizational members of the form converge or diverge, and it sets the stage for regulations that may come to pass. The factors that influence the paths of these earliest

organizations of a form must be identified. This dissertation analyzes factors that influence the emergence of community labs during founding, in setting their structure, and through their organizational networks.

First, I want to provide richer detail about some of the variation in community labs. Central to my arguments is the observation that organizations that are part of an emerging form experience variation as they attempt to adapt models that they draw from other organizations to new purposes. Throughout the dissertation, I examine factors that lead labs to adopt particular features. In this section, I want to establish a bit more about the variation that exists among community labs. I will provide two brief vignettes that contrast to the first: one features a lab that focuses on business rather than hobbyist biology and another is a lab struggling through the process of founding.

A Business-Focused Lab

Across the country from the lab detailed at the beginning of this chapter, another community lab was founded on the west coast in 2013. The founders are scientists and entrepreneurs. I had trouble nailing down interview times because their schedules are hectic due to time commitments at the labs and a number of other entrepreneurial endeavors. Like those at the first lab, founders of the lab wanted to provide biology bench space to members of the public who needed space outside of traditional labs but who could not afford space in biotechnology incubators. Though committed to wider participation and openness, this community lab is focused more narrowly on enabling project ideas that could be parlayed into startups. They do not cater to hobbyists, as many of the other organizations do. They wanted to focus on more "in depth science," as one founding member explained it to me. Though they allow people to join without biology expertise, the leaders screen new members to check that the members have

specific project ideas that could lead to business opportunities. The main activities at this lab are different too. Though they do offer some workshops and lectures, these tend to be focused on topics like how to start a business and how to use specific technologies instead of basic biology concepts like the first lab.

The ways in which the group came together are different as well. Instead of meeting online, the founders of the business-focused lab met while working at another community lab in California. They broke away and formed a new lab because of differences of opinion about how the labs should be run (see Chapter 3 for additional detail). The lab charges substantially more than most labs (several hundred dollars a month), and hopes to attract more committed and longer term members. The founders chose a for-profit incorporation status, contrary to the first community lab, and hope to use a funding model that takes advantage of income from any businesses that emerge out of the space.

A Lab Struggling to Open

Another lab back on the east coast is currently in the process of trying to open its doors when I interviewed the two founders by video skype. The two were inspired by the earlier community labs and, after they met through mutual friends at a party, they started planning to open a lab of their own. The founding team of this lab is much smaller than the other two labs – and spreading the workload can be challenging. Both men work full-time in non-scientific day jobs, and they save money from these jobs to purchase equipment for the lab. They report that they struggle to find much time to meet, and consequently the attempts to found the lab have been going on for over a year. They meet, collect equipment and occasionally produce events for children.

Unlike the other two labs, this lab has not established Meetup and Google groups, and it seems to be lacking the number of enthusiasts found at labs that have successfully founded. The pair often works extra hours in their day jobs to save up money for the equipment that they believe they will need, but they never feel as if they have enough equipment yet to open the lab to other members of the public. Unlike both of the other labs, this one has no professional scientists as founding members, and so the founders do not have guidance on exactly what they need. While the other two labs described in this chapter have leased their own separate space, this community lab has opted to lease a small room in a coworking space. They gave me a tour of the tiny room (perhaps it is 10 by 10 feet) over the video conference, proudly showing me their organized supplies and equipment. There is little counter space, and it is hard to imagine that the lab will be able to accommodate many members – but the space is cheap and it does not require the lab to be incorporated in order to sign a lease. Though they started to put together incorporation paperwork, the two founders never followed through. At the end of the interview, they tell me that they are close to opening the space – but when I check back a year later, they report that it has not quite come together yet and they are hoping they will make more progress soon.

Are community labs part of the same emerging form?

The lab that I described at the beginning of the chapter, the business focused lab, and the lab that is struggling to open vary substantially in how they are organized and what their goals are. Indeed, the remaining thirteen established community labs and several other labs in the process of founding are all slightly different. However, these organizations do share a number of characteristics among them. The biggest is a shared sense of identity – members reference other labs in interviews when asked about organizations similar to their lab; labs have drawn on each

other for charters in some cases; and several have membership and leadership that flows between them. They also are often classified as similar organizations by external entities like newspapers, which write stories about the labs, and by the FBI, which has organized conferences for lab leaders (see Chapter 4 for more details). Though there is variation, community labs that have successfully opened often occupy similar positions in the local institutional fields of which they are a part. They supplement educational opportunities, provide cheap lab space for scientists and hobbyist, support entrepreneurship, and provide workspace for artists (see Chapter 4 for more detail about how they fit into networks of organizations). They share resources like community forums and obtain their supplies in very similar ways regardless of their differences in goals or authority structures. Their identities and some level of structural equivalence classify them as similar in form. Community biology labs appear to be similar in identity and structural equivalence.

While many of them do have core feature commonalities, they also vary a good deal in who their audiences are, precisely what their goals are, what sorts of tasks they focus on, and the degree to which they interact with other organizations of various types. Based on the definitions of organizational form above, it might not be clear that community biology labs are, currently, a single organizational form that could be identified externally by an audience and be expected to have a particular set of features.

By some definitions, community labs appear to be rather similar in form – but by others, they do not seem to be the same form at all. Vital to our understanding of community labs, however, is the knowledge that many of the labs are in organizational flux. Community labs can be understood as minimalist organizations, which are organizations that require few resources to be founded or sustained (Halliday, Powell, and Granfors 1987). Because minimalist

organizations have few sunk costs, they adapt more easily to changes in their environments than organizations that have more substantial investments in particular infrastructure (Halliday et al. 1987). Community labs are often able to collect what lab organizers call "learnings" from their organizational endeavors. Lab members recognize that they are experimenting with a new kind of organization, and they readily make changes to the organization as they see necessary. These changes include but are not limited to changes in goals, the sorts of activities they conduct, funding models and revenue streams, authority structures, bylaws, membership agreements, and the types of community members that they intend to serve. Some changes fundamentally alter the organization – and would shift an organization into a different organizational form, particularly if we think of form in terms of core features. However, as these organizations change different features, sometimes they become more like the existing organizations (and sometimes they become less like them).

It is possible that the various community labs will never have the same form – or that, in fact, none of them will survive long enough to institutionalize a community lab form. There are some indications that labs may split into two different forms (see Chapter 3). However, the potential to diverge or converge is part of the earliest stage of form emergence and the factors that shape some organizations toward one set of features and another toward a different set should also be considered in an analysis of the emergence of a form. For now, the labs investigated in the dissertation are sufficiently similar in identity and environments that they should be examined together.

V. Processes of Form Emergence

Researchers have proposed a few different processes by which new forms emerge, though the literature is still quite scattered and underdeveloped. Previous studies concentrate on

three main themes: forms emerge through identity similarities, through being shaped by networks and fields, and through recombinations or novel combinations of existing features of organizations. Though seldom explicitly noted, these three approaches to understanding form emergence map to the three general ways of defining organizational forms. Each is helpful in its own way, as it draws attention to different processes at different levels of interaction.

Identity-Based

Identity, a phenomenon commonly used to help define organizational forms, also has been used to conceptualize the emergence of new forms. Indeed, for some theorists, new forms emerge when they become identified as a form by an audience (Hsu and Hannan 2005). Fiol and Romanelli (2012) argue that "similarity clusters" of organizations emerge out of communities of practice, or groups of individuals that "share an enthusiasm about a particular new way of doing things" (599). New organizational forms emerge out of these similarity clusters, which are groups of organizations that are similar enough to be identified as similar by audiences. While some similarity clusters will yield new organizational forms, others do not. Communities of practice, according to Fiol and Romanelli, have three main features – a shared domain of activity, a group of people interested in that domain, and interactions over time about that domain. Through storytelling and social identification, communities of practice develop a collective sense of identity, which leads to the creation of a cluster of similar organizations. This collective identity, they argue, has more holding power than other motivations for participation, and so new similarity clusters are more likely to have time to develop even through a series of struggles than organizations that do not have strong collective identities with other organizations. As similarity clusters of organizations emerge out of these communities of practice, external audiences gradually come to be able to identify these organizations as similar to each other and

different from previous organizations (McKendrick et al. 2003). Fiol and Romanelli's model addresses the common problem of where similarity clusters come from that later can be identified as a common form. It emphasizes the importance of the early community of enthusiasts, the stories that they tell and how these stories shape their common identity. This story dovetails well with definitions of organizational form that emphasize organizational identity.

Community biology labs certainly emerge from a common community of enthusiasts, often who share the dream of both engineering biological things and increasing participation in biology for members of the public. They share common stories about the value of the community labs as providing access but also as an important place of innovation because the space does not censor researchers or provide disincentives for "wacky" ideas and because it brings together people with disparate ideas and training. In Chapter 4, I describe some of these shared stories, which community labs also use as a way to situate themselves among existing organizations in their local organizational environments. Though community labs do share similar stories and motivations, they do not share exact organizational form – making them more like a similarity cluster than a form for the time being. However, there are groups that have begun identifying community biology labs as a similar set of organizations – even though they vary a lot in the actual form of the organizations. The audiences who tend to recognize the organizations as similar at this point are within the DIYbio community, biotech, the FBI, regulators or insurance companies. In this way, they are also becoming a form through external identification (though they have a long way to go).

Network and Field-Based

DiMaggio and Powell (1983) draw attention to the importance of the organizational field, defined as the set of organizations that "constitute a recognized area of institutional life" such as the suppliers, resource and product consumers, regulatory agencies, and organizations providing similar goods and services (148). Many approaches to understanding the emergence of organizational forms examine field level processes, often with geographical context also shaping organizations. These approaches are most related to the ecological approach to organizations and often draw on ideas from ecology.

Organizational forms emerge in the context of an organizational field, and those fields shape the forms. The boundaries of the field influence how participants in new organizations choose models to emulate and to compare with themselves (DiMaggio 1991). DiMaggio shows how art museums emerged as a form during the 1920s to 1940s, shaped by the art field and the networks of professionals who staffed the museums. When experimenting with the new form, certain visions won out over others because of a variety of field level and personal and organizational network factors. The structure of funding opportunities privileged particular visions – for example, providing educational activities in the art museums allowed them to draw upon funding from outside sources that valued education. Actors in new organizations have a variety of goals, and the resources available through their networks influence which goals will be pursued.[8] Museums were also shaped by new field-wide structures at the national level - professional associations to which members of the organizations belonged.

While Rao et al (2000) emphasize the role of social movements in the creation of new forms, they also acknowledge the important role of the organizational field in this process. They

[8] The article talks about things like corporate sponsorship, city patronage, involvement with higher education – all of which also occur in my fieldsite.

draw attention to the structure of different fields. Some fields, they say, are hierarchical. In these fields, certain groups of actors are dominant while others exist at the periphery. In hierarchical fields, it is difficult to innovate structurally at the center of the field – rather, new forms emerge at the periphery with little influence or resources. In these fields, social movements can be important in establishing collective action to form organizations. Other fields are fragmented, sometimes because state agencies and other constituents have conflicting goals or overlapping jurisdictions, the involved professions have weak jurisdictions, or the producers in the field do not have trade associations and so have less influence than they otherwise might. In these fields, new forms encounter much less opposition. Sometimes new forms are created in the interstices, or gaps between fields. Organizations that exist in interstices often must navigate a diverse set of interests (from adjacent fields and the people moving out of those fields into a common interstice), competing frames, and entrenched sources of resistance in the adjacent established fields. Interstices are often not very visible. Further, within an interstice, there is little solidarity between organizations. New forms created between existing fields face these obstacles. Rao et al suggest that sometimes social movements must construct new field-wide environments in order to succeed between established fields.

The legitimacy of new organizational forms is also influenced by the organizational identities of other organizations in the community (Ruef 2000). Ruef notes that new forms emerge within established fields, that they are most likely to be legitimized when they fit the existing cultural understandings and typifications in that organizational community, that the distribution of forms within the organizational community will influence the success of these new forms, and that social demands will also influence what the emerging form comes to be. Ruef goes on to examine population composition of organizations and whether new medical

organizations emerge. The context of an emerging form shapes whether new forms can emerge. Organizational fields can also vary by geographical location.

Others take a network approach that emphasizes transforming networks as the genesis point for innovative new forms. Novel new forms occur when different networks become intertwined and recombine through a process called "network folding" (Padgett and Powell 2012). During this process, connections are made across network domains, including market networks and personal relationships, yielding innovation of organizational forms. Like the other network approaches, networks are thought to shape new organizational forms. While the previous perspectives emphasize properties of networks and organizational fields that are important to understanding the process of emergence of new forms, this perspective emphasizes how change in those networks is a process that leads to new forms. The process, in fact, helps to explain how recombination, detailed below, might occur.

Recombinant Approaches

Some research has focused more on organizational features as a starting point for form emergence. Powell and Sandholtz (2012), for example, explore two mechanisms that they propose are at work in founding models of biotechnology companies from 1972 to 1981. The first mechanism that they propose is reconfiguration, in which attributes and elements that are already familiar in other organizations are put together in new ways that are ultimately recognizable (Powell and Sandholtz 2012a). The second mechanism is transposition, in which attributes and elements are introduced to a particular domain where they were not previously recognizable, often because the elements come from domains that are not adjacent to those in which they have now been imported (such as to major league baseball from Wall Street analysts as detailed in *Moneyball* (Lewis 2004)). According to this approach, new organizations (and

organizational forms) are built of potential organizational building blocks, some of which are reconfigurations of what came before and others of which are entirely new because they bring in new pieces that transform what can be built. In some ways, this approach is also a network approach – Powell and Sandholtz note that new models like this bring together networks, ideas, and flows that shape new career pathways and lead to the intersection of new fields (particularly when transposition occurs). However, the researchers draw attention to the attributes and practices of organizations as central to the form and focus on how and why certain attributes are combined.

Though they focus primarily on recombinations of features of forms, Powell and Sandholtz (2012) draw attention to the role of "amphibious entrepreneurs" in the creation of early biotechnology firms. Rather than drawing attention to organizational entrepreneurs more generally, they are interested largely in the people who crossed boundaries to bring new ideas, organizational practices, and assumptions into new domains. It is, at least partially, a network story, not unlike Ronald Burt's (2004) idea that bridging between two networks yields creative opportunities. By navigating between fields, these organizational entrepreneurs can contribute to novel organizational forms. In fact, by coming from a different field with different repertoires and cues for appropriate ways of organizing, these boundary crossers are likely to bring new ideas into their organizations. So, while Powell and Sandholtz believe the processes are grounded in an attempt to identify and bring in features of organizations in the founding members' knowledge pool, they believe the variation is very much shaped by the originating context of the members.

Sometimes mutations of existing forms do not become new forms in their own right. They might fail to survive as a form or they might be insufficiently distinguished (identity-wise)

from existing forms (Ruef 2000). Social movements can play an important role in differentiating such recombinations from existing forms (Ruef 2000). Community labs, which sometimes resemble hacker or maker spaces, seem to be a recombination that is partially distinguished through identity.

Using the feature-based definition of organizational forms, Rao et al. (2000) suggest that new forms are created when social movements seek to de-institutionalize existing beliefs, norms and values and establish new forms to instantiate a new set of beliefs, norms and values. Strong speciation of a form occurs when the four key characteristics (goals, authority relations, technologies, and marketing strategy) differ from existing forms (Rao, Morrill, and Zald 2000). Weaker speciation refers to new forms differing on fewer of those key axes. While not all recombinant approaches draw attention to these key features as the pieces of existing organizations that are recombined, this approach seems to fit in a similar category because it is derived from the idea that some parts of new organizations are drawn from existing ones. Rao et al, however, draw attention to the importance of social movements in mobilizing resources to create new forms to pursue particular beliefs or values.

Organizational forms that are recombinations or mutations of existing forms vary a great deal in how novel they are. Some are only slightly different from the forms that have come before while others are substantially different. Those that seek to distinguish themselves based on differences in identity, for instance, may not be substantially different in structure. Instead, organizations may be attempting to differentiate themselves from existing forms to avoid stigma or regulation or to acquire resources.

Models

Across the emergence processes that emphasize identity, organizational fields, and recombination of existing organizations is a common acknowledgement of the importance of using existing organizations as models for the creation of new forms. New forms are often constituted through narratives of what the organizational entrepreneurs want to do or believe they are doing. Different actors within these new organizations may relate them to different models and early decisions are often based on these models, as we see for art museums in DiMaggio (1991). Do-it-yourself community biology labs often use hacker spaces and maker spaces as organizations of comparison because they identify themselves as emerging from a similar intellectual tradition. At the same time, community labs also model off of science labs, incubators, art studios, and educational institutions, all of which contribute relevant organizations to the organizational field surrounding community labs. Labs recombine elements from these various models as they attempt to make their organizations stable. Whether we emphasize identity, organizational fields, or the mechanics of recombination, the models used by organizations with new forms are highly relevant to the processes through which they emerge.

VI. The Dissertation

My contribution to the literature on emerging organizational forms is a detailed analysis of a large number of organizations within a single emerging form, leveraging ideas from each of the literatures described above to give as complete a picture of that earliest stage of emergence as possible. I highlight relevant factors shaping the emergence of community labs in the United States and help develop an understanding of the mechanisms at work as a new organizational form emerges. I use explanations of the emergence process described above, interweaving them

around my case study and elaborating on mechanisms that drive these processes and factors and influence them.

I argue that the very earliest stages of a nascent organizational form are characterized by a struggle to structure the organizations in ways that meet a variety of stakeholder goals while also making the organizations sustainable. Members of the community labs reach for models of organizing from adjacent fields, fully aware of the lack of precedent for the community lab form. Many spend substantial time trying to understand the pros and cons of particular features of organizations. The organizations undergo changes based on outside pressures and failures within the organizations. I examine the fifteen organizations that make up the nascent community lab form from three different angles. I first describe the founding of community labs and the factors that shape the organizations during founding. I then examine the variety of models that community labs adopt, the factors that shape these features, and the ways in which a struggle between participation and successful administration shapes the labs. Finally, I examine how community labs and their members interact with other organizations. Throughout these chapters, I explore various lines of thought on form emergence: the importance of the conditions of founding and the characteristics of founding teams, the role of identity and boundaries in emergence, the structuring of new organizations through processes of recombination, and the role of organizational ecology in new forms. I illustrate the degree of variation in an emerging form and show factors that shape the variation.

In Chapter 2, I develop an understanding of factors that have shaped new community biology labs. I argue that the ways in which founding groups came together within this form shaped the characteristics of the resulting organizations. I argue that groups that emerge through online platforms that first recruit enthusiasts with common interests and only later shift the goal

toward building a lab encourage founding groups that are more diverse and have more diverse goals than those groups that emerge out of the more standard processes described in much of the literature. I also examine how the founding of community labs are shaped by the availability of certain resources including resources associated with particular geographical contexts (cities with science and technology industries), the viability of obtaining funding resources from various stakeholders (members, the public, or private organizations), and the availability of appropriate spaces and cheap equipment.

In Chapter 3, I describe the variation in structure of community labs and discuss mechanisms that influence that variation. I elaborate on theories of recombination by providing detail about how labs use their own ideas about their identity to choose or justify the adoption of particular organizational features. By looking at eleven of the fifteen members of the inchoate form, I detail the variation in how they choose to recombine to form their organizations. I argue that the organizations are torn between a desire for collective governance and the need for bureaucratic practices. I focus on five features of the organizations: the distribution of power, the type of incorporation, the audience of the organizations, the activity focus of the organizations, and the funding model. While some labs rely more heavily on collectivist practices, others are strongly bureaucratic. In the chapter, I describe factors that influence these very different ways of recombining features from other organizations in emerging organizations that generally identify with each other as having similar goals. I take a qualitative look at a number of organizations in a emerging form that show how ideals and practicality shape which models are adopted.

Like the research detailed in the networks and fields section, I argue that organizational context of community labs shapes the form that emerges. In Chapter 4, I elaborate on existing theories about organizational ecology and the importance of identity in differentiating new forms

from old forms. I illustrate how members of community labs use narratives to situate themselves among organizations in four different fields: professional biology, education, art, and technology. I argue that the labs develop niches in each field based on gaps that they identify in what organizations in those fields are currently performing, and I analyze the response of organizations in the fields based on the types of resources that flow between them. I also examine the beginnings of the emergence of an organizational field around community labs.

Methods

I collected data on fifteen community labs over a three-year period between June 2012 and June 2015, though I was only able to collect interview data on eleven of the organizations.[9] I began by reading extensively in shared online Google groups and from the websites of each community lab that I identified. In order to locate as much of the population of community labs as possible, I searched for labs using various methods. I followed up any messages on any Google groups about interest in founding community labs. I searched for and utilized lists of labs and attempted labs collected by DIYbio enthusiasts. I also asked everyone I interviewed to list the labs with which they were familiar. I also obtained data from Meetup.com based on search terms that I gave them (see Chapter 2 for more detail).

I came across several labs that were in the process of founding – like the one featured in the vignette earlier in the chapter. These labs are not included in the analysis, for the most part, because the organizations have not yet been formed and so I could not analyze their structure, funding models, or other features that form the basis of analysis in the chapters. I have, however, worked in information about their struggles where appropriate. In many ways, it was difficult to decide which organizations were founded and which were in the process – several of the labs

[9] In the months since June 2015, two additional labs have opened their doors.

have never formally incorporated, though they have spaces and have been running programs for some time. In the end, I decided to include the organizations that, as of June 2015, had an established space in which they conducted their work and were accepting members beyond the founders. They did not need to be incorporated to be included as having been founded.

For each lab deemed having been founded, I collected data from their public forums (including Google groups and Meetup groups), information and documents from their websites, and any articles I could find in the news. I also attempted to contact members of every community lab that I identified to set up interviews. I concentrated my initial interviews in two of the earliest community labs, gathering eleven from one lab and ten from another, and included founding members as well as members that joined later. Having provided a foundation with these two labs, I sought interviews from one to three founding members of the remaining labs. I succeeded in getting interviews from founders of nine of the other labs. Four labs did not give me interviews.[10] Several interviews were conducted in person, but the majority of interviews were conducted over the internet, using video conferencing whenever possible. Interviews typically lasted an hour, though several went much longer. I talked with a few subjects twice, and corresponded with several over email for follow-up questions. Overall, I conducted thirty-nine interviews. Through a semi-structured interview, subjects were asked questions about founding the organization, how the lab is structured, how it is funded, the sorts of obstacles that they have encountered, changes that they have made, how decisions are made, and their reasons for joining the organization or founding the organization. Interview data formed the base of the case studies for which they were conducted. I then supplemented the interview data with data

[10] One lab expressed interest in being included but never was able to schedule a meeting. I did not hear back from the remaining three labs, though I had previously interviewed the founder of one of these labs.

from the forums and public documents to construct case studies of each lab. I constructed a quantitative data set using all of these data sources to categorize information about each organization (founding date, incorporation type, funding model, authority structure, membership size, and other relevant lab information).

I have little data on three of the labs, all of which appear to be inactive. Their founders could not be reached for comment. I included each of these labs in the analysis when I had public data that could be incorporated to address a particular question. For the most part, however, these are missing data. The three labs are likely to be a little different from the rest in that they did fail. Often, there is no evidence that there were many members at each lab, so the recruitment efforts and organizing efforts of the founders probably look different from those labs that I did identify. I did interview people at one additional lab that failed, and that account has been incorporated into the dissertation. In other words, I collected interview data on all but one of the labs that were currently active.

Chapter 2: Organizational Foundings of an Emerging Form

I. Introduction

Before there are institutionalized ways of doing things, potential forms exist at an inchoate stage, where each organization develops its own way of organizing by experimentation. The resulting organizations vary in how they are organized, though they may ultimately have similar goals. Founders of community labs must explore ways of organizing to reach their (sometimes mixed) goals because the community lab form has not been institutionalized and clear patterns for organizing have not yet emerged. The founding process itself shapes the organization by shaping which stakeholders have a say in the organization, which ideologies will be most prominent, and which challenges will limit what the organization becomes. Each of the community labs could develop the model that eventually becomes institutionalized into an organizational form – or, perhaps, none of them will develop such a model. The factors that shape these early community labs will likely influence what community labs look like in the future. This chapter focuses on elements of organizational founding that shape community lab organizations: the founding members' characteristics and goals, the process of gathering the founding group, and the conditions of founding.

Founding Group

Founding groups of community labs may be the site of what some of called "social convergence" (Wienroth and Rodrigues 2015). Social convergence, the joining of social spheres that occurs when technologies converge (Wienroth and Rodrigues 2015), has been shown to lead to new social formations as the relationships of members of a field change around the converging

technologies (Glasner, Atkinson, and Greenslade 2006). Social convergence has been studied often in the context of biotechnology, where professionals in biology and in technology are brought together by technical advancements, forging new links, knowledge, practices, and stakeholders. Though initially unstable, when hybrid social formations become stable, they allow actors to create new institutions around the new technologies. In the field of biotechnology, citizen scientists are increasingly being included in these new social formations created when biotechnologies converge. Citizen scientists, such a do-it-yourself biologists, play a role in forming new social identities, organizations, and the new relationships that emerge surrounding new converging areas of inquiry (Wienroth and Rodrigues 2015). Personal genomics, for instance, has been shaped by citizens participating in experimentation with their own biologies as a result of their genomic analysis (Wienroth and Rodrigues 2015). In Chapter 4, I explore how citizen scientists fit within different fields. Here, I examine these first convergences of groups that take place within the founding groups of the labs.

The interaction of DIYbio enthusiasts that precedes the founding of a community lab is the earliest site of social convergence of groups that will eventually be part of the new institutions that community labs could become. This interaction, usually through online forums and often through in-person meetings facilitated by the Internet, brings a variety of stakeholders together from biology, technology, law, education, art, and other disciplines represented by the members of the public who are interested in DIYbio. As community lab founders' networks merge, the new hybrid social formation shapes the organizations that they create and the field of do-it-yourself biology organizations.

Founding members of community labs bring with them an array of different ideas about what the organization should become, often based on their own backgrounds and orientations

toward biology. Founder's mental models of organizing at the time of founding, have been shown to continue to influence the organization for quite some time (Baron and Hannan 2002; Baron, Hannan, and Burton 1999). The model shapes who is recruited into the organization, creates expectations of the organization and particular interests within the organization, and helps build a reputation for the organization (Baron et al. 1999). Particular models place more emphasis on particular kinds of resources, which influence how the organization can subsequently grow. Founding conditions may be imprinted on organizations, molding their subsequent development (Stinchcombe 1965).

In the chapter, I illustrate how founding groups gather in two different ways: by emerging out of a group that met through shared interests and decided later to found a lab or through instigation of a person or persons who gathers together a group intentionally to found a lab. While the early labs largely emerge, later labs more often are instigated. Groups that coalesce out of shared interest may include a wider set of goals. Because such groups emerge out of online processes that do not rely on personal networks, they may have more diverse knowledge networks that groups that form based on personal connections. Instigated groups often have clearer leadership and more focused goals. I show that community labs of both founding types rely on online spaces to coordinate and support their organizations. Internet technologies afford organization of community labs more quickly by facilitating the meeting of groups, the gathering of resources, and coordination of ideas. The chapter outlines the ways in which two technologies, Meetup.com and Google groups, facilitate organizational founding of community labs.

Founding Conditions

Conditions at founding shape the community labs that emerge. These include location, funding methods, and hurdles encountered when opening the physical space. Location is a major

factor in whether labs will found successfully. Community labs self-select to form in very particular locations in the United States, and location shapes the character of the labs that result, just as location shapes most organizations. I argue that community labs currently thrive in particular local contexts that contain organizations that support scientists and have sufficient population density for membership to reach a critical mass. Community labs choose funding strategies to cover startup costs ranging from crowdfunding, member contributions, or institutional funding. Each funding strategy shapes who the stakeholders are in the organizations. Finally, in opening the physical space, founding groups encounter hurdles as a result of the organization's lack of legitimacy. At this stage, they begin the earliest attempts to negotiate legitimacy. Founding conditions shape the locations the organizations pick, the funding methods they can accomplish, and the legitimacy obstacles that they encounter. At the end of the chapter, I briefly outline reasons that some would-be founding groups fail to found community labs.

Data and Methods

Populations of organizations experimenting with a new form do not consist of large numbers of organizations by their very nature, though more organizations will emerge once a few have hashed out different ways of organizing. For this reason, it is difficult to use elaborate modeling to understand survival, failure, or the predictors of founding success. Instead, in this chapter I compare organizations using case studies that I have constructed for the dissertation out of an array of data. Using the fifteen community biology labs that had been founded as of June 2015 and data on a number of attempts at founding community biology labs, I analyze the factors that influence the founding of community labs. I also anticipate factors related to founding decisions that may lead to consequences for the organizations that emerge, though I cannot fully

evaluate whether particular differences in founding decisions lead to ongoing differences in the community labs.

I used many kinds of data to construct my case studies. These included interviews of thirty-seven people at eleven community labs[11] and two interviews of people attempting to found an additional lab, public documents including tax reports, bylaws, lab web pages, proposals, crowd funding campaign documents, data from Meetup.com, data from public Google groups, and news articles. I described the interview data in Chapter 1. Below, I describe the data provided by Meetup.com and collected from Google groups.

Meetup.com Data

Meetup.com is the platform most often used by community labs for coordinating meetings. This platform allows people in a particular locale to find groups with shared interests that meet regularly. Meetups include things like knitting clubs, singles clubs, hiking clubs, professional groups and more. Meetup.com gave me access to very basic data about Meetup groups that cite DIYbio and/or community labs as the focus of their regular meetings. At my request, they used the following search terms to locate groups past and present that were likely to be DIYbio Meetups: groups with the basic terms "diy", "do-it-yourself" or "hacker"/"hacking"/"hack" in combination with "bio or "biology"; groups using the terms "diybio" or "biohacker"/"biohacking"; or references to the big labs "genspace," "biocurious," or "bosslab." These key words were searched for in the text of the Meetup group descriptions. Meetup.com sent data on 232 groups internationally. I retained only the 105 Meetup groups in the US based portion of the data.

[11] Several of the people I interviewed went on to found two of the labs for which I do not have interview data. I have no interview data from people associated with final 2 labs.

Meetup groups fall into two categories – those that are still currently on the website and those that have been closed. Meetup groups are closed in two primary ways: they can be deleted by the group leader or, if the group loses its leader and a new leader does not step forward, Meetup deletes the group. Meetup.com was kind enough to send me data for both the groups that are currently on the website as well as data for all of the groups that matched my criteria since the creation of Meetup.com in 2002. This means that I have data on the entire population of DIYbio Meetup groups that have ever existed, at least according to my search terms. Some groups that are in the DIYbio spirit may have been missed – though these groups would be ones that do not use the typical language associated with do-it-yourself biology. These missing groups might not be as centrally connected to the ideas of the main movement, which might make them look different from the other groups that I did find. This means I could be missing interesting variation, including groups that are less able to use the knowledge pool of existing labs and groups either because of a lack of knowledge of these groups, because they are attempting something slightly different, or because their expression of what they want to do in a Meetup is articulated without reference to the common language used in discussing DIYbio. Indeed, I know of two Meetup groups that I added to the data that were not found using these search terms. Both groups are associated with community laboratories, which is how I found them. Both have limited description text that references their community lab but not DIYbio or biology. In an ideal world, I would attempt to have Meetup.com search again for groups that included "community lab" in the text. However, I would need a larger portion of text than what was available from both the group description and the Meetups themselves to be able to determine that these labs are biology oriented – many maker spaces and hacker spaces also use the term "community lab" on Meetup.com. I have been unable to acquire additional data from

Meetup.com, though I have searched publicly available groups using these terms and have not found any additional missing DIYbio groups.

To confirm the data, I looked at every Meetup group that was still currently open to determine whether it was a group devoted to the pursuit of hands-on biology by members of the public. I could not access the closed groups on the website, so I relied on the data from Meetup.com to determine whether the group fit my criteria. Some were quite obviously appropriate (they contained DIYbio in the name of the group, for instance). Because I only have the first few lines of group description in the data (descriptions can include many paragraphs), I sometimes did not have enough text to determine whether the group was a DIYbio group. In the few cases where I could not make an adequate determination, I eliminated the group from the data. It is possible that in so doing that I eliminated a small number of DIYbio groups from the sample. These groups are ones that did not clearly broadcast their intent in the first few sentences of their group description, and it only applies to groups that were no longer in existence in December of 2014 since I could confirm the groups that were still active. In June of 2015, I updated all of the data (originally scraped in December of 2014) for the still active groups, and added a few new groups that had appeared in the interim (found using the same search terms given to Meetup.com). In the end, I identified twenty-nine Meetup groups associated with DIYbio, ten of which are associated with community labs. Nineteen of the groups are not associated with community labs (at least, not yet).

The data from Meetup includes basic group information like location, founding dates, ending dates, number of members, number of Meetups, number of positive RSVPs to the Meetups during the existence of the group, and the first line of the group description. I have combined this overarching group data from Meetup.com with publicly available data that I have

collected on groups that are still currently accessible on the site, which includes additional information like what sorts of things groups do at their meetings.

Google Group Data

I collected Google group[12] data about additional attempts to organize enthusiasts by searching Google groups for "DIYbio," "do-it-yourself biology," and references to known groups. I also searched through the international DIYbio group for references to local groups, which often included links to Google groups. The data for Google groups are less complete than the data that I have for Meetup groups because I do not have deleted groups for Google and in at least one instance I am unable to view the group because the permissions are private. As with Meetup groups, it is possible that I have missed groups that did not reference the common lingo or that are disconnected from the DIYbio identity label. Some labs have specialized groups for particular functions (like making administrative decisions), and I did not have access to these groups. The groups that I do have access to are the publicly available ones, which are the groups most necessary for early organizing, engaging the community, and recruiting new members. The data that I have on these groups include the place where they are located, the number of group members, the date of the first post to the forum, the date of the last post, and the number of topics that were posted during the duration of the group. I have also spent significant time reading the posts on the Google groups to understand the content. Location is sometimes less specific for Google groups than it was for Meetups – for instance, Oregon has a Google group that covers the entire state because Google groups do not need to be place specific since meeting

[12] Google groups are a type of forum where people subscribe and participate over time. Unlike some forums, any posts in these forums is attached to an email address, which allows people to have persistent identity. Some members identify themselves by name. Others use screen names.

in person is not necessarily a major goal. Still, many of these Google groups are very specific in location.

Limitations

My data collection has a number of limitations. A few of the organizations, which had little online presence and did not allow me to interview them, I know little about. Some of these organizations are not central to the set of organizations in terms of networks – they were not mentioned to me by members at other labs nor do the members seem to be taking part in discussions in the online forums about community biology labs. Still, these labs may be a little different than the labs whose variations I capture in the dissertation, if only because they are pursuing the project in such isolation. The other labs I am missing in terms of interview data often had online interactions that I could read through (such as extensive discussions on Google Groups). This supplements much of my data, as it allows me to "watch" members interact as they found and run the organization. It cannot give me a complete picture – nor can interviews, for that matter. The chapter (indeed, the dissertation) is largely about the variation in the new form – and the commonalities, in large part, too. I believe that I am able to construct a reasonably accurate picture of the range of issues in foundings and some of the possible consequences through the information that I have collected, even if particular organizations are not well documented.

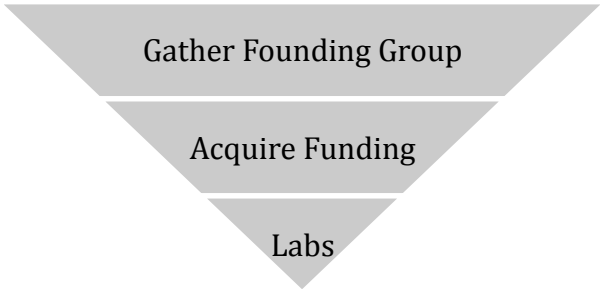
II. Steps in Founding a Typical Lab

Founding an organization that is not based on an established form requires some of the same basic steps required to found organizations of existing forms. Community biology labs typically must successfully accomplish three tasks: 1) gather a group of enthusiasts, 2) acquire

funding, and 3) acquire space and materials for the lab. Each step can be accomplished in an array of ways – and because there is no form to offer best practices, founders of community labs often approach the steps differently. In doing so, they shape the organization's stakeholders, the distribution of power in the organization, and the technical possibilities for lab members.

Each of these steps presents its own unique challenge that shape the labs that emerge and cause other potential labs to fail before founding. Figure 1 illustrates attrition at each stage of potential lab founding.

Figure 1: Attrition at each stage of lab founding



Many groups attempt to form around do-it-yourself biology. Not all of these groups choose to go on to acquire funding for a community lab. For some groups it is ideological – they want to experiment or learn about biology but they do not value a communal space in which to do it. For other groups, choosing not to create a lab is practical – they do not have enough interest or time to organize further. Only some of the groups that gather make it to the stage of attempting to acquire funding to create a community lab. Some of these labs fail to acquire that funding and so even fewer are eventually able to open their doors. In subsequent sections, I will outline the kinds of activities that go on in each of these steps, the challenges groups face, and why they fail. These earliest founding stages shape the labs that are part of the nascent community lab form.

Throughout each stage, there is considerable variation in how labs go about the tasks of creating a community lab – an artifact of a form not yet settled. These differences in the early founding steps lead to sometimes subtle and sometimes more obvious differences in the resulting organizations.

III. Who Founds Labs and Why

Now I will turn briefly toward an examination of who founds community labs, the different ways they seek to participate, and their self-reported motivations for founding the labs. Like the founding conditions, the demographics and backgrounds of community lab founders are likely to shape the organizations that emerge. Founders help shape the culture of an organization. The founding conditions in organizations shape those early organizations and become imprinted on the organizations as they develop (Stinchcombe 1965) Founders bring with them different logics or mental blueprints of how they think they should organize that shape the way the organization subsequently evolves, such as the degree of organization building that occurs initially, who has power in the organization, the degree of administration necessary versus the degree of self-management, labor turnover, and failure rate (Baron and Hannan 2002; Baron et al. 1999). The organizational blueprints preferred are dependent on founder characteristics. They are often drawn from other organizations familiar to the founders, and the selection of organizational blueprint can be correlated with demographic variables as well, such as gender (Baron et al. 1999).

There are not enough community lab organizations yet to make strong claims about how different combinations of founder demographics matter for the organization's missions, structures, or longevity. The form is not far enough along in moving from inchoate to a solidified form to draw conclusions about how these early groups influence the eventual shape the form

will take, either. However, I have begun to outline some of the factors that seem likely to be shaping long-term outcomes of the organizations. Founders bring with them motivations and backgrounds that shape the visions that they have for the organization. Visions range from democratic participation in the sciences to more open business opportunities in biology to engaging the public in science (I elaborate on the consequences of these various visions in Chapter 3: Searching for Structure). The organizational knowledge that they can offer draws from their experiences with other organizations in their lives. Some founders are able to bring connections to existing scientific institutions and lend legitimacy to their endeavor by drawing resources or board members from these institutions. Other founders bring business acumen and connections that allow the lab to partner with businesses for outreach. Some are connected to art schools, which serve as a supplier of future members, a sponsor of projects or classes, and an unintimidating entity to do outreach for labs, which otherwise sometimes are regarded suspiciously as risky.

Demographics and Occupational Backgrounds

Community lab founders are both male and female. Though men outnumber the women overall as is typical in among founding groups (Ruef 2010), women have played strong leading roles in the founding of many community labs, including some of the largest ones. Of the labs with smaller founding teams, men were more commonly the founders. Female founders of community labs noted to me that membership is usually skewed strongly toward men, and they suggested this was likely related to the same reasons that women are less well represented in the sciences more generally. Other studies indicate that women may receive less investment in their entrepreneurial endeavors despite the quality of work, leading to demand-side pressures for women to avoid entrepreneurial work (Thébaud 2015). However, Thébaud also found that

women actually received more support and higher ratings of ability than men when their business plans are innovative, which would likely be the case for community labs.

Founders are most often Caucasian, as are members. A small subsection of founders (and members) have Asian heritage (Korean, Japanese, Indian). Most rarely represented in community labs are African Americans, though two labs have been founded by African Americans. One has been founded solely by an African American woman. The other, led by an African American man, was founded specifically with the desire to get more African American children involved in STEM disciplines.[13] African Americans are overrepresented among founding groups in community labs relative to the percentage of African Americans in the population more generally and even more so relative to the percentage of professional scientists who are African American. Less than 2% of the doctorates awarded in the sciences were awarded to African Americans in 2010 (Fiegener 2011). African Americans may be overrepresented among founders because of unique difficulties encountered in professional science organizations, though previous investigations have also found that African Americans are overrepresented in entrepreneurial founding groups generally (Ruef 2010). One such founder told me that founding the community lab was a way to increase opportunities and interest of other minorities.

Community lab founders have an array of backgrounds in their professional lives. Several are students, often undergraduates but sometimes graduate students as well. Others holds PhDs in various life sciences or have significant career backgrounds in science and technology. Though this is by no means the majority of founders, it is one of the more common backgrounds. Several founders (particularly those who founded the later incubator labs) are entrepreneurs. Two founders that I interviewed have professional art backgrounds. These are the most common

[13] Both of the African American founders have PhD's, which certainly wasn't a requirement for founders.

backgrounds for community lab founders thus far – though there are a few people who do not fit into these categories.

Each of these backgrounds prepares the founders with a different set of organizational experiences (big science, the art world, education, and business) and a different orientation toward the types of science that they would like to achieve at the community lab. Students and those with PhDs more often mentioned outreach and learning opportunities than did entrepreneurs, who were often concerned with specific projects that they were conducting or with developing the labs with an eye toward business. While those with art backgrounds tended to be doing art-related work in the labs, they also emphasized outreach.

Different backgrounds also provided founding members with different resources for founding the lab. For instance, founders at a few labs were able to acquire funding resources through grants from the educational institutions through which they work professionally. Science and education related founders also recruited members of the board or oversight committees from their professional contacts as did entrepreneurs.

Few founders had backgrounds in founding or running organizations, though lack of experience of founding teams is fairly typical for founders more broadly (Ruef 2010). Those organizations with experienced founders appeared to experience less fluctuation in how the organizations were run. They typically started with more clearly outlined authority structures and revenue models and less often tried to select their structure as they went along in response to issues that arose. Organizations with stable models have been shown to fail less often (Baron and Hannan 2002). Though there is not yet a clear pattern of failure based on degree of early organization, community labs with experienced founders did seem to have stronger early organization. They were more likely to design clear structures for decision making in their

bylaws and actually use these processes, select and give authority to leaders very early on in the process, design specific roles with assigned tasks rather than acting as generalists, and have more narrowly articulated goals for the organizations. One artist who led a founding team has experience organizing before, including drawing up a business plan for her own one-person business, collaborating with and helping organize art events for local organizations, and writing up a business plan for an art collective which, though it never got off the ground, was a helpful experience in learning about organizing. The lab designed by this woman was, arguably, the one with the highest level of organizing. Her lab involved a written business plan before it opened, clearly defined roles and departments within the organization, and department heads that meet on a regular schedule. While in a few cases the design of the organization was relatively thorough, in most cases the organizations were not planned in detail before they opened their doors. Many underwent change over time as leaders learned about their organizations.

Labs with multiple founding stakeholders drew from the understandings and preferences of multiple founders when envisioning and executing their organizational design. Diverse founders continue to shape these organizations based on their competing motivations and understandings of what a community lab could be. Below, I describe the different motivations I encountered. In subsequent chapters, I illustrate how these motivations matter for the organizational models developed in the labs and for how the organizations fit with other organizations in their communities.

Motivations

The motivations and visions that founders of community labs hold are likely to direct how they shape the organization. At the same time, it is possible that some motivations are adopted from the models that founders select for the organizations (if one emulates a hacker

space, it may be difficult not to also emulate the commitment to openness or antiauthority sentiments). Though I cannot know the real internal motivations of the founders of community labs or the origin of these motivations, I can report what they told me in interviews for the eleven labs that have been founded and one lab in progress on which I have interviews of founders[14]. These include retrospective accounts of original motivations in most of the labs and a few accounts of motivations during founding in the labs that are currently being founded. I do not have the full account of motivations for all of the founders of each lab because I interviewed only one or two founders of each lab, except for one of the early labs in which I have a wider sample of members. Still, I will outline here the range of motivations that founders reported for founding community labs and make suggestions about how different motivations for participation and visions for what the lab could be could shape the kinds of activity that the organization undertakes. I have loosely classified the motivations as education and outreach, participation and discovery, and business motivations.

Education and Outreach

At many (though not all) of the community labs, at least one of the founders was oriented toward outreach. In the opening of the dissertation, I quoted one of the founders of one of the earliest community labs, who noted that she had grown up with a worship of science in the public which has slowly been eroded. Now, she finds it depressing as a trained scientist to see how unscientific the public has become. She continued:

> It's funny because apparently if you do surveys scientists are still considered a trusted source of information, but just day to day, when you have something like 30% of Americans not believing in global warming or evolution it's very depressing if you're in the sciences. And, of course, public opinion dictates, to a

[14] I have identified 15 active labs and 4 that are in the process of organizing.

> certain extent, what sort of funding goes to the sciences, how much of the federal budget it is, and it affects researchers directly.

As a scientist, Susan believes public outreach is an important way to educate and involve the public. The lab is a place where this can happen in a new way.

At another community lab, the founding was driven largely by an interest in outreach to minority students. The founder had noted that even students from well-prepared school districts did not seem to have been exposed to the hands-on experimentation side of biology. He believed that exposure to the hands-on side would be a good way to prepare underrepresented minorities for potential STEM careers, and that it would be a good recruitment mechanism to help these students become interested in STEM fields.

Those who emphasized the goal of outreach in founding the labs were often professionally trained scientists. They also tended to be involved in the education arm of the labs, which usually seemed to be a vital function of the organizations in their minds. Founders who emphasize outreach as a primary goal may be more likely to push activities that foster this outreach, including classes and lectures, as well as partnerships with particular kinds of organizations that may assist these goals, such as funding organizations that also emphasize outreach.

Participation and Discovery

An interest in participating in science and being part of a world of scientific discovery was another reason founders were interested in creating community labs. This group's motivations were often aligned with a vision of democratization of science, whereby anyone with an interest in science should be allowed to participate. This category of motivation is distinct from the outreach category in that while those who envisioned outreach did so because they

wanted to promote things like wider participation in the sciences, the outreachers were not necessarily seeking greater participation for themselves (often they already participated). While these categories did sometimes overlap in people's motivations, outreach was really more about helping educate people in science and participation was more about enabling a wider array of people to do science of their own. One founder oriented toward participation and discovery explains the utility of community labs as he conceives them:

> If [the lab] didn't exist, I wouldn't know anything. I would be the guy browsing through forums and saying, 'Well this is cool. I wish I could try my hands at everything - that I could experiment with this.'
>
> There is a big difference between, like, thinking about it and getting your hands dirty and realizing that it's much harder. That's the whole reason that the lab exists. For people like me to go and do things that biologists who are in a lab that is funded by whatever.

Like this founder, some people who found labs want to try out biology experimentation. They are excited about trying out things they have read about. Others are interested in being in on important discoveries that they hope can come out of these labs. For instance, one founder had a family member with a genetic condition that she wanted to be able to research.

Along with emphasis on participation and discovery, often there was an implication of openness and accessibility as a primary goal. A vision of openness can complement the vision of outreach. A vision of openness, however, also is often associated with members valuing open source style projects, freedom for members to undertake a wide variety of tasks, and an emphasis on doing as well as learning.

Business

The final general category of motivation for founding members of community labs were motivations that emphasized business ends. Business interests among founders tended to fall into

two categories: some founders were interested in entrepreneurship opportunities of a community lab while others wanted a way to make money outside of established institutions in their fields. For either endeavor, the labs were a tool to enable livelihoods. I discuss these issues in more detail in Chapter 4.

Nearly all of the labs have entrepreneurial members, and many had founders who were interested in entrepreneurship. This is particularly the case in the labs in California. Entrepreneurs tended to have a background in biotech or engineering. In the community labs, they wanted to do projects ranging from building hardware for biology applications to trying to engineer organisms toward particular commercial purposes. While some are open and collaborative in their projects, others are not interested in sharing. The entrepreneurial vision does not work well with a vision of openness, though sometimes they were able to coexist (see Chapter 3 for more detail).

A second vision included scientists who wished to conduct research outside of universities and research labs. Community labs were seen as a possible way to pursue projects cheaply that otherwise were difficult to fund. For a few founding scientists, they also served as a perfect stopgap between jobs. One founder on the east coast noted that he was interested in the lab because his professional skills were rusty after having spent some time out of institutional labs. The community lab was a helpful way for him to get his skills sharp and then work on a series of projects. Another PhD decided to pursue work out of a community lab after receiving his PhD as an alternative way to do a postdoc without having to deal with competitive and disheartening positions in his field. Community labs were also a place for people to teach (the classes) in order to make money. While they might also have outreach goals in this case, the potential to fund themselves may have been a motivation as well.

Artists in the space often fell into this category partially. They used the space as a different place to house their art, though they often also seemed interested in openness and in the possibility of contributing to general knowledge.

The various business interests did sometimes overlap outreach interests and participation interests. However, the business motivated groups most often were focused largely on business opportunities. These business motivations shape the approach these founders have toward the new community labs. In the early labs, entrepreneurs often founded alongside those people with other motivations. Though entrepreneurs might be focused more on equipment in the space and project funding opportunities, they did participate in other aspects of lab governance and founding. The founders oriented toward their own work also contributed expertise to others in the space. The business oriented groups participated in collaborative learning, as well.

Now, however, the business-oriented founders (particularly the entrepreneurs) seem to be more likely to branch out and found their own community labs using different models than the early labs, which emphasized openness. These founders have built labs focused solely on the business aspect – often emulating accelerators or incubators – which focused on members who had specific projects with business applications. The split of these founders from other founders after attempting to run labs together suggests that the visions and the execution of those visions did not match well.

Future Founders

Founders of future community biology labs may look different from the ones founding today. The people willing to try to create a new form of organization from the ground up will likely be more comfortable with ambiguity. Founding groups today may have a wider range of visions for the organization than founders will once the form has become crystallized. There are

signs that the community labs are already diverging into two separate forms: one that emphasizes widespread participation and outreach and one that emphasizes a more rigorous, project oriented approach. Founders of these two types of labs are diverging because of different motivations for participation (outreach and discovery versus business) and the realization that these motivations might need to be met in different organizational ways (see Chapter 3 for more detail).

IV. Gathering the Founding Group

The characteristics of the founding groups are influenced by how the groups come together. Though some theorize that members are selected for founding teams based on their functional values, such as complementary skills, or that high status founders are better able to draw cofounders, these considerations are often not strong factors (Ruef, Aldrich, and Carter 2003). Typically founding teams are homophilous (particularly with respect to gender, ethnicity, and occupation) and are formed based on strong ties (Ruef et al. 2003). Cofounders often meet through previous endeavors, working together, or are part of similar networks. Founding groups are often homophilous either through choice or because networks tend to be structured such that similar people come into contact with each other. Though founding teams tend to be homogeneous, there may be certain advantages to diversity in founding teams. Diverse founding teams based on weak ties, may have access to less redundant information than founding teams based on stronger ties, which tend to both be more homogeneous and isolated to smaller segments of knowledge carrying networks (Burt 2004; Ruef 2010). Creative teams that combine multiple cohesive groups that are cognitively distant create cultural products, like video games, that are more distinctive and highly rated (de Vaan, Stark, and Vedres 2015). How founding teams come together may influence whether the teams are homophilous or more diverse.

While founding teams for many organizations (like startups) come together or are recruited through stronger ties from professional or personal networks, community labs are often founded by people working outside of their professional lives, who often meet through internet enabled activity. Many community lab founding members do not have previous exposure to others in the founding group, and the groups may have fewer overlapping personal networks than would be the case in many founding endeavors. Gathering founding groups for community labs (and some of the organizational work that follows) is often facilitated through technology. Meetup.com, a platform that facilitates meetings, and Google groups, a platform that hosts forums, are key in gathering the founding team for many community labs and in enabling ongoing organization and recruitment. The diversity of founding teams recruited through online meeting results in founding groups that include individuals that bring a varying set of organizational tools and expectations. Groups that draw from outside of their personal networks by utilizing Meetup.com and Google groups to make contact with new members may be more diverse. As I will argue in the next two chapters, the array of models that founders of community labs draw upon to make their organizations work shapes each organization in different ways. By collecting a founding team through Internet-based platforms, some of the labs may be open to a larger diversity of interests than those that collect a founding team in more traditional ways. This section focuses on the genesis of founding groups for community labs in order to better understand the organizations that emerge. First, I outline the two basic ways that community labs gather founding teams. Then, I illustrate how online spaces are used to assist in the founding endeavor. At the end of the section, I describe reasons that some potential founding groups disband.

How Founding Groups Emerge

I have developed two ideal types to describe how founding groups emerge in community labs: coalescent foundings and instigated foundings. Coalescent founding groups come together around a shared enthusiasm for biology and then subsequently decide to found labs. Instigated founding groups are gathered purposefully together by an individual or pair of people in order to found a lab. These two types of founding vary in degree of intentionality. The lab in New York emerged slowly out of a group of common enthusiasts who met for projects and then eventually hatched the plan to open a common space. It coalesced based on shared interest. An individual artist who wanted to open a biology lab launched the lab in Seattle. She gathered to herself the group of people necessary to pursue that goal. The first was a matter of self-organization, while the second was instigated.

Coalescent founding groups and instigated founding groups may have different characteristics. Coalescent groups seem to be more diverse, may have more distributed power dynamics, and have a less focused mission that instigated groups. While members of coalescent labs almost always talk to me about at least trying to be democratic to some degree, instigated foundings often lead to organizations that are more centrally controlled. Furthermore, the tendency to be instigated has increased over time. While most early labs seemed more coalescent, later labs are much more often instigated. The coalescent/instigated typology is a useful tool for thinking about how some labs come to be more democratic and broad in their missions while others are more bureaucratic and focused. However, most labs fall somewhere along the spectrum between the two.

Coalescent Foundings

Coalescent founding teams tend to be characterized by initially very weak or nonexistent ties. Because they emerge using online spaces, members do not need to know each other or be connected to each other through networks in order to meet.[15] Consequently, coalescent groups may have access to a larger pool of interpersonal resources than similarly sized groups that emerge based on existing social ties. Theoretically, this could give coalescent groups an advantage over many founding teams than instigated groups, which recruit from existing acquaintances. Coalescent teams often have leaders that emerge, but also must contend with a larger number of people who have a say in the organization than teams that are instigated by an individual, who may retain certain decision-making power.

The New York City lab Genspace follows most closely the coalescent model of gathering a founding group. The concept of DIYbio had already emerged before the New York group got started. Though Boston already had a local interest group, most DIYers were still dabbling in their own garages and participating in discussions through an international Google group for DIYbio, a group that still is very active in 2015. As New York City residents on the international discussion group started realizing they had a critical mass to start meeting in person, one of the eventual lab founders coordinated their first meeting in February 2009, which became a regular meeting every few weeks in a member's house. The Genspace group established their own New York dedicated Google group for having discussions among themselves and other interested locals, and started using Meetup.com, a platform that helps coordinate meetings. During this time, they did simple experiments and scientific demonstrations. As their desire to be able to do

[15] Typically, an individual founds the Meetup group or the Google group and then people with similar interests join the groups. However, it is also common for a few interested people in the same location to meet through the international DIYbio Google group or another platform, and then form a local group. The local group may then coalesce into a founding team.

longer term experiments with more equipment grew, in March 2009 they began brainstorming their needs for a shared laboratory on their Google group. For the next year, they continued to meet at various locations in houses, coffee shops, and working spaces of other organizations doing experiments, social events, and planning meetings for the eventual lab space. The organization was gradually taking form. During that year, the original Google group members met a molecular biologist who was adjuncting at local universities and working in a tiny closet biology lab. In collaboration with this new cofounder, expanding within the building he had already located, Genspace finally opened its doors in December of 2010.

Genspace coalesced from a collective of individuals with a common interest in home-based biology projects. Though early leaders emerged in the group, the founding of a space was an idea that came after the group started meeting. The people who started the group were not necessarily the people who led the founding, which was very much a group effort in this case.

Instigated Foundings

Not all community labs emerge out of an existing group of enthusiasts. The founding of later labs in particular have been instigated by an individual or a pair of individuals who have the idea of creating a lab and then who recruit additional people to the founding team. Instigated foundings often include people who already have preexisting ties, but even instigated foundings use online tools to gather additional members, and so these tools provide a way to access people outside of one's social networks in both kinds of foundings. Instigated foundings more often included intentional recruitment of individuals who could add to the founding group's skill set. Instigated foundings also more often led to community labs with clearer leadership (often the people who instigated the lab in the first place), labs with clearer focus (on business, learning, or outreach), and labs with stronger organization at the outset.

Seattle's HiveBio is a strong example of an instigated founding team. A woman with a background in art and, later, clinical psychology became personally interested in having a space where she could do simple biology experiments. Having heard of community biology labs, she became interested in founding one that she could use. Researching her own community, she came across evidence of a defunct Meetup group (and Google group), and she contacted some of the former members and reformed a local group. She served as the primary planner of the organization, though she recruited members of the group to serve various functions, like Chief Science Officer and Chief Operations Officer. The group then crowdfunded the lab and opened the doors of HiveBio in October 2013. The lab has a strong organizational structure and centralized decision-making in which the instigator has the final say. Though HiveBio was instigated by an individual, it did rely on building a community of enthusiasts, as do coalescent groups. Even in labs that are instigated by individuals, groups of founders (or, at the very least, very involved members once the door is open) are extremely helpful to the organization because they provide a support group, leverage for necessary funding of the opening and the sustainment of the lab, and human resources for fulfilling the lab's various needs like ordering supplies, being open, and providing classes. When instigators add members to the group, they may recruit them specifically for their ability to contribute to the founding. Often additional recruitment is more about achieving critical mass, however.

Though many of the labs that have been founded by an instigated group had no previous experience with community labs, there are four labs that have been founded by former members of an existing community lab. In fact, all four labs emerged from individuals and founding teams from BioCurious, the largest community lab in the United States with over 65 members in September 2014 (see Chapter 3 for more details). All four of these labs are also located in

California. These labs that are founded out of other labs are a subset of instigated foundings, though the experience at previous labs provides the inspiration for the new founding rather than the idea of it from articles, as is the case with most of the other instigators.

Exceptions to the Rule

Both labs that emerge from existing groups of enthusiasts and those instigated by individuals most often recruit or try to recruit members before the founding of the lab begins. This provides a base of users for the lab as well as a number of human resources for organizing and running the space. However, there are exceptions to this rule. Not all instigators are able to recruit a community of supporters, though most try. One lab, for instance, was founded by an instigator who identified a great opportunity for a cheap lab space and secured that space before gathering a group of interested members. This community lab takes more of an incubator form, with people interested in doing specific entrepreneurial projects as member, and so it may not rely as heavily on volunteers and sideline enthusiasts in the longer term. A lack of a community of enthusiasts, however, is an exception, not the rule.

Though nearly all labs are founded by individuals who are familiar with DIYbio, one community lab in Pittsburgh was actually founded largely outside of the DIYbio community as a way to involve more minority students in hands-on science experiences. Emerging out of some outreach work done by a PhD student and his department, the lab space still prioritizes the educational mission, though it hopes to enable independent work in the years to come.

Comparing the Founding Teams

It is important to note that instigated foundings were rarer at the beginning of the evolution of the community lab form, with biology enthusiasts almost always having to meet at least online before the intention of starting a lab emerged. As labs became more common,

instigated foundings become much more prominent than coalescent ones. Most of the later lab foundings are instigated by individuals. Where early posts on the international DIYbio group centered more often around finding local individuals who wanted to meet up, later it became more common for such solicitations to inquire if anyone in a local area was interested in starting a lab. Using the creation of a lab as the starting point for communication is different than starting a group with a common interest in biology. Sometimes this approach fizzles out quickly because people may have to be convinced to take on the creation of an organization.

Though some instigated foundings, often inspired by existing labs, do attempt to set up democratically run organizations, the rest intentionally concentrate decision making in the hands of the board (I elaborate on decision-making differences in Chapter 3). While this typology (coalescent versus instigated) of community laboratories is useful for thinking about how the labs came to be, community lab foundings actually exist along a continuum. Indeed, some of the earliest labs that were most definitely group endeavors emerging out of Meetups or Google groups, were also partially instigated by charismatic individuals with a vision for an organization.

The Role of Online Spaces in Creating Offline Spaces

The distinction between coalescent and instigated foundings helps us understand the power dynamics behind the founding groups and how certain agendas take precedence (or do not) early on in the founding process. Now I turn to how groups are actually gathered to found labs. As I mentioned in the section on steps of founding, not all groups that have potential to become founding groups go on to found labs. Potential founding groups face a number of challenges that will be outlined below. Technology plays an important role in the founding of community labs by providing an online space for people to meet other biology enthusiasts, by

providing organizing mechanisms once biology groups choose to move toward founding labs, and by providing platforms for crowdfunding startup costs. Community labs have used technological platforms as a way to help them structure the activity that goes on within their organizations both during founding and beyond. Meetups are often linked with the labs' web pages and are used as the basis for lab calendars and coordination of events. Google groups tend to be used for a wider range of tasks and are often less formal in tone. They are less often referenced on the web pages. Both technologies help labs coordinate during founding, including during attempts to incorporate or while trying to acquire space.

"Hi All, good luck. One piece of advice that really helped with both Counter Culture Labs and Berkeley Biolabs was setting up a meetup group focused on DIYBio and biotech. It'll help you grow out your fledgling community," a member of a Google group writes in response to a post calling for people in Cincinnati who are interested in creating a community lab to organize a group. His response highlights one of the most common ways in which groups of founders come together. Meetups and Google groups afford much of the networking necessary to founding community biology labs. Though biology enthusiasts often communicate through Google groups first and in person later, sometimes Meetups come first and, after a group is already meeting regularly, Google groups are created to facilitate communication and planning. Occasionally both Meetups and Google groups are formed after the intention of creating a lab exists, most commonly seen with instigators described above. As noted in the case of coalescent lab foundings, many of these groups are created without the intention of creating a community lab. Instead, these groups often start as online places for gathering people who are interested in learning about biology or doing hands-on biology experiments. Consequently, there are more Meetup groups and Google groups devoted to DIYbio than there are community biology labs.

Meetups[16]

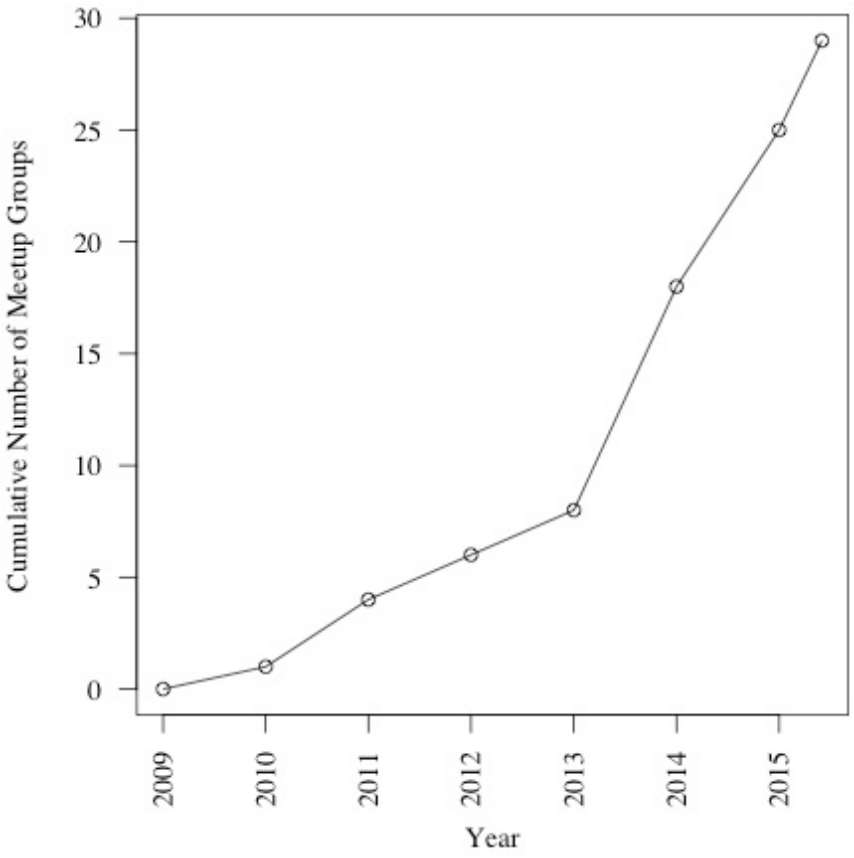
Meetup groups surrounding DIYbio are important to understanding the inchoate community lab form because the groups are one important way that these organizations network and form founding groups. Meetups are used in ten of the fifteen community biology labs in the United States. Those Meetups associated with labs are the most active Meetups. The earliest DIYbio Meetup group appeared in May of 2009 and lasted nearly a year before it was terminated. Subsequently, twenty-nine DIYbio groups have launched in twenty-four cities across the United States. Seventeen were still accessible in June of 2015, thirteen of which are actively hosting Meetups. Table 1 shows the cumulative number of DIYbio related Meetup groups founded over time.

The data show a gradual increase in the number of Meetup groups in the beginning followed by accelerated increases following 2013. The sharper increase makes sense after knowledge of the possibility of DIYbio has had sufficient time to diffuse and early groups have shown helpful patterns for activities for biology Meetup groups. An uptick could also be related to the increase in labs by this time, several of which got media attention that would alert members of the public to the possibility of doing biology outside of standard organizational settings (like industrial and academic labs). Though groups currently appear to be in a stage of proliferation, I would expect the number of new groups to start slowing down when the

[16] Note on naming convention in this chapter: For Meetups, Google Groups, and Labs in the charts and tables in this chapter, sometimes I found multiple attempts at organizing in the same location. Some of these attempts were not related to each other (For instance, two Meetup Groups existed in Los Angeles, but I cannot confirm that the two groups contained the same people. At times, early groups in a location were not related to later labs. Therefore, I named each group or lab in accordance with which started first. Los Angeles 1 was a Meetup group that happened before Los Angeles 2 happened. Los Angeles 2 had a Meetup group, but also a lab which is labeled Los Angeles 2 in the subsequent graphs.

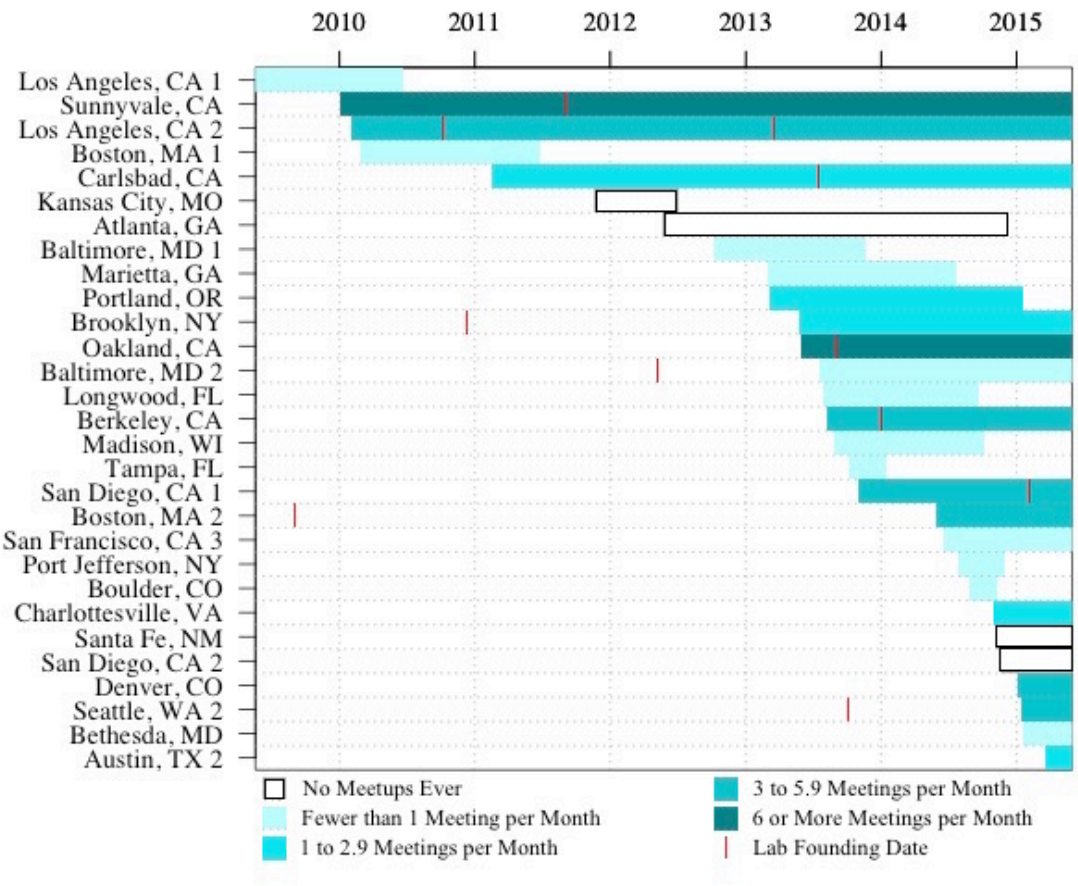
geographical market reaches saturation as groups are sufficiently close together not to need more.

Table 1: Number of DIYbio Meetup Groups over Time



Not all groups that are founded around DIYbio survive the same amount of time or have the same amount of meeting activity. Table 2 describes the founding date and ending date of each DIYbio Meetup group in the United States. Groups with darker bars host more meetings per month. White bars represent groups that existed but never hosted any meetings. Table 2 also includes lines to indicate when groups founded community labs and when that happened relative to the activity of the Meetup group.

Table 2: Duration of Meetup.com Groups



The table shows variation in Meetups centered around DIYbio. Meetups tend to be most common in cities. Those that occur in smaller locations tend not to survive long. The amount of group activity varies. Frequency of meeting is one sort of measure for intensity of group interest. The average group hosted 2.3 meetings per month during its lifespan. However, the distribution is skewed. Four groups never hosted a single Meetup ever (those in grey), and twenty of the twenty-nine groups hosted three or fewer Meetups per month during the group lifespan. On the top end of the spectrum, the group in Sunnyvale, CA hosted on average 12.9 Meetups per month during its five-year life span, while the group in Oakland, CA hosted 14.8 on average per month. Not surprisingly, those Meetup groups that hosted the fewest meetings were also the groups that

discontinued meeting.[17] Meetup groups varied in how many people RSVPed to the various meetups that they hosted. One group had 5069 RSVPs over its life span, while the least active groups never had any RSVPs. The highest average per Meetup was 13.5. The average mean per Meetup was nearly 5.

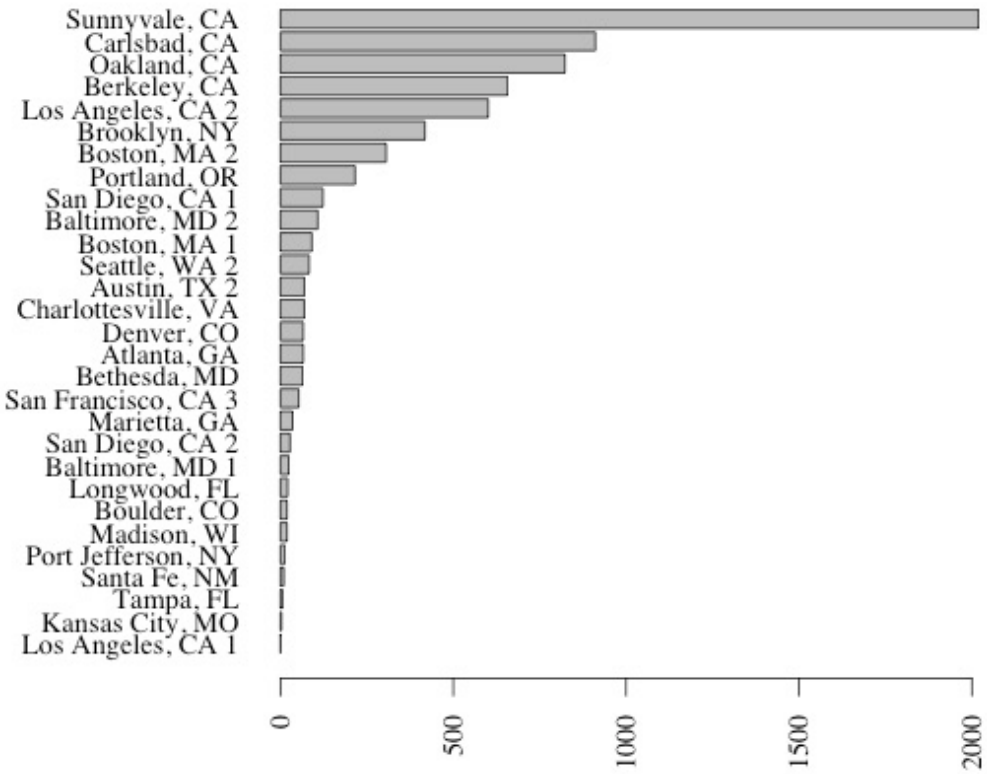
Ten of the fifteen community labs are associated with Meetup groups. Of the eight most active Meetups (three or more meetings per month), six of them are associated with community labs. The other two are so new that it is yet to be seen whether they will maintain their momentum. Of course, there are many reasons Meetups associated with existing labs might have more frequent activity. In part, Meetups serve as outreach for existing labs. Existing labs often invite the public to participate in activities going on in the space as part of recruitment. For instance, BioCurious, a community lab in California, posts nearly all of its lab events on Meetup.com, offering one price to the public and another price to members. Because these spaces have activities regularly and have established at least a basic structure for organizing and hosting events, they are set up better than other Meetup groups for having regular meetings. It is also possible that Meetups that are more active are also the ones that go on to form a lab – that these groups of biology enthusiasts are the sort that are willing to give time to both meeting up regularly and the time necessary to form a community lab. However, this current data is not fine-grained enough to piece apart this issue.

DIYbio Meetup groups vary in size substantially. Table 3 details the size of each Meetup group in June 2015 or, for those that have been retired, the size at the time the groups ended. For these groups, it is possible that the peak size of the groups was higher and groups decreased before they were eliminated. The Sunnyvale Meetup group is by far the largest with 2019

[17] With the exception of Portland, OR, which was meeting twice a month until a group leader stepped down. The Meetup group still exists, but it has not met since that leader stepped down.

members. The median number of members per Meetup group, however, is 66. The top eight groups are all associated with community labs.

Table 3: Number of Members by Meetup Group



Of course, the number of people in the group is positively correlated with the number of days the group has existed ($r = 0.80$, $n = 29$, $p = 0.00$). It may be that organizations using Meetup.com are better able to sustain Meetup groups for long periods of time because commitment levels in the organizations are higher than they would be for many Meetups not associated with organizations. The Meetup group becomes a tool that complements the activities that the organizations are doing rather than the central connection between participants.

Meetup groups, whether associated with community labs or not, have the general goal of bringing together like minded individuals to spend time discussing or doing things of mutual interest. Precisely what sorts of meetings and activities a group undertakes depends on the group.

Meetup events in DIYbio groups can be categorized in four general ways: social, project, lecture, and planning meetings. The social meetings are geared toward community building and hanging out, and might include things like grabbing dinner together or going out for drinks. Project Meetups center around executing particular DIYbio projects. Some of these are more formal than others. Some are planned by an individual who teaches/guides the meeting, which might include a fee. Other project Meetups are more group oriented, with everyone coming together to figure out how to do a particular project. Some projects that the groups undertake are accomplished in a single meeting, while others span several meetings. The lecture Meetups are often centered around a specialist who has agreed to talk to the group. Those organized by community lab Meetups often are larger lectures and, again, are more formal. The smaller groups also have guests come talk to them in smaller settings. Finally, those Meetups that are interested in putting together an organization (including lab space) sometimes have organizational planning meetings coordinated through Meetup.com.

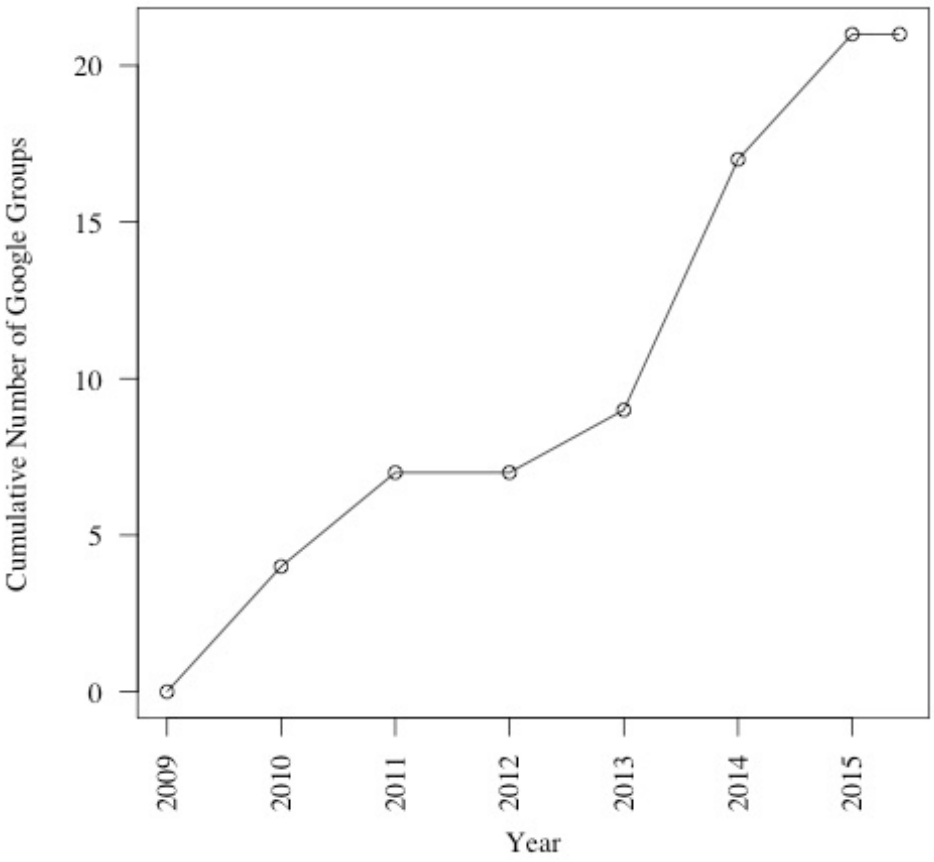
Meetup.com provides an early form of organizing for would-be community labs and continues to help members coordinate events, engage with the community, and recruit once the lab is built. However, Meetup.com is not the only online platform that is central to DIYbio organizational efforts. DIYbio enthusiasts also use Google groups to coordinate their efforts.

Google Groups

Though Meetup.com provides functionality explicitly for coordinating group meetings, Google groups are also central to this function. As mentioned previously, the international DIYbio group on Google groups was the first such group to appear. Originally created by a few men in Boston, the group now serves DIYbio interests all over the world, particularly in the United States and Europe. Over four thousand people had subscribed to the group in June of

2015. It also still serves as the coordinating group for the Boston lab, though the very active chatter about various DIYbio topics drowns these postings out. Other local Google groups have popped up across the globe. Often local groups are created because people in particular locations would like to be able to meet in person. In this way, these Google groups serve a similar function to Meetup groups. However, Google groups can also serve as a repository for shared information, a place to help each other troubleshoot ideas, and a place to organize the group or plan a lab. While meetings may serve some of these functions, Google groups allow local group members to communicate, coordinate, socialize, and plan even when they are not meeting.

Table 4: Number of Google Groups over Time



According to the data that I collected, Google groups devoted to DIYbio increased over time as shown in Table 4. Though no new groups were created in 2011, new groups did come

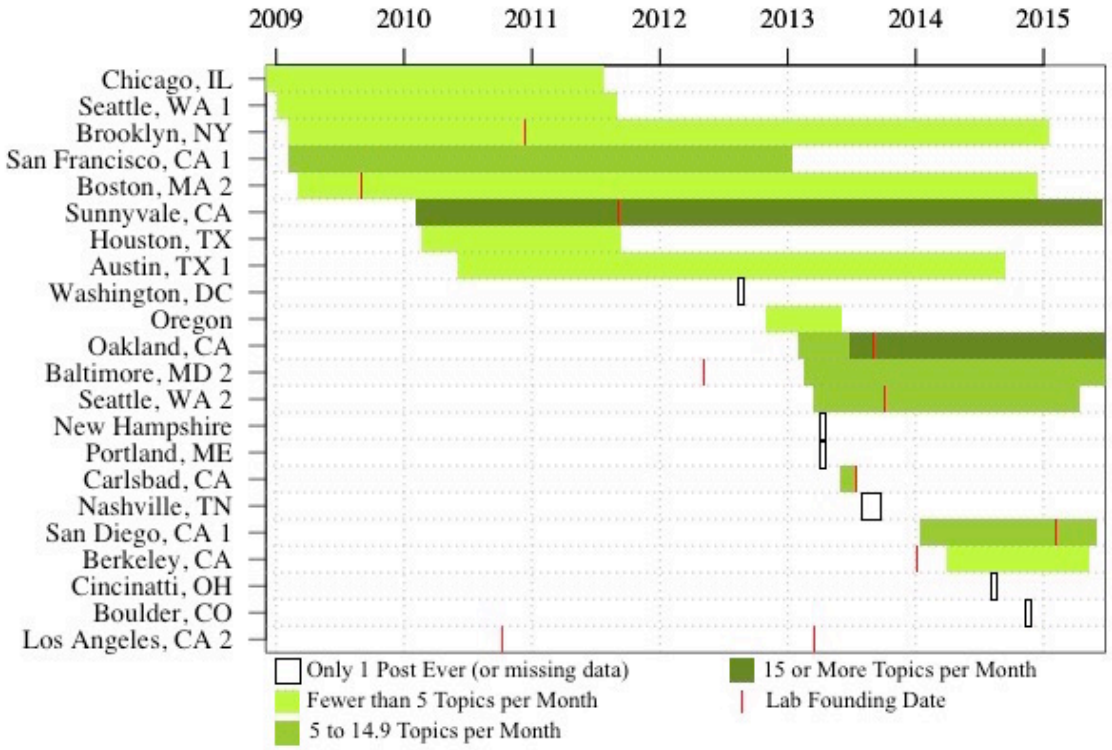
into existence in 2012. 2013 saw the sharpest increase in new groups. As with Meetup groups, Google groups vary a great deal in how active they are. Some have only one post. Others have hundreds. While some are active for a short time, others persist for longer. Table 5 shows the duration of each DIYbio Google group that I was able to identify. The darker the color, the more posts per month in the forum. White represents missing information as well as groups that only ever had one post. Red lines represent the date of the founding of a corresponding community lab for Google groups that are associated with a lab. Los Angeles' Google group was private, so information is missing. However, the founding of the lab (both times) is noted. Nearly half of the Google groups are associated with specific community biology labs.

Four of the groups identified never went beyond a single initial call to organize a group. As with Meetups, ten of the Google groups are associated with community labs, including the five most active groups. The sixth most active group, San Francisco 1, is not associated with a community lab. There was a lab in San Francisco shortly after this group became inactive, but there is no sign that the group and the lab were associated. Oakland, the most active Google group, averages 37 topics every month.[18]

Most of the community labs that have public Google groups had these groups before the lab was founded. In some cases, the group was active only a few months before the lab was opened. In other cases, the Google group was active for a year or more prior to opening a lab space. Some of the groups that do not have labs have discussed founding labs, though usually in a very shallow way.

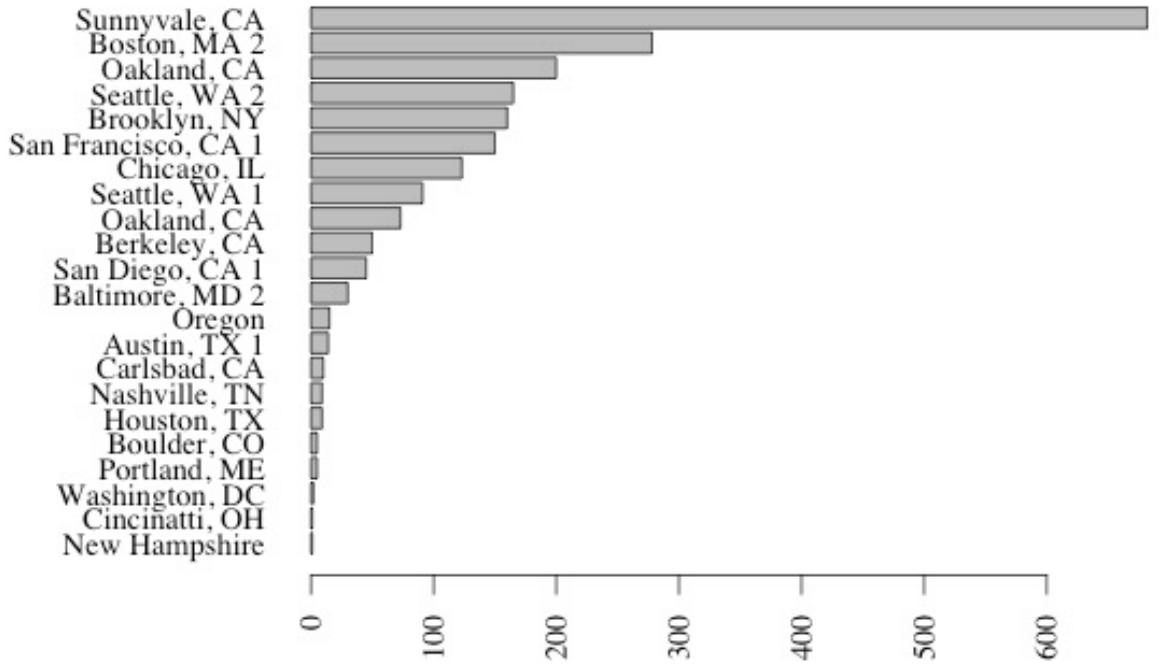
[18] Note that Oakland had two groups, which overlapped briefly. The second group was actually a rebranding of the first group with a new name.

Table 5: Duration of DIYbio Google Groups



The groups range in size from just a single member to 682 members in June 2015. Table 6 shows that ten out of twenty-two groups had less than twenty members. The five Google groups with the most members are associated with community labs. Each of these labs has Google groups with over 150 members. The other community labs have Google groups with between ten and ninety-one members. A few groups that are not associated with labs have substantial membership – San Francisco (150) and Chicago (123). Google groups are smaller than Meetup groups, on average. This may be because Google is a less popular platform for this kind of coordination. However, Google groups might be smaller because they involve a different kind of participation than Meetups.

Table 6: Number of Members in Google Groups



The international DIYbio Google group, which has over 4000 members, is dominated by discussion of particular projects and problem solving surrounding projects that group members are taking on, though it also includes postings on event announcements, relevant new papers, crowdfunding campaigns, new technologies, an occasional philosophical discussion, solicitations for participation in local meetings, and questions to the group about how to open or run labs. Individual place-based Google groups share many of the same topics. Users talk about projects, discuss the latest news in the area, and coordinate local meetings. They tend to spend more time on things like governing the community lab if they have one, founding a community lab, planning meetings, announcing meetings, advertising local events that might be of interest, and discussing approaches to organizing. Several groups did some of their planning of the lab on their forums. Many groups post minutes (or at least summaries) of meetings for people who did not get to attend.

As with Meetup groups, one of the big thrusts of these Google groups is to get people together in one place. But Google groups go beyond and serve as a way to communicate between meetings and allow for activities like planning or coordinating information to persist as a group even when members are not collocated. It is very common to see posts by big players in the DIYbio community on forums other than their own local forum. Often the posts are outreach (such as when one founding member of another lab tried to get people to pool intellectual resources about keeping groups active) and serve as a way of networking between groups (which I have seen less often in Meetup groups). A handful of DIYbio enthusiasts seem to follow multiple place-specific boards because they like to know what is going on and lend their expertise, as seems to be the case with one man I interviewed who did not like actually meeting in person but enjoyed the virtual side of the community. People who span the groups in this way serve to informally network the groups and spread knowledge from one group to another.

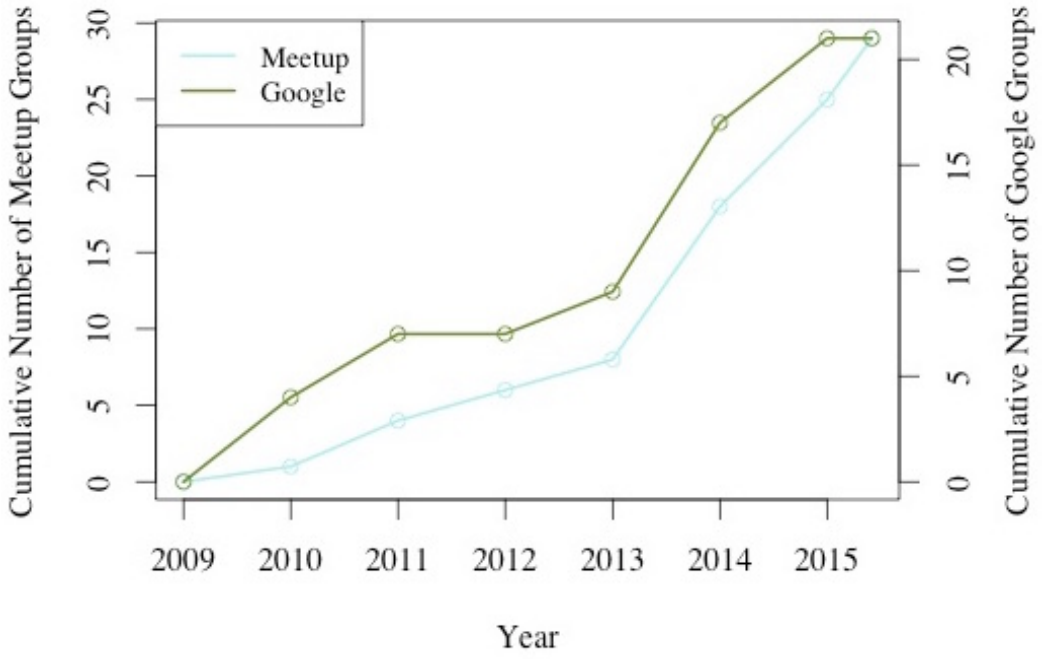
Comparing Meetups and Google Groups

Fifteen Community labs have opened their doors and I have identified three more labs that are in the works.[19] Of the fifteen labs, ten of them are present on both Meetup.com and Google groups. The remaining five have no presence on either. The growth in the number of Meetups and Google groups over time (Table 7) is very similar.

Between 2009 and 2013 the number of groups grew slowly and then grew slightly faster from 2013 to 2015. Faster growth might be something to expect as the form becomes more replicable by new entrants to the field. The slight increase in growth could be a sign that community labs are transitioning from a nascent stage to a more established stage of being an organizational form, though only time will tell. The acceleration could instead reflect

[19] Any or all of these three could fail to form. Of the Meetups and Google groups that have been identified above, several had the intention of creating community labs but did not succeed.

Table 7: Cumulative Number of Meetup and Google Groups Over Time

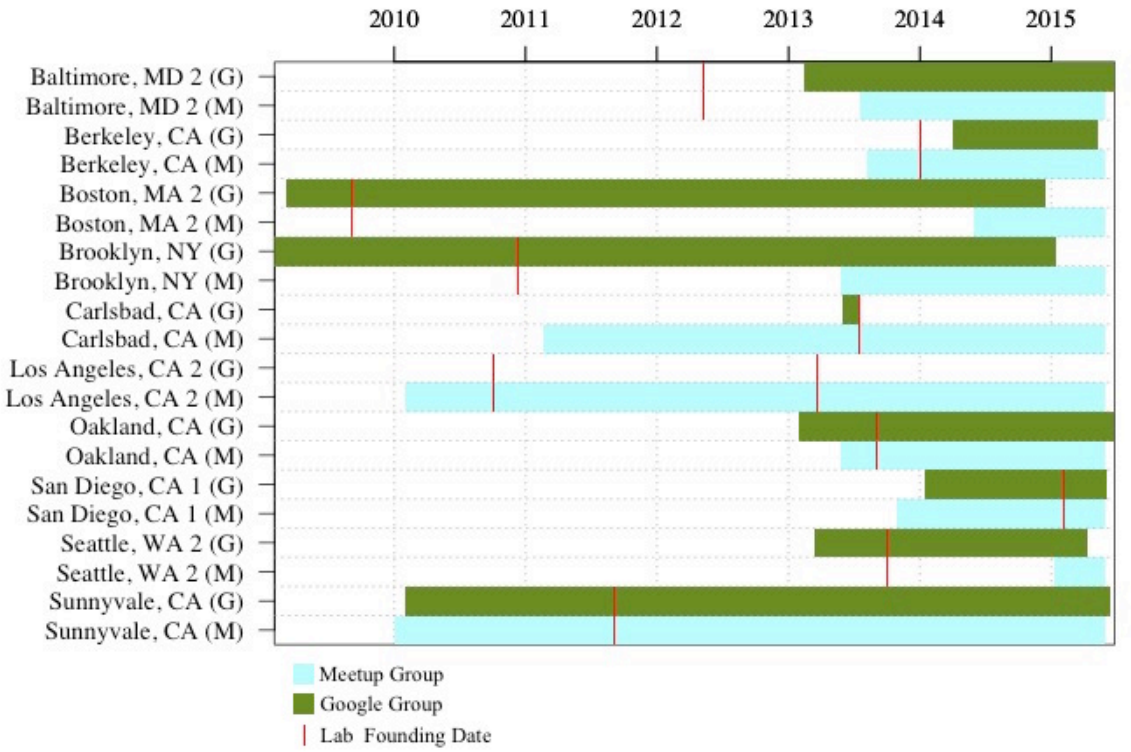


cheapening technology that makes labs even easier to build, an improving economy that gives hobbyists more money to spend, or increased enthusiasm for biotechnology. Most community biology labs had either a Meetup group or a Google group before they opened their doors, with the exception of Baltimore. It is possible that there was at one time a Google group that has been deleted that was used earlier. Three groups had only a Google group before opening the lab. One group had only Meetup groups first. Four groups had both. Labs that are very active on one platform tend to be active on the other as well. The two platforms appear to have different utility for the labs, which is why the labs tend to have accounts on both.

Table 8 provides details about the duration and intensity of the Meetups and Google groups for each of the labs on the same chart. The dark green bars represent Meetups and light blue bars represent Google groups. The red lines represent the founding date of the community labs. Most community biology labs had either a Meetup group or a Google group before they

opened their doors, with the exception of Baltimore. It is possible that there was at one time a Google group that has been deleted that was used earlier. Three groups had only a Google group before opening the lab. One group had only Meetup groups first. Four groups had both.[20] Labs that are very active on one platform tend to be active on the other as well. The two platforms appear to have different utility for the labs, which is why the labs tend to have accounts on both.

Table 8: Meetups and Google Groups by Lab



Five labs do not have either Google or Meetup.com accounts: San Francisco, Pittsburgh, Los Alamos, Houston, and Richmond, VA. The lab in San Francisco was short lived (possibly because it was not really associated with the Google group or Meetup groups in this location – indeed, neither of these groups had overlapping time frames with each other or with the lab in San Francisco). The lab in Houston was similarly short-lived. The lab in Pittsburgh is an unusual

[20] Los Angeles has missing data so I do not know whether it had one or both.

lab in that it is for encouraging STEM participation in minority communities, and it hopes to draw members first from high schoolers in the area and then later from the community. It was not a grassroots endeavor, but rather one instigated by a highly educated scientist, his colleagues, and an urban innovation foundation. It will draw funding and community, at least initially, from the foundation and from local schools. It has only been open since January 2015, so I would guess that when they reach the next phase, which will include more typical community lab activities (like membership), they may branch out into either or both Meetup and Google. Los Alamos was instigated by a single creator who is not networked with other DIYbiologists. Of the five existing labs that do not have Google or Meetup accounts, the one in Norfolk is the most similar to the other labs that do have accounts. It is unclear why they have not used these platforms.

Other Ways Founding Groups Emerge

The majority of community labs put together founding groups using social media through Google groups or Meetup groups. However, not all labs are founded by groups that meet this way, and a few groups that have used these platforms began to emerge prior to joining the platforms (though they may have collected additional members through Google or Meetup). These founding groups are different from the others because they do not emerge through the same process.

The most common way that founding groups meet without the use of the Internet is through participation in previous community biology labs. Primarily, this has only happened in California, a region with high population density, particularly of people in science and technology, over a large span of geography. At least four labs have spun off of BioCurious, the first community lab in California. Several of these labs got their start from participation in the

community lab. Members formed groups to found new labs for a few reasons. In part, some of them simply wanted labs closer to where the actually lived. Members reported to me that some of members commuted a few hours in each direction to go to the community lab. Many of the founders of spinoffs also had clear ideas of things they wanted to do differently at their labs including promoting higher quality work by being more exclusive or different models of control that promoted different ideology (see Chapter 3 for more detail). At least one lab seems to be the result of member relocation. Several of these labs were founded by groups of people from the previous lab. Others were instigated by individual members of previous labs who then gathered a new founding group through processes discussed above.

Two of the community labs that I have identified were instigated by individuals with an interest in science and science education who are not connected heavily with the rest of the movement through the forums or through networking while creating the labs. One of these has developed her lab mostly on her own, relying on crowdfunding and participation in local programs aimed at developing business ideas. Another partnered with a few of his academic contacts and an organization that does community development to put together a lab to do community outreach. These sorts of endeavors are the hardest to identify because they are not networked with the rest of the community labs and, unless they succeed, they leave no trace.

Potential Founding Groups Stagnate or Die

Many Google groups and Meetup groups last for some time. However, not all of them survive and certainly not all of them go on to become labs. The first hurdle DIYbio enthusiasts face when organizing is keeping the group together. I was able to interview via email members of several online groups that stopped meeting. Groups failed for three primary reasons: no one has the time to organize the group, there is insufficient interest to sustain the community, and

member attrition. One man explains that the first group he started disbanded because "we were all financially insecure undergrads at the time, and didn't have money to pursue the meetings further." His second attempt ran into a different obstacle: "I was in the process of changing jobs when I started the group. When I finally started at the healthcare startup, I was too busy there to organize a project once a month, and there weren't volunteers available to work on projects or lead discussions." The group in Portland discontinued meeting after the main organizer stepped down. Finding someone who will do the work of setting up meetings, coordinating projects, and obtaining minimal supplies is challenging even at the Meetup level. Each of these tasks takes time and some group leaders have trouble maintaining enthusiasm over time for the tasks or experience life events that cut into their leisure time.

Other groups ran into the problem of not have enough interest in the community.[21] Indeed, both among Meetup groups and Google groups, this was the most commonly cited barrier. Many would-be local groups were established by individuals who never got any response from the local community. Even though a few labs have managed to be founded without gathering a big community, this requires significant individual resources and time and creates issues in sustaining the lab after it exists. It is much more common for those who do not recruit a group to give up the endeavor.

Finally, member attrition is common in all of the Meetup and Google groups. People join for a time, get busy, and stop attending. This happens once labs are open as well. Overcoming

[21] According to their own reports, though of course people might report that this is the cause of failure in cases where people failed to show up for other reasons, like inconsistent schedules, vague or uninteresting meeting or forum topics, personality conflicts, lack of awareness of the Meetup or Google group, and other issues that make groups less attractive for reasons other than the main topic.

attrition is difficult (and seems to be a matter of finding people who are serious about pursuing the hobby and having a critical mass of interest such that some churn can be overcome).

Though some groups fail to keep meeting, others simply do not move toward creating a lab but do sustain the group as Meetups or Google groups. At times this is because no one steps up to move toward that next level of organization. Other times, the Meetup meets the needs and interests of those meeting up and that desire to have a shared space never emerges. One very active Google group member explained to me his point of view on organizing and DIYbio:

> So, I never really wanted a physical meetup group. I think the idea of meeting with others about diybio is sort of silly, and I dislike the idea of community labs. I think that's somewhat not diybio. People don't seem to be happy with diybioers just having their own home labs. Pretty strange.
>
> Do-it-yourself biology is not a biotech startup or venture, and it's not a company or an organization. It is a loose affiliation of people who are interested in, or actively pursuing, their own biology projects on their own terms, outside of institutional support. Often these people are using their own resources to build their own labs either in their homes or other facilities they are paying for.

Not only did he not want to move toward creating a lab, he also did not find much value in meeting locally (though he had been to local meetings and had organized some of those meetings). Instead, he was interested in the most loosely organized way of having a community, through the Google group forums. Though he is not active in local meetings (aside from a few attempts), he is extremely active in multiple Google groups, including the international one and other groups.

Each Meetup and Google group could potentially be a founding group for a community lab. Most, though not all, community labs gather founding groups and later organization members in this way. Founders of community biology labs encounter obstacles not unlike founding groups of all kinds. Using the Internet as a way to coordinate founding activity is relatively new, but it is something that is used across many organizational areas.

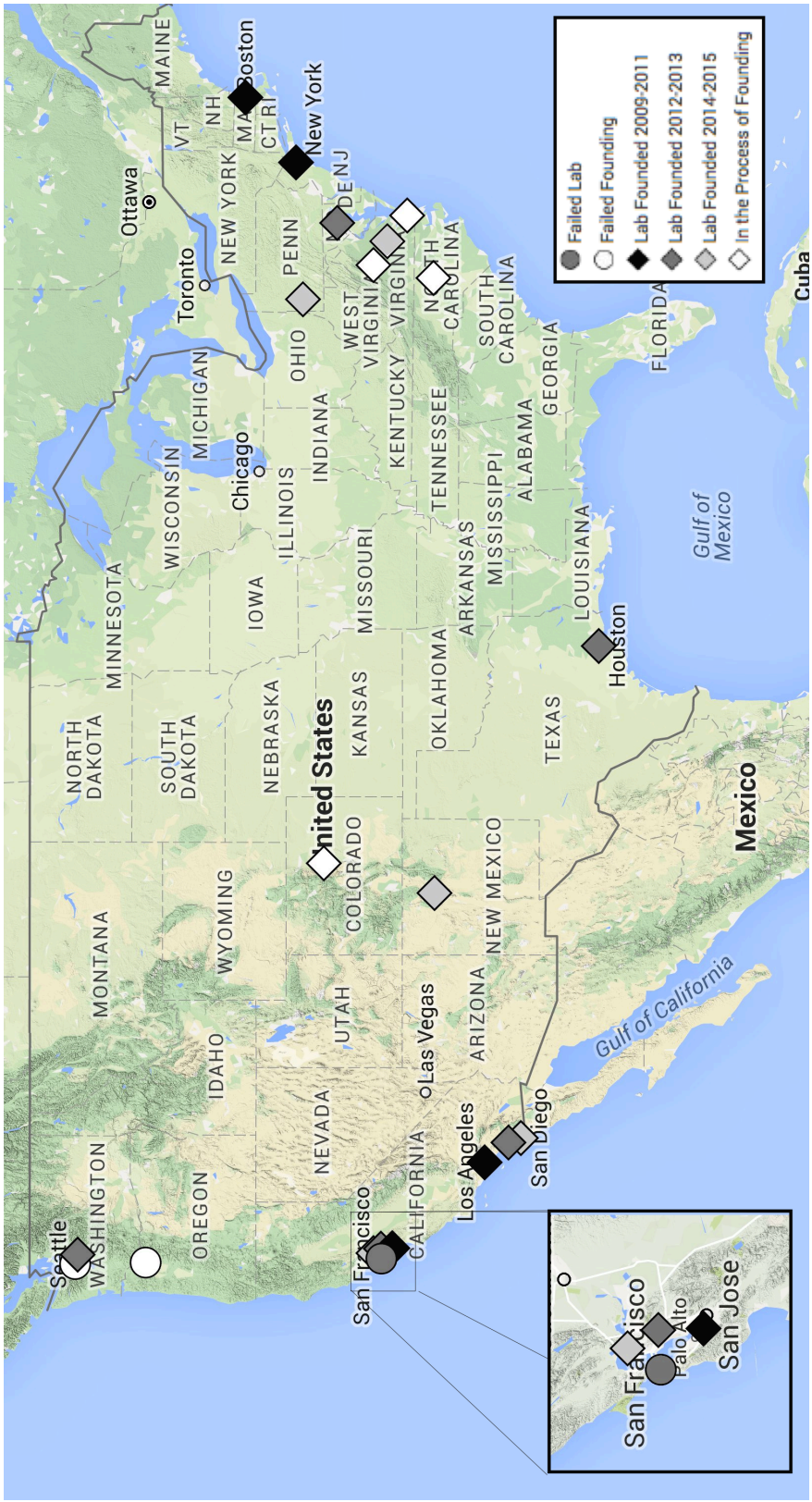
V. The Influence of Local Settings

Not all locations lend themselves as readily to the founding of community labs. Of all of the groups that form around do-it-yourself biology, only those in very particular kinds of locations have so far been able to open labs. Note, for instance, that many of the Meetup and Google groups that either collapsed or simply never became associated with a lab are in smaller towns or cities not associated with technology, science, or many institutions of higher education. In Chapter 4, I discuss some of the ways in which community labs draw resources from surrounding organizations. Here, I will discuss some of the conditions that seem necessary in order for community labs to be founded in a particular locale. Map 1 shows the locations of community biology labs in the United States as of June 2015. The earliest labs opened in major cities along the coasts of the United States. Subsequently, labs continued to develop largely in California and the Northeast, though other areas began also to see community labs appear. The South has seen little successful development of community labs so far, though a few are now attempting to open in Virginia and North Carolina. Community labs are almost entirely absent throughout the middle of the country, with the exception of one in Los Alamos.

Key Features of Host Cities

Community labs seem to be founded successfully only in locales with particular local organizations and population properties. Population density explains some of the affinity that community labs have shown for cities. All of the labs that opened by the spring of 2015 were located within or within a few miles of cities ranked in the top 300 in population size in the United States (U.S. Census Bureau 2015) with the exception of Los Alamos. Large population centers support community labs in two important ways: they provide a large mass of people from

Map 1: Locations of Community Labs in the United States



which to draw supporters and they contain a number of resources that are very helpful to new labs.

Do-it-yourself biology is a sufficiently uncommon interest that large, densely populated areas are key to accumulating enough people in one place to found and fund the lab. Many founding groups will find it difficult to have a critical mass of members to sustain the lab financially and to take on relevant tasks even in highly populated areas. Particularly with founders of an organization with a new form, finding and retaining founding members can be difficult. These founders must be both interested in the unusual matter of DIYbio and they must be willing to flounder through the creation of an organization for which they have no pattern. Locating such founders who can meet in one place is easier in large populations. Cities also are more likely to contain resources that new labs require, like organizations in education and science. Both of these types of institutions are sources of donated or cheap supplies (see Equipping the Space below). The organizations also tend to occur in areas with a relatively well-educated population. Locations typically have high numbers of biotechnology, technology, or academic organizations (including national laboratories, in some cases). In interviews, founders of labs often note the presence of local biotechnology, incubators, technology sectors, and academic labs as part of what has shaped the character of their labs. In Chapter 4, I describe in detail how these organizations are necessary to community labs. Here, I will note that labs typically draw resources from biotechnology, technology, and academic organizations in the form of equipment and expertise. These organizations also inadvertently supply one portion of the group of founders that have been common in community labs: trained scientists. Higher education and science institutions provide proximity to experts to consult, interested parties to join the lab, and often resources such as old equipment. Los Alamos, the only lab to exist outside

a large city, is close to Los Alamos National Laboratory. The thousands of scientists employed by the national lab may be a major contributing factor to why the community lab was able to found in that location.[22]

Not all locations are equally welcoming to community labs. Several founders told me about the struggles they had when finding a location. One, for instance, talked to a city planning committee, which was not enthusiastic about a community lab. The founders decided to move one county over. Though it does not explain why community labs are located almost entirely within cities, local constraints that must be navigated add additional challenges to opening the lab.

Character of Surrounding Organizations Rubs Off

Community labs often take on some character of their location, so where they actually form shapes what sorts of character they might have. One founder explains to me that community labs are hyper local because the time it takes to conduct scientific experiments means that people who use the lab often must live very close. “The lab, or any lab, I think is going to take on the identity of the people who can be there," she explains. Four labs have founded in Silicon Valley, an area known for a vigorous start-up scene. However, each has a unique character. The lab in Berkeley is most like an incubator, while the lab in Oakland embraces openness, transparency, and the counter culture, and the lab in Sunnyvale walks the line between top-down control and public participation.

The community labs in Seattle, New York, and Baltimore benefitted from local art communities. In each lab, artists were members of the founding group, and subsequently, art that

[22] Though I cannot confirm whether this lab is actually very active because I have not had any response from the founder. There do not appear to be regular events, so it may be that this location is not ideal after all.

uses biology as its medium has been a central part of outreach, membership includes artists, and outreach activities and classes often incorporate art. Other labs do have artist members, but few feature art as centrally in their activities as those that had artists on the founding boards. However, a member of one of these labs notes that the locations are still very different and so are the labs. A founder notes,

> Every DIYbio organization is part of an individual, very unique community because they're in many different places geographically. Like, the culture of Seattle is nothing like the culture of New York, for example, where Genspace is. So the needs of the community in New York and the resources available are going to be so different from city to city.

Community labs appear to be adapted particularly well to cities at this juncture. Organizations with new forms are likely to thrive in different types of environments depending on their needs. Community labs, which often gather founding groups through communities of shared interest using the Internet, seem to be initiated more easily in environments with a dense population, though this may be a temporary property of the inchoate stage of the form that can be overcome once the community lab form has fully emerged. Organizations that create founding groups in different ways or require different resources may require different conditions for their early organizations to succeed. Local factors shape whether community labs will be able to found, and the local character provides one source of variation in the community labs that emerge.

VI. Funding the Founding

For groups that move past meeting and decide to try to open a lab, funding that opening is the next big hurdle that they must overcome in order to open a community lab. There is no single established way to go about funding the startup costs, and some ways (like loans from banks) are

closed to the labs. Founding members must make decisions about priorities for spending money including: how big of a space is necessary, how to acquire and build equipment and how much equipment is necessary to open the lab, and where to get the funding and whether this method aligns with their vision for the space.

Three funding strategies were typically used (sometimes in combination) by labs: member funding, crowdfunding, and institutional funding. The three funding strategies require very different approaches to execute. Member funding, or funding of the lab by contributions of founding members, requires founders who have money to invest. Crowdfunding requires successful recruitment of donors and some degree of networking. Institutional funding requires resources through networks (and sometimes grant writing capabilities). I did not have the opportunity to observe any of the groups make decisions about how to fund their community labs first hand, but I did observe discussions on forums on strategy and was told about decisions to go particular directions in interviews. Founding members are constrained by their own material and network resources and their skills as well as the time they have to put raising funds. Their choice of fundraising strategy is also shaped by how they perceive the endeavor. For-profit labs may choose not to crowdfund, for instance, because they do not want the involvement of extra stakeholders. Labs that are open to democratic rule may be more likely to crowdfund. Choosing a model was deliberate at most labs. Sometimes it came down to what the founders could manage (Could they successfully do the kind of outreach necessary to make crowdfunding work? Did they have enough money to found by themselves?), but often the decision also was related to what they wanted to accomplish. Founders realize that the funding strategy that they select is relevant to how the organization will run.

The choice of strategy shapes who the stakeholders will be in the organization. Labs funded by founding members give these founding members a particularly strong stake in the organization and may shape who is allowed to make decisions in the organization (such as who can become new members, ongoing funding strategies, the types of projects that are conducted, and who has authority). Founders of one lab told me that they had founding members contribute money specifically in order to give the founders an ongoing stake in the lab. They hoped to solve the attrition problem found in many community labs by funding in this way. Crowdfunded labs tend to be created by those who already embrace a democratization of science, and their many backers are additional stakeholders beyond the founding group (though just how much power these stakeholders have is unclear). Private grants probably have the most powerful stakeholders. A lab funded by an NSF grant (see below) will have to take measures to meet the requirements of that outreach grant while one funded in part by an entrepreneurial organization will fall partially under that organization's control (including hiring decisions).[23] The number of stakeholders with a voice and the power those stakeholders wield is shaped by who funds the organizational founding. As the organizations become more formally structured and the form settles, I expect that the funding strategy for these no longer experimental organizations will become more and more routinized and entangled with stakeholder interests.

The following section on funding for founding the labs is based on data from crowdfunded labs because the data are publicly available. It is important to note, however, that crowdfunded labs may not be representative of all labs. Some of the smallest labs, which are funded by individuals, may have much lower costs. The incubator labs that are founding-member

[23] It is not very common for community labs, at the moment, to be funded directly by venture capitalists, though projects within the labs sometimes are funded in this way. Those labs seeking to attract the interest of investors may be more successful if they tailor their image toward entrepreneurship.

funded may have higher costs as they tend to target more experienced scientists and thus might need more, and more expensive, equipment. Therefore, the variation in how much founders spend to get labs up and running that I illustrate in this section is almost certainly underestimated. Some labs likely get by with less while other labs may spend much more to get up and running. Most labs accrue some supplies before they open the doors. One non-crowdfunded lab has spent a few years slowly buying pieces of equipment, trying to amass what they believe they need before they can open the lab. Several crowdfunded labs gathered equipment during the crowdfunding process, which often garners public attention. Such publicity sometimes leads to tips on where to get cheap equipment or to offers of donated equipment. Other labs have opened with more minimal supplies and then slowly gathered more as needed or as they were able to do so.

Costs of Founding a Community Lab

Community lab arrangements vary significantly from place to place, but they all share a general set of expenses. Based on my interviews, discussions on Google groups, and a few organizational planning documents, community labs face the following founding expenses: lab space rent, cost of equipment and supplies, liability insurance, waste disposal, utilities, and personnel (theoretically, though seldom in practice). Though I do not have the full startup cost for any of the labs (indeed, I do not think most of the labs know the full cost of their initial start up), I can speak broadly about some of the variation in these costs.

Rent and utilities vary significantly across lab spaces, often due to geographical differences, square footage differences, and whether the lab is renting space within a maker space or not. Seattle's HiveBio, for instance, budgeted $800 per month ($650 of that rent) while Counter Culture Labs in Oakland, CA budgeted $2500 for their rent and utilities in their new

space. Another lab in California tells me that their electricity bill in recent months has run around $1800 per month. One lab has an arrangement with their city to rent their large space from the city for $1 per month for 5 years (with the electric and gas covered by the city for the first year) in an effort to draw biotech entrepreneurs and encourage growth. The city took on $56,200 in costs for this lab (see City of Carlsbad 2013 for details).

Equipment costs can also vary. Many labs have equipment donated by local universities or companies, but sometimes they also buy equipment off of eBay or other platforms from failed biotech companies or places upgrading to newer equipment. One lab budgeted $1000 for new equipment. Another had over $1000 just for a fume hood. Structural upgrades, including things like plumbing, electrical, enclosures, ventilation, and more are also sometimes necessary when a new lab space is opened. One lab budgeted $17,000 for these types of upgrades. This is an outlier, however. Most labs do not seek to raise so much money. Some labs are extremely successful in finding donated equipment while other labs require more funding upfront to acquire their equipment and supplies. Often those that receive donated equipment are better networked with the local community.

It is also common, as part of the startup funding costs, for organizers to plan ahead to cover their costs for several months. Instead of just raising money to cover the first month, founders seek two to six months of funding. Additional startup money gives founders time to get the sustainable funding model for the organization in place. Opening a community lab can range in cost a good deal depending on renting arrangements, availability of free equipment, and scale of the operation.

Funding Strategies

Below, I provide more detail for each of the three funding strategies typically employed to fund the startup of community labs: through contributions of individual founding members, through crowdfunding campaigns, and, rarely, through funding from private institutions. As I mentioned above, each strategy reflects a different rationale and involves different stakeholders in the fledgling organization. The variety of funding options and the stakeholders that come with them are in part a reflection of different values among founding teams in this inchoate form. In addition to selecting funding strategies based on values, sometimes members also select strategies based on the viability of the strategy. Of the fifteen labs across the United States, seven used funding from founding members, two used mostly crowdfunding campaigns, one was able to startup using funding from private backers, and three used a combination of funding strategies. I do not have founding funding data for two labs.

Member Funding

Member contributions to starting the lab are a major way that community labs fund their openings. Genspace, a nonprofit lab in Brooklyn, NY, is one lab that used this method of funding. As noted in tax documents filed in 2012, one of the cofounders loaned $11,019 to the lab for startup costs. By 2013, half of this loan was paid back, according to records. Sometimes member funding is also supplemented by member donation of equipment and time. Member funding is easier to organize than crowdfunding campaigns or acquiring funding from external sources. Member funding can also be quicker because it requires less organization and less wait time while applications are reviewed or crowdfunding campaigns are underway. On occasion, member funding is slower – as was the case with one lab, where the two cofounders worked hard in their day jobs to slowly buy each piece of equipment before they could open the lab. The

downside of member funding startup capital is that it places the financial burden on a few individuals.

Though in some cases member funding may be practical, in other cases, the decision to fund through founding members is made deliberately based on how it will influence the resulting organization. One lab in California wanted to incentivize participation by making members literally invest in the outcome of the lab. Six founding members contributed money toward opening the lab for a variety of reasons. For one thing, this lab is a for-profit lab that serves as a kind of incubator. Because it is for-profit, it cannot use some of the crowdfunding platforms below. For example, Experiment.com, which specializes in helping fund science ventures, requires that all results be open and shared. For-profit labs could use Kickstarter, but that platform attracts a different audience, and it is perceived that a campaign on this platform requires more effort and charisma than on Experiment.com. In addition, the founders of this lab had previously been members of a different community lab where, like occurs in most of these lab spaces, sustained interest in putting in volunteer time was low. They felt that a different incentive structure would work better for their new lab endeavor. By having members put money into the community lab, they intended to incentivize continued time investment from these founding members. Attrition of founding members (and other members too) is one of the major challenges encountered in sustaining community labs, and this funding method is one of the few ways that the community has found to deter it. The cofounder that I spoke to reported that after about nine months, they finally were at a break-even point in terms of money in and money out per month.

Crowdfunding

Crowdfunding is also a popular way of acquiring funds to open community labs. I located the crowdfunding pages for five community labs, two on Kickstarter, three on Experiment.com, and the rest from other crowdfunding methods.[24] Using this funding strategy, founders still put in some money through the crowdfunding campaign, but they have been very successful in getting support from the larger community. One lab leader tells me that crowdfunding is an important way to achieve disintermediation. Rather than relying on banks or investors, people can invest directly in the lab. In addition, crowdfunding helps remove angel investors as the primary factor for who can get funding for new organizations.

Table 9 shows breadth of variation for each of the crowdfunding campaigns for which I have details.

Table 9: Summary of Crowdfunding Campaigns

Lab	Platform	Goal	Pledged	End Date	Backers	Mean Gift
BioCurious Sunnyvale, CA	Kickstarter	30,000	$35,319	9/23/10	239	$148
Biomaker Bench Noblesville, IN	Experiment	3,500	$703	9/19/13	16	$44
HiveBio Seattle, WA	Experiment	6,588	$7,428	12/31/13	55	$135
BioLogik[25] Norfolk, VA	Experiment	3,000	$4,310	5/10/14	78	$55
Biodidact[26] Los Alamos, NM	Kickstarter	6,000	$866	10/16/14	16	$54
Biodidact Los Alamos, NM	MainStreetCrowd		$1,667	Fall 2014		
Counter Culture Labs Oakland, CA	Kickstarter	30,000	$33,170	6/11/15	187	$177

[24] I did my best to search for all of the community labs that I've identified, but I can't be sure I haven't missed some of them.
[25] This is a lab in the process of getting open.
[26] Biodidact's first crowdfunding campaign failed. On Kickstarter, if the campaign fails, they do not receive any of the money.

Though it may not be exhaustive, the data provides a good point of reference for funding community labs through crowdfunding campaigns. The first community lab to use this strategy was BioCurious in Sunnyvale, CA, which managed to raise $35,319 from 239 backers over the course of three months, putting them $5,000 over their initial goal in 2010. Indeed, with the exception of the attempted lab in Indiana and New Mexico's first attempt, each of the community labs raised more money than they asked for in their prospectus.

Once again, the data show a large variation in aspiration for the spaces (goal amount) and in community size (number of backers). BioLogik is a small community lab that is located in a single room of a hacker space, and its budget reflects its size. BioCurious is currently the largest community lab in the United States in terms of membership. Located in the heart of biotech and startup communities, it has a large population to draw from and correspondingly large aspirations.[27]

Crowdfunding does not work for every lab, as we can see with Biomaker Bench and Biodidact, both labs that failed to gain their goal funding. Biomaker Bench, which does not appear to be associated with any Meetups or Google groups, stopped posting to Twitter shortly after the failed campaign and no traces can be found of it today. Gathering a group of enthusiasts seems to be key for founding community labs, and this certainly seems even more necessary for a crowdfunding campaign. As one of the cofounders of a lab that opted for member funding rather than crowdfunding for their new lab explained to me, crowdfunding is a model that works best when a lab has a charismatic individual who can lead the charge. Leaders in these successful crowdfunding campaigns do tend to have some personal draw, and they are well networked in the DIYbio and local communities.

[27] Differences may also reflect cost of living and local incomes.

Biodidact, on the other hand, has acquired a space and equipment using founder funding and donations. They appear to have pieced together additional funding for necessary equipment together after multiple attempts (these attempts are ongoing) at crowdfunding, including a kickstarter campaign that failed and a crowdfunding campaign on mainstreetcrowd.com that did raise money for the lab. In addition, the founder lined up a corporate sponsorship with the local newspaper, making this lab founding a hybrid between member funding, crowdfunding, and private funding.[28]

These crowdfunding campaigns draw interest through a few different channels. First, many of them made themselves known on the international DIYbio Google group, which is a helpful place to draw small amounts of money from a large number of people. Labs also have Twitter and Facebook followings that they use to advertise their campaigns. BioCurious was featured on Kickstarter's blog, and Counter Culture Labs[29] has been featured in Wired Magazine and other publications. Other labs are featured in local newspapers. In return for giving, funders were offered an array of items – decals, t-shirts, and other objects with the lab logo, kits – parties thrown in their honor, memberships to the lab, and other sorts of incentives. Though Kickstarter usually includes rewards, Experiment.com, where several of the groups did their funding, does not. People who contributed to these campaigns (which tended to be smaller) likely did so either because they were excited about the project or because they knew the people running the campaign.

[28] Despite repeated attempts, I have been unable to make contact with anyone at this lab.
[29] Counter Culture Labs actually did open before this campaign, but the money is necessary to make the lab useable by a larger membership and functional for all desired tasks.

Institutional Funding

Though it is fairly rare, some community labs have been able to acquire funding from other institutions in order to open their doors. One lab was partially funded through an outreach portion of an NSF grant that a professional scientist (who was also a founder) had obtained. Another lab is entirely supported by an organization that helps build entrepreneurship opportunities in underserved communities. The lab exists as a part of the existing organization rather than as a separate entity, though the long-term plan is for the lab to be able to support itself through membership fees. This lab is the first lab to have full-time employees (a director and a second employee to help coordinate and run classes).

Labs receiving institutional funding have, perhaps, the clearest mandates from their stakeholders. Usually grants come with specific requirements that must be met, and so starting up with institutional funding shapes the activities, goals, and sometimes organization of the lab from the outset. While members who fund the lab may wield power and crowdfunded labs may disperse power among members, the labs with institutional funding have clearer mandates from their funders.

Labs that rely on funding from other organizations can be vulnerable to a loss of that income. One lab that relied on an NSF funded project for significant amounts of revenue early on was forced to change its funding strategy when the grant ran out. Ultimately, the lab sought and obtained funding from another external source. The lab that exists as part of another organization continues to rely on this funding. The withdrawal of external funds could lead to failure for these organizations if it cannot be replaced with other external funding or new kinds of internal funding.

Startup Funding for New Organizational Forms

Choosing a funding model for startup costs is likely challenging for many organizations that are new forms. They may struggle to identify likely funding models for the new form, and trial-and-error may be necessary to understand the consequences of choosing one method or another. Organizations trying out new forms also lack legitimacy, which can makes it more difficult to receive funding from banks or other such institutions. Angel investors, which may be a good way for some new forms to gain funding, are not likely to be interested in forms like community labs, which are high risk and often not geared toward business. Consequently, community labs must explore other founding funding models.

Legitimacy is a double-edged sword. New organizations using established forms may be constrained in what the organization will look like and how it will function because of pressures toward isomorphism (DiMaggio and Powell 1983), and this will likely constrain the choices that they have when seeking startup funding. On the other hand, organizations with nascent forms may also struggle at the outset with precisely what sorts of activities they will do, who their audience is, how they hope to govern or sustain the organization, and what their goals are. The flexibility of the organizations is accompanied by uncertainty. The population of organizations experimenting with an early stage of an organizational form likely varies in funding strategies to a greater degree than the population of organizations in a more established form (or a later version of the same form). At this very beginning stage of attempting to organize community labs, experimentation is the norm. Thus far, community labs have not begun to converge on a single strategy for funding their founding. I argue later that the labs may be diverging into two different forms (see Chapter 3). I expect that as the organizations become more common, certain strategies will become standard for each kind of community lab.

VII. Opening the Lab

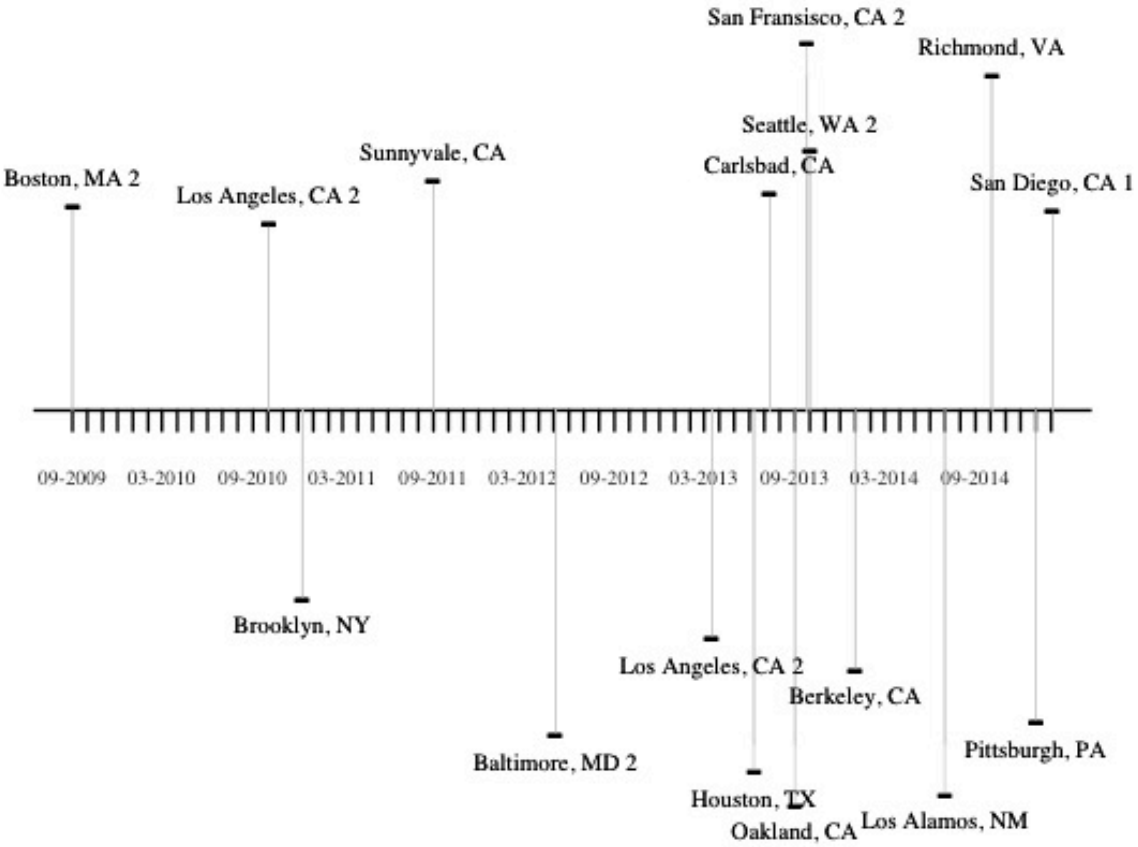
After community labs clear their first major organizational hurdle (finding initial funding), founding groups must then complete the task of successfully opening the doors of their laboratory. In reality, this task often happens alongside acquiring funding because determining the level of funding needed requires quite a bit of planning, in most cases. The final task of opening the space has three major hurdles: finding and securing an appropriate space, acquiring needed equipment and supplies, and assessing whether to get insurance and then acquiring insurance. In completing each of these tasks community labs must brainstorm and evaluate different options. Unlike funding the founding, the opening tasks are beginning to look similar across organizations. However, though they typically undertake similar tasks (finding space, securing insurance, gathering equipment) before the labs open for members, the labs do have some variation in the choices they make.

In each step of the opening phase, community labs run into problems of legitimacy. During this phase, community labs also run into their first experiences being classified organizationally by external audiences (insurance companies, realtors, and law enforcement agencies). Though it is not yet clear how these classifications will play out, choosing to be aligned with educational institutions or science institutions or hobbyist organizations as needed to appease these external entities (and later, the government if the organization becomes a legal entity) is a first step toward articulating the longer term vision for what the organization will be. In the section, first I provide a timeline of lab openings. Then I describe the different space arrangements that labs have tried and the consequences of each option. I detail the difficulties labs have because the organizations are hard to classify, then describe how they go about equipping the space.

Timeline of Lab Openings

Community labs began opening their doors in 2009. To determine their founding dates, I asked founders in interviews what date they founded. For those labs where I could not reach founding members, I looked for documentation on their websites, Google groups, Meetups, or news sites to determine when they opened the doors to their labs. In some cases, dates given to me by members in interviews conflicted with dates that I found in announcements of openings. In this case, I went with the documentation from the original time period. Figure 2 shows the timeline of founding of community biology labs in the United States. Los Angeles appears twice in the figure because it disappeared and then reopened at the second date.

Figure 2: Timeline of the Opening of Community Biology Labs



Brooklyn claims to be the first community biology lab, and in many ways it was. Brooklyn's lab was the first community lab to open its doors in its own space (rather than within the space of another organization) in December of 2010.[30] However, other community lab founding groups had already started putting together organizations prior to Brooklyn's opening. Boston's lab attempts began the earliest, in a shipping container in Boston in 2009 – though the group also met at a local space geared toward educational outreach, where they helped set up a wetlab that they used for some time before later transitioning to their own space. Los Angeles also began working out of a hacker space in 2010. The lab in Sunnyvale incorporated in October of 2010 before Brooklyn opened, but did not open its own doors until the following September. Though it took a few years for the first five labs to open their doors, lab openings became increasingly common in 2013. Several labs are gathering resources and hoping to open their doors soon.

Types of Spaces

Determining the appropriate space for a community lab and finding one can be challenging, in part because of the unknown nature of a community lab. Founders must select the appropriate sized space, which can be difficult given budget constraints and only a rough understanding of how many members they are likely to have over time. Founders also sometimes run into difficulty with zoning, with finding landlords who will rent to them, and with adapting spaces not designed for experimental research. When making the choice about which space to choose, availability and budget are the main factors. Various organizations have also indicated that they took into consideration proximity to public transit, personal connections with landlords, anticipated growth, and proximity to other maker or hacker spaces.

[30] It was probably the first lab to both acquire a space *and* have an organizational structure.

Founders' experiences in finding appropriate spaces for their community labs varies a great deal from very simple searches that yield viable results to those that had to negotiate with multiple potential landlords before finding one that was not concerned about the safety of their endeavor. Some groups used realtors while others used word of mouth in the search. A few noted difficulty in finding landlords willing to rent to amateur biologists. Community labs have not yet established legitimacy in conducting biology experiments, and it can seem risky to potential landlords. In addition, figuring out what zoning laws apply to the space is difficult for many labs (the labs that really thought about it, anyway). Community labs typically either take up residence within an existing space run by another organization that has related goals or takes up residence in a space of their own. Taking up residence in another organization's space is often cheaper and does not require a lease. However, these spaces are often smaller and the lab has less control over the space.

One popular arrangement for new labs is to rent space in an existing hacker space or maker space. These spaces use similar models of membership, with monthly fees for access, and have similar ethics for open access. Rooms in existing spaces are relatively cheap as they tend to have less square footage than other options and also take less administrative time for founding members in terms of handling utilities, leases, access to the building, and renter's insurance. Renting the corner of a hacker space allows labs that do not wish to incorporate avoid a lease, which is a tricky proposition if the organization is not incorporated because without a corporation to assume the lease, an individual in the organization must assume legal responsibility for paying the rent. If the organization folds, the individual remains liable. Therefore, those labs that do not incorporate often wish to avoid a lease. However, renting rooms in other spaces has its own challenges. Because the rented room tends to be small, it limits the

amount of activity that can take place there, particularly since community labs require quite a bit of equipment that does not overlap with most hackerspaces and maker spaces. DIYbiologists in rented spaces are also subject to the whims of the landlord organization, such as having to abide by their open hours and having to work around events hosted in the space. One lab reported to me trouble with equipment and experiments being moved while they were being run, though once they explained that this was a problem, the issue became less severe. Another lab eventually had to transition out of their space when the landlord organization decided that it needed the space for its own expansion.

A second common arrangement is for organizations to rent their own separate spaces. Such spaces come from a variety of types of locations. One is in a building devoted mostly to art spaces. Another is in a building devoted to maker spaces. A third is rented cheaply from a local government that seeks attract entrepreneurs. These arrangements depend on what is available locally and the amount of resources the founders have to put into the space. Renting a whole space also has challenges. The financial and organizational challenges include larger startup costs for paying rent, handling utilities, signing more complicated leases, and finding spaces comfortable with a biology lab renting the space. However, community labs in their own spaces are larger. These labs also are more able to make changes to the space as necessary for doing experiments.

Labs have run into a few problems with spaces that they have rented. At a warehouse space on the west coast, a lab member reported to me an awkward situation in their lab. They had opted to rent an upper floor of a very cheap warehouse. Usually the smell of weed could be detected in their space, which turned out to be because the floor below them was a pot growing operation. Eventually, SWAT busted that floor. They reported that having pot growers for

neighbors mostly did not interfere with their lab space, but that it did on occasion make it awkward to give tours to prospective members, particularly those in families (this particular lab received a lot of donations from parents whose college aged children used the space).

Other issues exist in rented spaces not designed for experimental research. Members reported to me a variety of lab conditions that made lab work more difficult than it might be in professionally maintained labs, which take precautions to avoid environmental contamination of experiments. These include: temperature fluctuations, moisture problems, leaky ceilings, and "dirty power." Christopher, for example, was running a system of sensors monitoring cells at a medium sized community lab on the east coast. Because the power in the building is "dirty," or fluctuates in levels, the sensors could not detect whether the state of the cells had changed or whether the power had fluctuated. This meant that they had a lot of noise in the data that obscured the actual event that they were trying to monitor. When they ran the experiment off of a laptop battery, it was successful. Unfortunately, they lost two days trying to figure out why they were getting noisy data. This sort of issue can be a problem in any of the kinds of spaces that community labs rent, though some spaces are worse than others in terms of temperature issues, moisture issues, and other building circumstances.

While renting from a commercial building or from a maker or hacker space are the most common options, occasionally DIYbio founders try something new. The Container Lab in San Francisco was one such attempt. The idea behind this lab was that DIYbiologists could, very cheaply, create small labs that were contained within old shipping containers. A few lab founders (at least one of which had been involved in lab foundings elsewhere) put together a small lab that resided in a container in a park in San Francisco. When a controversial project engineering glowing plants decided to leave their original community lab in the Bay area, they moved into

this tiny lab and worked there for a time (McDede 2013). Unfortunately, this tiny lab lost momentum and did not last a year.

Community labs make a variety of arrangements, and some labs iterate through several different arrangements. One started out in a hacker space, moved into someone's garage during a relatively dormant year, and then moved out into a space of their own. Because community labs are minimalist organizations (see Halliday, Powell, and Granfors 1987), they have flexibility to try out new space arrangements in response to their needs and resources. Several labs have moved from rooms in hacker and maker spaces to their own individual spaces, but I do not know of any that went in the other direction.

Difficulties with Organizational Classification

Founders encountered several difficulties while opening the labs as a result of an inability to classify the organizations under existing classification schemes. As noted above, uncertainty surrounding the community lab form made securing a location difficult for some labs. Labs also encountered trouble acquiring insurance and ordering certain supplies because they could not easily be classified by external organizations. Typically they were able to gain insurance and order supplies from reagent suppliers by providing additional information about themselves and comparing themselves to existing organizations that the entities had supplied previously.

Seeking liability and renters insurance is, in part, a classification hurdle that must be cleared. Not all of the organizations that I studied had insurance, but many did. When the first opened up, one founder tells me they went shopping for liability insurance. He explains that the reaction of the company they went to was "We don't even know what you are. We can't insure you." The closest that the company could come was insuring them as a hobby shop. They decided to forgo insurance for a time, but after hearing about an instance at a hacker space (that

was not a DIYbio space) where someone injured himself and then threatened to sue, they started looking again. This time they conferred with another community lab, which pointed them to a company that insures miscellaneous things. Another lab described the difficult process of acquiring insurance for me. The lab required general liability insurance in order to secure the space that they desired, so they also approached a place that insured hacker spaces. Community labs are not a clear category to most institutions with which they interact, particularly insurance companies. Before the company would insure them, company asked many questions about what activities occur in the lab. After disclosing details about the kinds of chemicals that they would use the lab and the sorts of procedures that fall into the biology category, the insurance company eventually decided that the community lab seemed safer in a lot of ways than other places that they insure, like maker spaces, which use equipment like table saws and routers. The lab was ultimately able to secure insurance by comparing themselves favorably to a similar kind of hobbyist organization. A founder at a third lab assures me that the process really was not that hard – they reached out to an insurance company, which used the lab's website as a guide to the types of things that they do there, and gave them a quote that seemed fair. Though concerns about how to get insurance are common on the hacker space mailing lists, this founder assures me that she has not heard of many that had trouble actually acquiring it in the end. Subsequent labs have found it easier to acquire insurance (many of them use the same insurer, which now has gone through the process of classifying the labs). I suspect that the founder who undertook their insurance search was more astute at navigating the difficulty of insuring an organization with an unusual classification.[31]

[31] This lab is also one of the biggest, with the largest founding group that I know of, which probably means that 1) people were less overwhelmed with tasks during founding and 2) there

Community labs also encounter classification difficulty when obtaining chemicals and biological specimens through suppliers. Many suppliers will ship only to confirmed biology labs, usually institutional science locations in academic and industry labs. Community labs have typically been able to gain access to suppliers by providing details about the lab space, often including their voluntary certification as BSL (Biosafety Level) 1 labs, which follow a particular set of procedures and are limited in the sorts of organisms that they work with (for more information, see Chosewood and Wilson 2009). In this way, they can become classified in a recognizable way so that they can interact with these very necessary supply organizations.

Equipping the Space

The final task necessary to open the space is to find the appropriate equipment. Equipment includes things like PCR machines, micropipettes, autoclaves, centrifuges, test tubes, glassware, slides, balances, stir plates, pH/conductivity meters, water bath shakers, CO2 incubators, fluorescent microscopes, refrigerators and freezers for storage, ultrasonic baths, thermocyclers, and more. Labs either buy or receive equipment as donation. Those labs that align themselves with universities or industry labs through networking tend to receive more donations than those that do not.

Different labs go about equipping themselves in different ways, but most that have successfully launched found that they could acquire the equipment that they needed. Buying equipment cheaply off of eBay or other platforms is one popular way for labs to gain equipment, particularly for labs that started appearing around the time of the recession and were able to snap up equipment cheaply from biotech companies that were going out of business. Labs also receive

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was more expertise on the table when it came to organizing and more intellectual resources (and network resources) to draw upon.

quite a few donations. These sometimes come through contacts of members with lab managers at universities or other businesses. Other times, people read about the lab in the news, on the forums, or on their websites and either arrange to send them equipment and supplies or drop the supplies off unexpectedly. Most of the equipment bought or donated is old equipment given up as labs upgraded to new stuff. Even in the case of equipment bought from businesses going out of business, labs may purchase older models that are less expensive. Some equipment may be hacked together from kits, from open source specifications, or through ingenuity of lab members. Occasionally, lab equipment will be donated by someone working in the lab as their contribution to the lab in place of membership dues.

It is not entirely clear whether those labs that could not open their doors struggled with acquiring equipment. Members of one noted a general lack of organization and motivation for members to take on the necessary tasks to open a lab, and gaining the necessary equipment may well have been one of the tasks that they lacked the organization to undertake. Another group of founders that has been struggling to open a lab has noted that uncertainty about equipment has been one element that has kept them from opening the doors. This lab has not had much donation of materials (indeed, it seems to lack some of the local publicity that has helped other labs). The would-be founders have slowly been accruing equipment that they believe that they need by saving up and buying it online, often through eBay or other reselling websites. Part of the challenge for these founders is that neither has a background in biology, and they are not sure what equipment they actually need in order to be a viable lab. They continue to collect equipment, but they tell me that every time they are nearly ready to open, they see something

else they feel like they should have. They have collected a substantial amount of supplies, which they showed me during a video conference tour of their space.[32]

The ways individual labs go about equipping themselves depends on the members. In labs with extensive connections to universities, it is common to be able to acquire old equipment more easily from that source. Some labs have funding sources or interested community institutions that help them acquire equipment. Most labs use a combination of the methods listed above to acquire all that they need to make the lab functional (though all of the equipment is not always acquired before the lab opens).

Lab Opening Conditions are Relevant to Lab's Future

The logistics that shape the choices during founding can continue to shape the organization that follows. Those organizations that rent space within hacker spaces, for instance, find themselves constrained by the wishes of the host organization with regard to how much space they can have, when they can be accessed, and the type of equipment allowed. Founders that I interviewed noted that they sometimes had competing priorities and differing understandings of how the spaces should work. For instance, biology projects often run overnight and, if the space is disturbed or power is unplugged during that time by others in the space, the experiment is ruined. However, labs that are able to run out of hacker spaces may have more flexibility on lease length than labs that go for spaces of their own.

For founders that are limited in resources at founding, initial spaces may be quite small. Small size may influence the number of members that an organization can accommodate and the

[32] While equipment acquisition is a reason that they forward in explaining why they continue to stall in opening the organization to members, they have other limitations that are likely major contributing factors. This includes a dearth of recruited enthusiasts, indecision about organizational structure, and uncertainty about how sustainable funding will work.

kinds of activities it can host, which will affect the funding model that the lab can support. This initial funding condition, then, can influence the trajectory of the organization. The other costs associated with opening a lab also influence the trajectory of the organization. A particular organization's ability to acquire good, cheap equipment influences how much equipment they can acquire with their initial funds and how much resources are left over for achieving other goals.

VIII. Failing to Found a Lab

Not all groups that try to found a community lab are successful. Below, I examine an example of a group that aspired to create a lab but never managed to found one. In September of 2011, after over two years of struggling to create a community lab in Seattle, WA, one of the group leaders, Michal, posted a postmortem account of the end of the effort to create a lab as the final post on Seattle's DIYbio Google group. Over the course of the group's two and a half year existence, it had succeeded in meeting up for drinks, meeting several times for small experiments, and had even made moves toward setting up a lab space in a local hacker space. However, they never successfully opened a space. Many of the difficulties that this and other would-be labs encounter foreshadow difficulties that are ongoing for the organizations that do successfully found labs. The problems include a lack of leadership, lack of critical mass, trouble making decisions, lack of consensus, and different visions of the space.

The first difficulty that I will examine is when the group does not adequately gather a group of enthusiasts, particularly the kind of enthusiasts necessary to support the lab through donations, membership fees, and attendance of their classes. While there are several community lab attempts in the works in 2016 that are suffering from a lack of critical mass, DIYbio Seattle actually collected a pretty reasonable sized group – 91 members in the Google group. Other labs

have been unable to recruit founding members and sufficient membership to fund labs or to take on the necessary organizational tasks.

While Seattle seemed to have a critical mass, the membership had trouble solidifying that into a community with shared goals, a problem that is common in would-be and existing labs. Michal describes the issue in his post:

> In Seattle the group never took a project past a good idea. Our raison d'être is a broadly shared interest in applied biological knowledge and technology, but not a defined goal. This failure is caused by confusion about the identity of this group. We don't know ourselves. "A Biopunk Manifesto," by Meredith Patterson is a good example of an attempt to define an identity, although for another group. In Seattle, we took our individual impressions of what DIY is from others and mapped it onto what our own should be for us. This imitation was not good enough to form a community. I believe DIYBIO in Seattle does have an identity, not as a group, but as individuals.
>
> Maybe, we came together as a group because there was an advantage in succeeding at individual ventures. If our group had been a resource to lean on for support, we should have defined the roles of participants. In other groups it is not uncommon to have members work on the organization itself. Seattle DIYBIO has failed to produce a community as everyone's ties to the group were too tenuous. Possibly as a detriment to the success of this young group, many have balked at the idea that he or she joined a club. We have been meeting on a sporadic basis since January 2009 and in that time, not for lack of trying; we failed to galvanize the kind of participation which results in action.

Michal believed that the lack of shared goals made it difficult to create a single community committed to the lab. The lack of commitment meant that no one stepped forward to take on the arduous and sometimes thankless task of doing the actually organizing and founding. A related challenge was a lack of leadership. Indeed, Meetups and Google groups and even existing labs run into the issue of no one stepping up to do needed organizational tasks. If a leader or a few leaders do not appear, moving toward a more formal organization is very difficult. The second attempt at a community lab in Seattle would solve this problem a few years later as a new

instigator turned up, collected back together some of the previous enthusiasts, and provided the organizational plan.

Another common issue to would-be labs (and, later, successfully founded labs) is attrition. Every potential founding group and every lab that I interviewed ran into the problem of attrition. Members, including sometimes the active ones that are key to these tiny organizations, sometimes get busy, get bored, have to move, start a new job, or start a new family and move on from the group. This issue is difficult at all stages of organization, including founding. The Seattle group started with nearly 20 people showing up at the early meetings, but attendance decreased over time. For many groups, attendance decreases as initial enthusiasm wears off, and this is particularly the case when the group does not have a way to sustain or reinvigorate enthusiasm, as some events like classes or lectures or exciting projects might. Thus a group might slowly die from lack of impetus. Many Meetups and labs also reported losing major organization members, causing disorganization like a lack of someone to set up meetings, the loss of the person doing PR, or the loss of the person keeping track of money.

As with any organization, balancing stakeholder expectations can also be challenging. Michal also details this issue in his final post about Seattle.

> We shared a pursuit of new knowledge, skills through participation in an open, thought provoking, productive, and safety minded community. However, all diy-bio'ers did not seek a common experience coming to the meetings. Even if everyone actually agrees safety is critical, a group project never materialized. We each followed our own interests, but away from the DIYbio community. For example, the lack of a clear answer to the reconciliation between openness and commercial goals was a defining problem. Openness can [be] tremendously beneficial to the lot, but this ideal worries those members in pursuit of financial profit. Reconciliation of these goals is likely not impossible, but requires a complex business model. Currently, I do not know how to do it, nor did anyone else participating. It was in “Biology is Technology”, a DIYBIO must read, Rob Carlson helped me understand that there is no clear answer for this entrepreneurial model in biology. DIY biologists will have to figure out what these models are if the ideal openness is to flourish while engaging members with commercial goals.

Corralling potential founders into sharing the same vision in order to make an organizational plan is difficult. Some potential labs do not succeed. Michal points out a major issue for an inchoate form – when entrepreneurial models do not exist to handle the new combinations of goals and stakeholders in a new organization, these organizational entrepreneurs have to settle on a business model and balance the goals of interested parties (more in Chapter 3). This task is not straightforward, and many attempts will fail.

IX. Conclusion

Previous literature has found that homophily and network constraints shaped by strong ties are the best predictors of founding group composition, while weak ties seemed to be poor predictors for whether individuals would end up in the same founding team (Ruef et al. 2003). Rather than seeking out those founding partners who would increase the functional diversity of the founding team, by having a diverse occupational background, founding groups tend to be occupationally homophilous (Ruef 2010; Ruef et al. 2003). Indeed, Ruef (2010) concludes that when forming a founding group, founders are most likely to seek out people whom they trust and with whom they have strong relationships rather than those who might bring additional perspectives to the founding team but are otherwise strangers.

In my case study, I found three distinct styles of founding: those that harnessed technology to meet alters, those that met through pre-existing community lab endeavors, and those that founded alone. All of the earliest community labs were founded by those who used technology to help bring together a founding group. Some intentionally recruited cofounders, while other founding groups coalesced during shared interaction. Contrary to what Ruef and his colleagues have noted in founding groups more generally, the groups that were formed using

Meetup.com and Google groups recruited founding groups with more functional diversity and decidedly weaker initial interpersonal ties than those groups that founded labs after having worked together at previous labs. A few of these technology-enabled groups did actively recruit additional founding members to meet functional needs in the founding team. Further, strong ties played little role in founding teams of community labs – particularly familial ties and marriage ties, which are common in the formation of many founding teams. The process of recruitment of founding teams shapes the degree of homophily, the kinds of network constraints likely to be at work, and whether strong ties are dominant or whether weak ties might also be employed.

Founding groups that start out with greater diversity, both of interest and of experience, may have ongoing differences from those groups that were less diverse. Researchers confirm that entrepreneurs' affiliations prior to their entrepreneurship shape the strategies that they employ in new fields (Baron et al. 1999) Egalitarian processes like those promoted by communally run internet-based groups may give voice to a larger number of stakeholders and allow a greater number of visions to emerge than in groups that form out of a common experience (like working in an existing lab together) or individuals who have a specific goal. An abundance of visions may be a liability, as noted in the section about failure above, though it may also give organizations a number of options from which to choose as they find that certain visions are less successful in certain areas. Chapter 3 includes more information on how the organizations adapt their funding models, for instance, based on demand. The backgrounds of founding members shape the resources that they can bring to the organizational project and may also be associated with their motivations and visions for the lab. Founders tend to be oriented toward outreach, discovery, or business, though some founders incorporate two elements or all of these. Founding

groups vary in how many of each orientation they hold, and a few founding groups were oriented solely toward outreach or business.

In the chapter, I also have detailed how location is a major constraint for this new organizational form. In this early stage, labs are located in cities, though this may not be a requirement for the form once 1) it is a legitimately recognized form, 2) organizational dilemmas have been solved, 3) more people are aware of community labs, and 4) more examples of exciting work have come out of such spaces. Increased demand for participation will make spaces more viable in smaller communities. The labs are currently shaped by the organizational community in which they are geographically located as well, and I think this is unlikely to change. Silicon Valley provides ample entrepreneurs and engineers and scientists and so spaces in that location are likely to continue to be dominated by these interests.

I have also noted how funding opportunities further shape whose interests are most likely to be served during the founding organizational activities. Group funded endeavors like crowdfunding or member funding may encourage the incorporation of more viewpoints than private funding because it incorporates more direct stakeholders in the planning process.

The logistics of opening the lab itself also shape what is to come. Those organizations that rent space within hacker spaces, for instance, find themselves constrained by the wishes of the host organization. Limitations on initial resources that keep initial spaces small may influence the number of members that an organization can accommodate. A particular organization's ability to acquire good, cheap equipment influences how many resources are left over for achieving other goals. During this phase, community labs also run into their first experiences being classified organizationally by external audiences (insurance companies, realtors, and suppliers).

Organizational Foundings of Emerging Forms

Organizations with uninstitutionalized forms are bound to require slightly different processes during their foundings. Founders without an established way of creating their intended organization must choose how to proceed based on 1) ideas that they can come up with by drawing from their own experience or from other organizational models, 2) what they think they are capable of achieving, and 3) what aligns with their combination of goals. In this chapter, I have illustrated the kinds of problems that founding teams in one inchoate form have had to solve and the options that they have chosen. As with community labs, the founding processes for organizations with emerging forms are likely to vary from organization to organization within the same general emerging form as each founding team picks options based on differing assumptions and capabilities. With no guiding best practices or pressures to minimize risk by copying established members of the form, organizations with new forms will try a range of options. Some of the strategies may work better than others, and may become adopted more frequently by subsequent founding groups. I hypothesize that processes for founding a new type of organization will vary according to whether the founding team is more diverse and based on weaker ties, like the community labs who used technology to bring together their founding group, or whether the founding team is based on homophily and stronger ties, as with some of the labs that emerged from existing labs. When founding groups are recruited from more diverse backgrounds, I expect that the organizations will initially entertain a wider set of visions and draw on a wider range of models for the organization. For founding groups that are more homophilous, I expect the vision to be more focused and the models to be less numerous. Emerging forms with founding teams with both sets of characteristics are likely to contain the most variation in approaches.

Emerging forms generally are also likely to encounter struggles with legitimacy, which can raise difficulties that established forms do not encounter during founding. For community biology labs, gaining insurance was difficult because the form is not a recognized way of organizing. Some of the organizations also encountered issues gaining space because landlords did not understand the risks entailed with an unknown type of organization. Labs discovered special challenges in ordering from biological suppliers because their organization status was unusual. The struggle with legitimacy is likely to be a central one for most inchoate forms, both in founding the organizations and in running them.

Other struggles for the inchoate community lab form may be less common to other emerging forms. For instance, how to fund the startup of the lab was not an obvious decision. For many budding forms, standard loans or angel investors may still be viable and obvious options. However, community labs could and did choose from an array of options. Possibly, the degree to which an inchoate form must struggle over how to find funds is dependent on how clear their goals are at the outset.

Emerging forms are also likely to vary in recruitment processes for founding organizations. While the community lab form relies heavily on internet-based ways of meeting, other forms may be born from founding groups that have met through professional connections, educational institutions, or personal networks. I could imagine a typology of emerging forms that separates out forms being founded by founders belonging to similar existing forms (i.e. people who work in hospitals found trauma units) and forms like community labs, that tend to be founded by founders drawn together by a shared subject matter interest and not through their existing networks. The latter will include more diverse occupational backgrounds, and thus a larger diversity of expertise and possibly goals.

Founding an organization that is part of an emerging form entails a different process than founding an organization that is part of an established form, and organizations will vary a great deal more in how they go about it. Experimentation is a characteristic of a nascent form. It is required for new kinds of organizations to learn how to survive. The particular elements of founding that require experimentation are likely to vary from form to form, however.

As an emerging form moves toward a more developed form, ways of founding will become more established. Those seeking to start community labs will be able to take action building on knowledge of previous organizations. The organizations are already becoming more adept at acquiring liability insurance as the knowledge is shared around the community. A leader at one community lab is, even now (in January 2016), attempting to put together a website about best practices of do-it-yourself community biology labs. When new organizations start accepting those practices, the inchoate form will be significantly closer to being a developed form.

Chapter 3: Searching for Structure

I. Introduction

The structure best suited to a new kind of organization can be far from obvious to would-be founders. When Ethan, a young man in his twenties living in a college town, decided that he wanted to create his own biology lab to provide access to himself and others in the community, he set out to understand how to structure such an organization. What sort of incorporation best serves the goals of such an organization? Who should make decisions within the organization? How can it be sustainably funded? How should members be recruited and included in the organization? What sorts of activities would be central to the organization? The most challenging part of trying to found the lab, he told me, was that he could not go to a lawyer to acquire a prepared template of the legal documents he would need nor were there established templates describing how to go about starting a community lab, as might exist if he was founding another type of organization like a bar. Another lab leader agreed in describing her lab's ongoing organizational questions, "What is the right model? What's the way to do things? How are we going to run in the long term, and how are we going to scale?" A founder at third lab laughs, "We are definitely in territory that's, uh – we're just making it up as we go!"

Community labs, however, do not draw their organizational features from nowhere. Instead, they recombine features of organizations that members have access to in their environments. Which features they try is shaped by models that they see and also by pragmatic concerns and ideas about what the organization should look like that differ from member to member and from lab to lab. Consequently, community labs vary along several dimensions. This chapter explores the ways community labs organize and why some labs choose different

approaches than others. I seek to explain the high variation among organizations that are not working from a model of an established form. I examine the factors that influence how community labs structure their organizations in five ways: who has decision making power, how the organizations are incorporated, how inclusive membership is designed to be, what sorts of activities the lab takes on, and how they seek sustainable funding. Community labs draw elements from other organizations to help them structure their approach to each of the five organizational elements. The degree of commitment to collectivist approaches shapes the models upon which they draw. Most labs also experience tension between their ideal organization and practicality.

I first argue that community labs seek to balance collectivist and bureaucratic practices in the lab. I illustrate how tensions surrounding collectivism lead to variations on the community lab form in California and detail how certain factors lead certain labs to organize in different ways. I then discuss the models that community labs draw upon as they organize and the features that vary from lab to lab. I discuss in depth one case study, Counter Culture Labs. Finally, I expand upon the factors that influence labs to adopt particular organizational features.

Balancing Collectivism and Bureaucracy

Much of the variation occurring between community labs can be traced to tensions between a collectivist model of organization and the practical difficulties of implementing such a model, which leads many community labs to also adopt bureaucratic practices. Collectives, a type of organization that became popular in the 1970s, are an attempt to provide alternative organizations that fulfill some social need outside of the bureaucratic organizations that established institutions typically are (Rothschild-Whitt 1979). Collectives include organizations like free medical clinics, food cooperatives, communes, and research collectives. As an ideal

type, collectives are as democratic as possible, making decisions through consensus. In practice, organizations tend to be a combination of collective and bureaucracy (Chen 2009; Rothschild-Whitt 1979). Researchers have detailed the particular challenges facing collectives including difficulty in reaching consensus, the tendency to work best with homogeneous membership, the emotional intensity required for this type of decision making, and the external pressures toward bureaucracy (Hansmann 1996; Rothschild-Whitt 1979). Researchers have also illustrated the ways in which individual organizations balance collectivist practices and bureaucratic practices. Burning Man, an inspiration for at least a few of the labs near Silicon Valley, has a strong ideology of collectivism but, due to size, has had to adopt some hierarchical structure in the past few decades in order to coordinate such a massive event (Chen 2009). Chen (2009) illustrates how collectivist practices are carefully used to prevent the bureaucratic practices from marginalizing the desires of members.

Most community labs are hybrids, to different degrees, of collectivist and bureaucratic practices. Labs are often founded by those who wish to bring access to biology to people who would not qualify under existing science institutions. Many of the founders and members also have cited bureaucracy as something that makes academic and industrial labs expensive, limits what research can be pursued, and takes away freedom. Consequently, a large number of people in the labs are committed to the idea of democratizing science through the labs and keeping bureaucracy to a minimum. However, collectivism is challenging for labs and ideals are often not met due to practical concerns. Previous research has illustrated how collectives fail and how individual organizations struggle to balance practices. This chapter illustrates how an entire set of organizations attempts to balance practices, the factors that make certain practices more likely

to be adopted, and how organizations spin out new organizations as a result of the tension that comes from balancing collectivist and bureaucratic practices.

Recombining Models

Community labs draw on existing organizational forms as models for their own organizations. Recall from the introductory chapter (see Recombinant Approaches on page 32), one approach to understanding where new forms come from emphasizes recombining features of existing organizations in new ways. Organizational entrepreneurs draw together features from organizations with which they are familiar – and the more diverse the entrepreneurs in an organization's founding groups, the more highly differentiated the organization is likely to be from existing forms (Powell and Sandholtz 2012a). Features that organizations draw from others can include things like goals, authority structures, marketing strategies, organizational structures, and other strategies or procedures. When there are multiple organizational forms in the environment from which to draw inspiration, organizations choose from those aligned with their organizational values (Perkmann and Spicer 2014). Perkmann and Spicer outline three types of forms that organizations draw upon: anchor forms, which are a central point of reference; ancillary forms, which are other forms from which they might draw elements to augment the anchor form; and antagonistic forms, which are used as contrasting forms that organizations want to differentiate themselves from.

Community labs draw features largely from organizations in engineering, technology, and biotechnology. They model most closely after hacker spaces and incubators but also draw inspiration from startups. In addition, some labs draw explicitly from other types of collectives that manage public goods. Many labs use nonprofits in other fields as models as well. Many of the areas from which they draw inspiration are collectives like hacker spaces, the open source

movement, and art collectives. Others are distinctly bureaucratic like incubators, academia, and industry labs. Still others, like Burning Man and biotech startups, are hybrids. Community labs typically want to differentiate themselves from established science organizations that do not serve the needs of those who would seek community labs. In this chapter, I detail how some of the labs draw on certain organizational features from other forms.

Differences in organizations have often been explained by resources and constraints in an organization's environment (Aldrich and Fiol 1994; Hannan and Freeman 1989; Ruef 2000). However, in resource poor environments, organizations with very similar environments may adopt very different elements to recombine for their own purposes, producing very different organizations by drawing on different models (Baker and Nelson 2005). The role of individual cultural entrepreneurs and interaction with stakeholders explains how certain models become adopted in certain organizations (Johnson 2007).

Community labs do not all exist in the same environment. Those in Silicon Valley, for instance, are exposed to more startups than those on much of the east coast. Consequently, community labs sometimes draw elements from different models. Even those in similar environments, however, choose different elements to recombine when making their organizations. I will explain some of the factors that shape why organizations in a similar environment choose to construct their organizations in different ways in the next section.

II. The California Labs

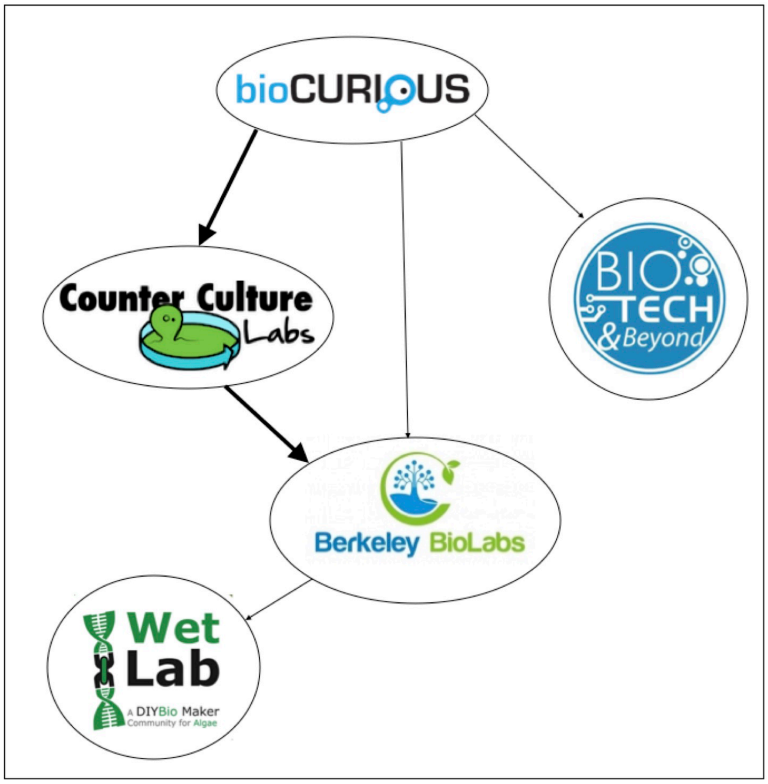
California has been a prolific site for community lab foundings. Seven have been founded, six of which have survived to the present day. Five of the labs in California are related to each other, evolving out of differing needs of members within the initial California lab, BioCurious. The split among the California labs reveals some of the challenges in balancing

collectivism and bureaucracy, and provides examples of how founding teams draw features from different organizations as they attempt to form a new organization.

The first community lab in California, BioCurious, is a hybrid of collectivist rhetoric and intent with largely bureaucratic rule. Though sometimes the leadership takes suggestions and votes from members, a core team wields most of the power in the organization. Over the course of a few years, several members of BioCurious broke off from the lab and founded new community labs using slightly different patterns of management. Often, the new labs were formed in reaction to either a desire for different kind of management or difficulties achieving certain goals due to challenges resulting from the management style. Figure 3 shows the flow of members between community labs in California. In part, new labs were founded out of a desire to have labs in different places. Commuting in the Bay Area can be a major time sink. However, most of the new foundings centered around difficulties existing in BioCurious. On the one hand, Counter Culture Labs took egalitarianism to an extreme, believing there was too much centralization of power at BioCurious. Counter Culture Labs wanted to create a lab that was ruled by members as much as possible. On the other, Berkeley BioLabs and Bio, Tech, and Beyond tried to solve the politics problem noted at BioCurious by going to the other extreme, which one member called a "benevolent dictator" model. Rather than try to have community participation and complete inclusivity, which to some seemed the major factor in inefficiencies at BioCurious, power would be even more concentrated.

BioCurious ran into a handful of difficulties in governing the organization. One founder who left to found another lab noted that BioCurious never really had the unified presence of the founders in the lab that the organization really needed because most of the founders had full-time jobs. He notes, "The community has to be able to coalesce and figure out how to run a shared

Figure 3: Founding Member Movement In California



The thick lines represent multiple members of the lab leaving to found the lab that the arrow points toward. See Table 14 for logo attribution.

resource, which is actually quite difficult." Though the lab was heavily based on a hacker space model (its governance and membership was designed to mimic local hacker spaces), the biology aspect of the lab turned out to make governing the space a little more difficult. Biology work involves procedures and contamination issues that do not typically have to be addressed in hacker spaces. As a result, someone has to be responsible for making sure the lab is safe and for enforcing safety rules and cleanliness rules. Maintaining a flat structure is very difficult, even though BioCurious founders hoped to have a flat structure for the organization. As a founder notes, flat structures sometimes revert back to hierarchical ones, and bureaucracy can become entrenched even if the organization tries to avoid it. In interviews, several members noted frustration that BioCurious operated more as a bureaucracy than they believed that it should,

particularly since members of the organization did believe in a more hacker-space-like flattened structure. Though it maintains a desire for egalitarianism, it is largely run through bureaucratic practices. The board makes most of the decisions.

Counter Culture Labs

Though BioCurious continues to be one of the largest community biology labs in the world despite the shift in the way power is distributed in the organization, some members were committed to a different vision of lab management. They were frustrated by an inability to affect change in the lab and by a lack of communication between the management and the members.[33] Members were also disgruntled by what they perceived as a lack of freedom to do what they wanted brought to a head when BioCurious policy prevented the Glowing Plant project from conducting their research in the space (see The Glowing Plant Project on page 215). Subsequently, some members broke off to found Counter Culture Labs.

Counter Culture Labs (CCL) is committed to the collectivist approach. It adopted a policy of radical openness, which meant that it made all of its decision-making as transparent as possible, posting minutes publicly and inviting everyone to participate in meetings. They also adopted a governance structure that enables wider participation in decisions about the organization than BioCurious had been implementing. Finally, they pursue more controversial projects, such as open source insulin, in contrast to BioCurious, which has chosen to be more conservative in the sorts of projects that it allows in its space. CCL's commitment to limiting members as little as possible allows more controversial projects to be conducted in the lab. The collectivist ideal is constantly pursued in decision-making.

[33] In 2013, BioCurious lost its nonprofit status because it forgot to file paperwork. Members did not know this for some time.

Bio, Tech, and Beyond and Berkeley BioLabs

Bio, Tech and Beyond (BTNB) in Carlsbad and Berkeley BioLabs in Berkeley took a different lesson from the structure of BioCurious. The founders of both of these labs had done work at BioCurious, but found that the organization did not lend itself well to meet certain scientific standards for a number of reasons that subjects at other labs also expressed to me. A central difficulty of a community lab that is collectively run and very inclusive is that it is difficult to maintain the space. One lab member explains to me,

> I want a lab that is well (enough) maintained. I know it doesn't need to be class 1 cleanroom but the environment needs to be reproducible enough that an experiment done today can be reproduced tomorrow if I set it up the same way.
>
> I asked [another member] if I could watch/help while he was going through a PCR-electrophoresis-Imaging protocol. I asked [him] because he was one of the most prolific users of the lab despite its lack of order. If he could get things done I should have been able to follow his approach and get things done. On the day we ran the protocol, someone unplugged the electrophoresis run while we were using it and didn't plug it back in. We took the gel to the room where the imaging system was. The light box was sitting precariously on a cardboard box in the back bathroom next to the men's urinal. When we turned on one of the light boxes, it popped the circuit breaker. We fiddled a bit more with it before getting it to stay on. The image was good enough for the sole purpose [that the other member] had (presence or absence of a line). Not good enough for the science I wanted to do.

The woman above describes how difficult reproducible science it within a lab where people move other people's equipment and where disorder is the rule. Though BioCurious attempted to control cleanliness, one of the consequences of allowing very amateur members in the space – and not having strict, present leadership – was that people did not take care of the shared space to a degree acceptable to those trying to do reproducible science. The woman quoted above had to go into the men's bathroom to retrieve the light box needed for the procedure. Such storage of equipment is at best awkward and at worst unsanitary and socially inappropriate. Members told me that there was not enough authority at BioCurious. Because everyone running BioCurious

was doing it as volunteer work in their spare time, it was difficult to maintain the space. In addition, sharing the space with less experienced members who did not follow procedures or understand the importance of preventing contamination made it difficult to do work that often requires that processes be left unattended for hours or sometimes days.

Founders of Berkeley BioLabs wanted to find a way to incentivize better maintenance of the lab space. One way they hoped to do so was to increase the price of participation. Members paying hundreds of dollars a month would have more investment in maintaining the space, they hoped. The solution that BTNB and Berkeley BioLabs implemented was to try a different organizational design, which would limit who was allowed to participate and impose even more centralized leadership. "We came up with this plan that looked a lot more sustainable to use and that was to become an incubator. To take the spirit of do-it-yourself bio but turn it into an incubator for companies rather than sort of do-it-yourself hacker space," one of the founders tells me. They coined the term "hackubators" to describe this organizational form that is somewhere between an incubator and a hacker space. The labs drew upon California's startup culture, one piece of which is the incubator, which allows people to develop early ideas into companies. Though they still make reference to hacker culture and the individualistic ideal of cobbling together ideas into a money-making business, the organizational model for these labs is decidedly bureaucratic. The hackubators both also are geared more heavily toward entrepreneurship. A few of the early founders of Counter Culture Labs, in fact, moved on to Berkeley BioLabs because they came to believe that their entrepreneurial endeavors required a slightly different organization – one that would be for-profit instead of nonprofit.

While the hackubators reacted in part to the need to find a way to do more rigorous science, they also sought a different way to structure the community lab as a way to solve some

of the financial troubles encountered at BioCurious. BioCurious, which nearly had to close its doors in 2013 due to cash flow issues, had struggled with making a sustainable funding model based off of a hacker space membership model and revenue streams that mimicked nonprofits. In a news article, Joe Jackson, a founding member of BioCurious and Bio, Tech, and Beyond, explains that BioCurious was a first attempt to incorporate citizen science and biotechnology. "We had to learn as we went along," he writes. "Now that I am launching version 2.0 here [in Carlsbad], we have already made many adjustments, especially focusing more on entrepreneurship and creating revenue streams for the lab itself," according to the article (Bigelow 2013). Founders of the labs believed that the path to sustainable community labs was through concentrating on membership revenue rather than classes, donations, and grants, which had been integral to the funding model of BioCurious. They hoped also to be able to gain resources from companies that emerged from their spaces, either by taking some stock in the company as part of inclusion in the space or by some sort of required donation from successful businesses. Bio, Tech, and Beyond also took advantage of free space that they gained through a proposal to the city of Carlsbad. For $1 a year, they have a lab space for 5 years. In return, they were supposed to encourage the growth of biotech in the area. Importantly, even though these hackubator organizations diverged in organizational form from BioCurious and Counter Culture Labs, they continued to draw on hacker spaces as models. For instance, one of the organizations modeled the rules for its board of directors off of a local hacker space. One Bio, Tech, and Beyond founder still thinks of the hackubator as DIY "because many of these folks are bootstrapping and very much improvising to get their project off the ground." The continued reference to hacker spaces, despite the fact that these organizations do not look much like hacker

spaces, is a legacy of their origin within labs modeled more clearly on hacker spaces. Furthermore, it is a way to claim membership in a common endeavor.

The Wet Lab

The Wet Lab was founded by a member of BioCurious who had also been involved in Berkeley BioLabs. He later moved to San Diego, where he started his own DIYbio lab (rather than joining with the hackubators in Carlsbad). Unfortunately, I could not reach him for interview. However, based on the Meetup group, Google group, and the lab's webpage, The Wet Lab appears to be a participatory lab geared toward both education and entrepreneurship, interested in donations, with authority concentrated in the hands of the founder. Though they claim on their website to be a nonprofit, the founder did confirm to me via a short email that the Wet Lab has never incorporated.

The lab has taken a somewhat unusual route among community labs, teaming up with a local public library, which has opened a lab in their library space. The Wet Lab, which is housed in a local maker space, helped advise the library in setting up the lab, a member sits on the advisory board, and volunteers from the lab conduct workshops and lectures in the library's space (local biotech firms and research institutions also participate).

Divergence

The labs in California cover the gamut of forms in the overall community biology lab population. One is a collectivist, two are bureaucratic, and two are somewhere in between. Though most of the early labs look at least partially like the collectivist model, the hackubators emerged later and are largely bureaucratic. Since their emergence hackubators have diverged more fully from the other two types of community labs. Early in their organizational history, both hackubators mentioned to me the importance of DIYbio and their commitment to open

access. Both labs concentrated on companies as members in the space but in the beginning, they also had more amateur members who, though they had projects they were working on, were not necessarily pursuing business ideas. At the time, neither hackubator was particularly exclusive about who they let in, so long as they had the right equipment and space. However, in time, both hackubators have been able to become more exclusive in who they offer membership to as the spaces have filled up. They now can take projects with stronger business plans or that have more viable scientific ideas, making more controversial projects less attractive. As of fall 2015, neither lab's website emphasizes do-it-yourself or hacking, though one founder does assure me that they still embrace DIY. On their websites, they refer to themselves as incubators or accelerators. While they still seemed geared toward increasing the opportunity for more people to do more biology research (they are, after all, far cheaper than other local incubator spaces with biology capabilities), they seem to have diverged from the overall community lab form. Berkeley Biolabs in particular has further diverged – all of the founding members with links to DIYbio have left the space, and it has transitioned into the hands of one of the early members. Now it looking almost entirely like an incubator. Because these labs are in relatively close proximity, there may be pressure to diverge and create their own niches in the citizen biology organizational space, a property that has been shown in organizational markets that have reached a certain degree of local saturation of a type of organization (Carroll 1985).

Above, I have started to describe some of the differences in community labs and the factors that made them adopt different features. Organizations sometimes seek more collectivist models because they are committed to participation for all – but other organizations make decisions based on pragmatic concerns. Collectives are difficult to maintain and sometimes bureaucratic structures help organizations meet their goals. In the remainder of the chapter, I

further explore the features that differ between community labs and some of the reasons members claim to have adopted or eschewed them.

III. Community Labs Choose Organizational Features

The description of the tensions within labs in California and the solutions that they sought foreshadows some of the central themes in this chapter. Community labs draw on a counter culture that emphasizes inclusion and a lack of prescribed rules, but they must balance this culture with the practicality of getting things done. As these new organizations are adopting features for their own organizations, they choose which features to adopt from which organizations in their environments. The five features that I examine are 1) decision-making power, 2) form of legal incorporation, 3) membership recruitment and regulation, 4) areas of organizational competency, and 5) funding strategies.

Others have examined when and to what degree organizations draw on multiple models (Chen and O'Mahony 2009; Johnson 2007). Perkmann and Spicer (2014) show how a single organization uses organizational values to modify organizational forms. In the remainder of the chapter, I show how community labs drawing on different organizational values create a spectrum of organizations designed to promote citizen science using different features from each other. Central to most of the features that community labs draw upon is the notion of inclusion. All of the community labs want to be alternative organizations for science and nearly all of them have drawn from the ethos of the hacker space. The labs are all counter culture and antiauthority (to some degree). However, some labs also adopt a commitment to inclusion from the maker culture or hacker culture from which some founders have been recruited or from the founders' origin as outsiders to science organizations that have led them to create the space in the first place. Other labs have far less commitment to inclusion. The difference in orientation appears to

have substantial consequences to the kinds of organizational features that each organization finds attractive.

The organization of decision-making is influenced by the degree of inclusion required. Many labs would ideally like to make decisions collectively because of a commitment to inclusion and a desire not to have centralized power structures. However, at many labs there is also a push toward more centralized power because of the very real struggle in making collectivist forms work. While organizations might draw on hacker spaces for inspiration, most labs find it necessary to implement bureaucratic practices as well.

When choosing how to incorporate, organizations draw on models around them including hacker spaces, nonprofits, and startups. They often choose incorporation based on both the kind of organization they think they should be (Are they for profit? For the public good?) and on the particular kinds of activities and funding they expect to be important.

The organizations craft an image around who they want to belong in the lab. Some seek to include all, and others are seeking very particular people, often with higher scientific expertise, as was the case in the hackubators labs described above. Deciding who belongs impacts the remaining features of the organization.

For organizations that prioritize inclusion, the need to educate those without expertise is higher than for those organizations that are geared toward those who already have expertise. This dictates what sorts of activities will be necessary for the organization. Only in the labs that are able to recruit sufficient numbers of biology experts are significant amounts of entrepreneurship likely to take place. Further, those labs that are very inclusive may experiences issues like BioCurious had. Inclusion is not always conducive to the work conditions preferred by certain participants.

Finally, funding models are usually adopted based on what works, and they are subject to change. Generally, education-revenue-heavy funding models require higher levels of time to maintain but may be aligned with activities of the organization or may become necessary because of who the organization recruits. The income for labs using funding models that emphasize membership fees fluctuate less but require a large membership or higher fees.

The degree to which the labs prioritize inclusion versus the degree to which they prioritize entrepreneurial needs impacts the sorts of features the organizations adopt. In examining the features adopted by a whole set of organizations seeking to promote more accessible biology lab space, I show which factors shape feature adoption across a set of organizations that identify themselves as a common kind of organization. I also illustrate how the organizations draw models not just from existing organizational forms, but also the sorts of knowledge they draw from each other. Next, I will provide a more detailed account of the factors that influenced the organization of a particular community lab. In the rest of the chapter, I will provide an overview of the features of the ten community labs for which I have sufficient data, and describe the factors that have led to differences between the organizations.

Case Study: A Community Lab Searches for Structure[34]

As I mentioned above, Counter Culture Labs (CCL) was founded by a number of members coming out of BioCurious. In part, it was meant to shorten the commute from those who had been commuting across the Bay to Sunnyvale. However, an ideological difference was

[34] In this section, I draw data and quotes from public online forums from the organization's Google group. Though the data is all publicly available, I have chosen not to identify the names of the individuals who posted these quotes in this dissertation. Instead, I reference the name of the forum thread and the date of the post. I believe that this method provides transparency in my data and appropriate attribution while still preserving some privacy for forum members who may not wish to have their names referenced in an academic document.

a major underlying factor in the division. Counter Culture Labs is designed to be one of the most inclusive labs in the country, embracing a collectivist mindset and a vision of radical openness and as few rules as possible. Of all the spaces, it inherits the mindset of Burning Man most closely, likely because of a large overlap in membership of the two organizations.

The group that would eventually become Counter Culture Labs began meeting in November 2012 through Meetup.com. Over the course of two years, the community discussed the best ways to organize their new lab during Meetups and through two Google Groups. The group was, from the outset, networked with Sudo Room, a local hacker space in the area. Members of this hacker space combined with members from BioCurious (both former and still active) to eventually found the lab. Throughout the process of founding the lab, founders of CCL drew on a wide array of information about organizations including: personal experience, the expertise of founders of hacker spaces and other DIY groups with whom they were networked, the charters and bylaws of hackerspaces and DIY groups, lawyers who reviewed their legal documents, academic texts on managing common pool resources, government documentation of incorporation processes, workshops and PowerPoints designed for founding nonprofits or startups, and organizations that specialize in helping nonprofits or startups get off of the ground. The lab incorporated in September 2013, nearly a year after meetings began. They did not move into their first space until August 2014 (before which time they did do some work in the back room of one of the leader's houses). In May 2015, they launched their first Kickstarter campaign to convert the space into a working lab. I will order this case study as I will order the chapter sections that follow. I will address lab governance, incorporation, audience, and funding models.

Collective Governance

Counter Culture Labs was heavily interested in a collective governance model similar to the ones used in some of the hacker spaces with which founding members were affiliated. In the earliest days of organizing, they collected and archived hacker space governance documents, attended presentations on how to best run a hacker space, and also explored information on maker spaces (which are similar to hacker spaces, but welcome all sorts of fabrication projects). Even though they wanted to draw on models from hacker and maker spaces, they believed they were organizing something new and experimental – a sentiment that they articulated directly in discussions on their forums. They searched for additional models that might help them make sense of how best to organize. Because of their experiences with BioCurious, they were particularly sensitive to the challenges of maintaining common pool resources where the incentive is to use but not always to maintain the resource. Members of the founding team reviewed principles of management from Elinor Ostrom, a Nobel Prize winning econonomist who wrote about management of common pool resources.

Early decision-making during the founding of the lab used consensus-making processes, and the leadership decided that members should continue to have substantial power in the organization. Typically rights and responsibilities of members are not included in the bylaws of an organization,[35] and a consultant who helped them review their bylaws recommended that they not include it in the bylaws when it can be done in less formal, more easily modifiable ways. However, CCL was so committed to the members having a place in decision-making that they decided to include the section none-the-less. According to the bylaws, members have the right to

[35] The charter and bylaws, modeled off of a local hacker space and documents from already existing community labs, were collaboratively edited by members of the organization in a Google document.

elect and remove members of the board, dispose of all of the corporation's assets, vote on any merger and the conditions of that merger, and elect to dissolve the corporation. A general meeting of all members is held on at least a quarterly basis, according to the bylaws. In order for members to vote, one-third of voting members must be present. Though not included in the original bylaws, the current version of the bylaws (ratified March 2015) requires that members "make a good faith effort to reach consensus" before voting, though an affirmative vote of 75% will pass the issue. The attempt to make decision by consensus is true to the collectivist form.

The lab is headed by a board of directors, which votes on the interim issues and the organization. The original bylaws authorized five to eleven board members, though the board voted to increase the cap to 13 to accommodate additional members who wanted to be on the board. The board is elected from members of the organization with no seats given to outside entities. Anyone who has run has so far been elected to the board, so in many ways the board is just a collection of the members who want to be actively involved in running the lab. The current board is made up of engineers, chemists, data analysts, security specialists, biotech scientists, software developers, a teenager who aspires to be a mathematician, a network programmer, and a bioinformatician. The board elects the officers. Board meetings are open to the public.[36] Though the organization's board does have the power to make decisions for the organization, the members regularly note that they are committed to transparency, being responsive to members, and valuing consensus whenever possible. Board meeting notes are posted online for review and are sometimes discussed in the online forums.

[36] Or so they advertise on their website

Nonprofit Incorporation

The appropriate way to incorporate was not at all obvious to the founding members of Counter Culture Labs. They considered for-profit and nonprofit forms. An early intuition expressed on the Google group was that nonprofits had advantages regarding the collection of donations and applying for grants and that for-profit startups could subsequently spin out of the group.[37] However, members went through a long and detailed search process before they finally settled on what sort of corporation they would be.

As the group moved forward, they considered a number of different incorporation types and researched the specifics of each. The group members wanted to be able to take advantage of being a nonprofit (for taxes and grants) but also be able to sell things like t-shirts, manage a reagents store that could buy supplies wholesale and divvy it among members, and allow for-profit projects to take place in the lab. Drawing on their knowledge of the lab in Baltimore, which operates with an LLC that indemnifies the nonprofit lab, they discussed an umbrella corporation that was a for-profit company that the lab, a nonprofit, might be able to hold part of as stock. In this way the portion of the group that was committed to being radically open in their project details, which by their understanding conformed better to a 501(c)3, could fall under the nonprofit while the group that wanted to be more entrepreneurial could pursue their projects. Members also discussed the advantages of for-profit corporations. Members, who in these types of spaces often bring a lot of equipment with them, can cash out of a for-profit organization and withdraw their resources whereas once they donate to a nonprofit, their equipment no longer belongs to them. However, another member countered that they were trying to build a commons and they did not want people to withdraw resources or have a lot of power because they held a

[37] This is the approach BioCurious had taken.

lot of shares. The tax benefits and lower cost insurance, they suspected, outweighed the benefits of a for-profit corporation. After much discussion, research of California's codes, and voting, CCL decided to pursue a nonprofit incorporation – though even after work began on the charter and bylaws, sometimes other structures were mentioned.

In September of 2013, Counter Culture Labs incorporated as a nonprofit public benefit corporation in California. It would not be until November of 2014 that they would file the paperwork to be registered as a charity in California. They filed paperwork to become a 501(c)3 in the spring of 2014[38] and were still waiting for word from the IRS in the fall of 2015. When I asked what became of the umbrella corporation idea, a founder replied, "The discussion about setting up some sort of umbrella organization for any for-profit activities is fairly old, and dates from before some of the people interested in that angle decided to split off and start Berkeley Biolabs."

Counter Culture Labs, then incorporated, helped form Omni Oakland Commons, a collective of collectives "with a shared political vision—one that privileges a more equitable commoning of resources and meeting of human needs over private interests or corporate profit (Omnicommons.org Accessed October 2015)." Joining the Commons was a solution to an ongoing difficulty in finding a space that was both cheap enough and in a neighborhood that would have access to public transportation. They had been considering joining with Sudo Room, the hacker space with which they had shared membership. In the end, joining together with other collectives helped them to afford their space. They now share a former bocce ball court with Sudo Room. A representative from each of the collectives, including one from Counter Culture

[38] Though they considered using a fiscal partnership with another organization like School Factory to facilitate nonprofit status, the decided in the end to apply for 501(c)(3) status independently in order to not have to pay fees. They have been awaiting the official status now for some years due to application revisions and slow processing.

Labs, sits on the board of Omni Commons. Omni Commons, with a thrust toward openness and open access, also ties Counter Culture Labs to this mission (one they shared) and a number of other organizations sharing the building. Being closely tied to a collective may increase incentives to keep CCL in a purer collectivist form rather than moving toward bureaucratic practices, as many of the other community labs have done.

What's in a Name?

Choosing whom the community lab would serve was an important part of the founding discussion, and it came up both when they chose their new name and in discussions about how membership would work and who would be able to vote on community decisions. In making both decisions, members expressed a desire to be inclusive and accessible. The name would be an important way to indicate their values and activities to the public. Membership rates and rules would ultimately shape who could participate and how.

In May 2013, members of the founding team decided that their existing name, "East Bay DIYbio," should be changed. As they began brainstorming new names, which was done in a collaborative process using digital tools, they simultaneously had a discussion about who should be included in the lab. The name, they felt, should not be counter to their ideas about the space. It should indicate who would be included in the lab. Part of the choice involved deciding if they would be devoted just to biology lab space or if they would be more inclusive of all science. Some believed that biology had brought them together and should be the focus and that other hackerspaces were already equipped for many of the other sciences, which don't require the array of biology equipment. Others were very committed to the idea of embracing all sciences, noting that a lab equipped for biology could easily host other sciences and that the community would be better for being more diverse. Some suggested that they could target biology to begin

with but also broadcast that they invited citizen scientists of all kinds. The group administered a poll of all Google group members and determined that, while people varied widely on whether they preferred only biology or all citizen science, they would pursue biology infrastructure first but brand themselves as including both biology and the rest of citizen science. Their subsequent motto, "YOUR biohacking & citizen science lab," integrates both (Counter Culture Labs 2015). In the same survey, the community confirmed a devotion to include both professional scientists and biohackers (their preferred term for citizen scientists in biology). After an expansive brainstorming of names, the group finally settled on "Counter Culture Labs," which, when shortened to CCLabs "brings to mind Creative Commons" ("Name brainstorming" 5/10/13)[39], a project toward open knowledge that members of the space take very seriously.

For the sociologist, the word "counterculture" brings to mind Fred Turner's work on counterculture and cyberculture (Turner 2006). Members of CCL also embrace much of the same devotion to networked peer production and envision a new social frontier in biology as the computer counterculture did in the past (Turner 2006). Turner (2009) argues that Burning Man provides a cultural infrastructure for commons based peer production, reframing work as a form of artistic creativity and community building rather than profit seeking. CCL appears to have adopted a similar model for thinking about the kind of space they want to be. Indeed, CCL has members that participate in Burning Man. One year, they had to postpone planning meetings during Burning Man because much of the board had attended. Their name indicates an identity that is tied up in tech and hacker culture.

[39] See footnote 34.

Inclusive Membership

Counter Culture Labs also spent a lot of time considering how to make membership policies match with their intention to be inclusive. Through an early group survey, they had determined that they were equally interested in catering to citizen scientists and to catering to professional scientists. The space would be open to participation by people with any level of expertise. Moreover, they did not want to exclude people based on their financial means. Membership needed to be designed to be inclusive.

The founders toyed with ideas about ways that members who were unable to pay might be able to be included. There seemed to be general agreement that members who could not pay could "do a set number of hours of volunteering on individual projects, administrative volunteering, teaching a regular class or something similar that would be of value to our fledgling community" ("Charter" 5/6/13)[40], a model that had previously been used at BioCurious. The exact nature of that work was not immediately settled. While some thought managing a front desk and staffing the lab to be open would be enough, others were more interested in such members being involved in learning biology and helping others complete their work in the space. The desire to let anyone participate was in tension with the need to have enough paying members to keep the space solvent. Though they considered the idea of having nonpaying members not be included in decision-making in the lab, they eventually eschewed membership categories based on voting rights. All members have full rights to membership.

Membership does vary in price (the following prices are in September of 2015). Individual memberships are $90 for one month ($80/month for those who set up recurrent payments) or $900/year if bought at once. Members can also opt for a "Biosafety Level Zero

[40] See footnote 34.

Membership" at only $20, which gives the member all rights except access to laboratory area, equipment and hazardous materials (they can work on certain projects, build electronics, and hang out), and the right to vote. Finally, the "sponsored membership" category takes into account those members who cannot pay the full amount but are willing to put in "sweat equity," as some members referred to it ("Name Brainstorming – the Winnowing" 5/11/13)[41], which is approved on a case-by-case basis. Becoming a member at CCL involves filling out an application, passing a safety quiz online, getting and project approved, and signing a membership agreement.

Funding Model

Attention to establishing a viable financial model came into sharp focus in June of 2013, when BioCurious announced publicly that they were only a few months away from becoming insolvent. Members of CCL, which was searching for a space to open a lab, began expressing worry that they were rushing into organizing without having a good financial plan in place. The group called a series of working meetings in which they considered the elements of income on which they hoped to rely. The most stable, they thought, would be membership fees because these tend to ebb and flow less than classes and projects. BioCurious, they believed, made as much from classes as from membership. The group spent a significant amount of time trying to determine how much square footage was necessary to support a member, how many members they hoped to have, and how much square footage they could hope to support through membership. They began collecting information about grant making organizations in the area as a possible source of income. They also collected information about how much they would be likely to bring in from membership fees, which they estimated to total about $800 a month (with approximately ten paying members at the outset).

[41] See footnote 34.

Once the lab opened, they found that their intuition had largely been right. Though other labs make a substantial amount of their income through conducting classes, CCL is located in a poor neighborhood and they try to keep classes as affordable as possible so that people can participate. They are contemplating moving toward a sliding scale so that people with higher means can pay more to attend classes, which should help raise money for the lab but also help pay the people who teach. Membership fees have been one source of income, and some of the co-founders helped to "close any gaps" in funding initially by paying money out of their own pockets. In the spring of 2015, they raised $33,170 from 187 backers on Kickstarter to help renovate and equip the lab. This money is also helping offset costs. In the future, they'd like to find grants to help cover some costs too. As one founder notes, "At my day job, I barely bother to apply for grants that are less than $100K, because by the time you pay salaries and overhead, there's barely anything left to get something accomplished. At CCL, given the shoestring budget we run on, that kind of grant could cover our entire operating expenses for more than three years!"

Summary

Many of CCL's early decisions were based on a commitment to inclusion and collectivist decision-making processes. The lab was heavily influenced by involvement in hacker and maker culture, which emphasizes the value of independence, as well as culture of the open-source community, which emphasizes sharing and cooperation. CCL drew features from organizations in these communities, recombining elements of hacker spaces and tech start ups with nonprofits and management practices for common pool resources. The founders' experiences at BioCurious and other hacker spaces helped shape their understanding of potential difficulties, like a sustainable funding plan.

In subsequent sections, I will examine how community labs vary in the features that they select from their surrounding environment. I will outline the factors that shape which features are adopted and the potential consequences of adopting one feature over the other. I argue that community labs experience tension between the desire to accommodate everyone interested in participating in biology and the difficulties of actually doing so. While some labs adopt the most inclusive policies possible (like Counter Culture Labs), others opt for focusing more on membership with higher expertise. Certain labs remain more focused on the ideology of inclusion when designing their organizations and draw features from organizations with a similar bent while others labs organize around efficiently facilitating the actual biological work that they wish to accomplish and stray further from the hacker space models. Still other labs are committed to inclusion but choose more bureaucratic models due to experiences with difficult decision-making processes in collectivist organizations. Consequently, some labs emphasize collectivist decision-making processes, while others incorporate bureaucratic processes to help make labs run more smoothly. Labs choose different types of incorporation based on their focus on outreach or output, and also based on pragmatic concerns about their funding models. Labs construct an image that reflects the constituencies they wish to include in the lab. Whether or not members require additional expertise dictates whether educational activities will be central to the lab's activity repertoire. Counter Culture Labs falls at one end of the spectrum of labs – it is very inclusive and very collective. Below, I will illustrate how the population of labs differs.

IV. Decision Making in Community Labs

The tension between collectivism and bureaucracy can be seen clearly in decision-making procedures and structures within the labs. Decision-making varies between labs – some use boards and committee structures to arrive at decisions and wield power, while others try to

include as much of the membership body as possible in decision making and in executing necessary tasks. A few of the labs describe themselves as "anarchies" and eschew most attempts at clear organization of power and decision-making. For each lab, I assembled information about their decision-making practices based on interviews of leaders and members. I also reviewed founding documents when possible that outline the intended decision-making processes. I have excluded organizations for which I do not have interview data from this analysis. I asked interview subjects how decisions were made in the lab, whether they had an authority structure and what that looked like, how tasks are divided, how conflicts are resolved, and how collective decisions are made. Respondents also revealed information about decision-making when I asked questions about challenges that they have encountered in how the organization is run and changes they have made, how they manage every day tasks, how the goals of various members differ and how those differences are managed. For several labs, I also gleaned information from their forums.

Decision-Making Models

Labs fall along a spectrum of who gets to make key decisions in the labs. At one end, everyone is allowed to vote on decisions at quarterly meetings (though interim decisions may be made by whoever is present). At the other end, a "benevolent dictator" model prevails in which certain members have final say. Many of the labs fall somewhere in between shared authority and dictatorships. In these labs, voting over some issues may take place and reaching consensus is ideal, but decisions may ultimately be under the control of a handful of people. Table 10 shows how decision-making power is distributed in the ten community labs for which I have enough data to draw such conclusions. I classified the organization's decision-making model as diffuse if the narratives and practices indicated consistently pointed toward distributed decision-

making. I classified the decision-making as concentrated when interview subjects indicated individuals who were formally vested with decision-making power who held and exercised final authority. Labs were classified as in-between in cases where the organizations made an attempt to include the members in brainstorming and decision-making, at least aspirationally, but I was told that some individuals wielded ultimate decision-making power.

Table 10: Distribution of Power in Community Labs

Location	Diffuse	In-Between	Concentrated
Berkeley			✓
Carlsbad			✓
Pittsburgh			✓
Seattle			✓
Brooklyn			✓
Sunnyvale		✓	
Boston		✓	
Los Angeles		✓	
Baltimore		✓	
Oakland	✓		

The majority of community labs have concentrated power – they are mostly bureaucracies. A few labs (including most of the earliest ones) have some collectivist component, with Counter Culture Labs making the strongest attempt at being a collective in its purest form. Los Angeles and Boston's labs refer to themselves as "anarchies," but this largely means that decision-making is unorganized. Everyone has freedom to do what he or she wants, but decision-making falls more often on a few key leaders who, in practice, make decisions for the organization. A few factors seem to push organizations toward particular decision-making structures. Next, I briefly outline the factors that push organizations toward collectivism or bureaucracy, and then I examine what it at stake for community labs when they choose decision-making methods.

Collectivism

Only one lab really strives toward collectivism in its purest form – Counter Culture Labs. However, a few other labs also try to incorporate elements of collectivism by including the broader membership in decision-making when possible. Often founders choose to try to be collectivist because of their philosophy about what the space is meant to be – something other than what they have experienced in other organizations. Counter Culture Labs, for example, has a strong commitment to open participation in the lab, and so they constructed their decision-making processes around including everyone by discussing options transparently and voting on key decisions. They try as best they can to reach consensus rather than majority vote. CCL was also reacting to some of the members' experiences at BioCurious, where a few subjects (who were not at CCL) noted that board members rather than all members had the final say and communication with the membership was not as effective as desired. During discussions about the shortcomings of BioCurious and subsequent discussions that occurred during the founding of CCL, members emphasized a desire for more openness and full participation for all members. A large amount of attention was paid who would be allowed to vote during the founding of CCL, possibly due to discontent with how decisions were made at BioCurious.

Bureaucracies

Quite a few labs have opted to structure decision-making in more central and concentrated ways. Two factors push organizations to choose bureaucratic structures: some of the organizations are simply not concerned with participation of members in running the lab, so it is not worth it to try a collectivist structure while other labs that choose bureaucracy do so because members have experienced the difficulties of running a collective and opt for a structure that they hope will be more efficient.

At one of the incubator labs, they explained that the founding members who invested money in the organization get to make the decisions. Those owning members that are in town around the lab give reports to those who are not, and those who are not in town "don't try to exert a lot of influence on things because they know that they're very far away. They don't see things." He notes that the leaders of the lab are all mature, and they are comfortable trusting each other to do things. They did not want to establish complicated rules, so, he reports, they generally try to talk out differences when they are making decisions. The bureaucratic model was chosen in part as a way to fix issues they saw at previous organizations. One founder notes that anyone who has been part of a collective knows that it is not the way to make decisions. The bureaucratic model is also a way to get buy-in by decision makers. Many of the labs that tried collectivist elements found that in absence of responsibilities assigned to particular individuals, many tasks simply do not get done.

It is not just the incubator labs that have decided to keep decision making in the hands of a few people. One lab was founded by a woman who had previously been part of an art collective that tried to make community decisions. She found that this turned out to be completely unworkable after the organization fell apart because there were too many opinions. When she went about designing the community lab, she organized it with a clear authority structure with departments led by department heads, all of whom are members of the executive committee. Decisions that need to be made are voted on by the executive team, for which the instigating founder has the final say in the event of a tie (though she had not had to exercise this power at the time of the interview).

Balancing the Two

At several labs, decision-making is done through both collectivist practices and some centralized authority. Several organizations that intended to be collectivist have become hybrids largely because of the real difficulties in maintaining collectives (see Polletta 2002; Rothschild-Whitt 1979). One lab, for instance, was designed to be a member driven organization, with community-based decision-making in the bylaws. A leader in the lab informs me "that hasn't quite worked out as well as we hoped it would." Only a few people really take the time to be involved in the organization aspect of the space, so a few people have power by default. Though they are working to figure out how to involve more people in the decision-making process, for now he notes that a lot of organizations (lab or other type) have a similar problem where 20% of people do 80% of the work. At another lab, a board member tells me that they are membership oriented, which she thinks is a nice contrast to traditional corporations, where you "pretty much know your place." Anyone can lead, start projects, or start a company in her lab. However, she concedes that while the board is not authoritarian they do actually make most of the decisions. They often solicit feedback through email, but a lot of decision making is informal and involves talking to people and then making a decision based on the two-member board vote. Though these labs may strive for collectivism, they have found some amount of bureaucracy necessary.

Controlled Anarchy

Some labs try to avoid having even collectivist decision-making and, rely instead entirely on informal and disjointed decision-making processes. The leader (by default) of one such lab tells me that the organization is really a "controlled anarchy." Two labs fit this category. While both have leaders, the leaders claim not to want decision-making power, and they both say that they pass off any responsibilities and decisions to whoever shows up. Though one of the

organizations is incorporated and has bylaws, the founder tells me that the bylaws are very generic and not very interesting, and they do not appear to shape decisions made in the day to day. In practice, these organizations are largely run by one or two people and, though they may claim that power does not rest in anyone's hands, it does belong to the leaders who keep the organizations afloat. Both of the labs have very small membership, so they may also be using some consensus making processes informally. Members of one of these organizations call it a "do-ocracy," a term that actually originated in the Burning Man organization. The lab member means that whoever actually takes on a task decides how it is done. However, from the Burning Man context, do-ocracy actually describes an organization with some bureaucratic practices, but which still allows members to suggest and lead projects in directions of their choice (Chen 2009). In this way, the hybrid organizations are more similar to do-ocracies. The two labs that are controlled anarchies seem to be versed in the culture and language surrounding Burning Man, and draw inspiration from it, but they draw from the anarchy ethos that is characteristic in the event and was the way the organization was run in the early years rather than the actual organizational structure that has been present for the last few decades.

The sociological concept of the "organized anarchy" may also be helpful in understanding these and many of the other community labs (Cohen and March 1986). Cohen and March described organized anarchies as organizations without clear, consistent goals, where the organization does not understand its own processes and often uses trial-and-error, and participation is fluid as members move in and out of the organization (p. 3). Though they were speaking of American colleges and universities, community labs often fit the criteria of organized anarchies. While these labs that are "controlled anarchies" are certainly organized

anarchies, many of the labs that attempt to be collectives or bureaucracies also fit these conditions.

What is at Stake

At many labs, there is a tension between the hacker-inspired everyone-gets-a-say culture (even the bureaucracies like to invoke images of hackers) and the need to actually get things done, the logistics of actually including everyone, and the difficulty in making people participate. The price, it seems, of choosing bureaucracy over collectivism is that the labs with bureaucracies actually tend to cater to fewer visions of what the lab will do. Counter to what theorists would expect, the organizations that cultivate mostly one point of view (they lean toward education, for instance, or they are exclusively for entrepreneurs) all have more concentrated decision-making structures. Because collectives tend to rely on consensus making, they often recruit like-minded individuals, which makes the consensus process easier to achieve (Rothschild-Whitt 1979). However, the community labs with collectivist features seem to actually foster more visions of what individuals should be able to do in the lab. It may be that such labs simply recruit people with a common vision of collectively run lab space rather than a common vision of what they want to do within the lab. Consequently, these labs seem to support more points of view – members who are focused narrowly on education, those focused on entrepreneurial endeavors, those just wanting to have fun, and people in between. Most (but not all) of the labs that are largely bureaucratic narrowly focus on the vision of a few leaders.

Board of Directors

The board of directors is the major decision-making body for community labs. Labs take primarily two approaches: they either select the board entirely from the membership, or they

select a board that includes a few people who are active in the lab space but also draw people from external institutions onto the board. Each approach has strengths and weaknesses.

Boards made up of people external to the lab help build connections to outside organizations, may bring in organizational expertise, and bolster the lab's legitimacy. The boards may help draw resources into the organization, like donations of materials. By connecting the organizations to educational organizations and science organizations, externally derived boards bring expertise and legitimacy from both realms. Several labs have science and safety advisors on their board that have professional expertise in these areas. This helps those labs manage external perceptions, particularly the worries that regulating bodies might have about science being conducted by the public. One lab recruited people that members knew to the board – a few from academic institutions, a safety officer at a biotech firm who also serves in a safety capacity on the board, and a person who does marketing in her day job and also directs it for the lab. Another lab draws from education and life sciences departments at a local university, the local school district, a representative from their funding source, a few large biotech and life sciences companies, their parent organization, and a few other large companies in the area. Though community labs that have external members on the board tend to mention those members in strategic ways that help indicate that the organization is safe and doing legitimate science and/or education work, they also tend to emphasize that the board functions largely in an advisory capacity that helps monitor the organization and evaluate options. While the board may have the final say in decisions, lab leaders emphasize that the leaders and communities still have power in the day-to-day operations.

Boards that are drawn from internal membership give members more official control of the organizations, which could be attractive to both collectivist minded organizations and to

entrepreneur driven ones. The organizations that drew internally still have board members that are affiliated with science and educational organizations, because members are often affiliated. However, the board members were less removed from the emotional work within the organization and were less often held up as examples when establishing legitimacy. The organizations that draw the board from their membership sometimes struggle to have a perfect match between duties and experience of the board member. However, drawing internally from membership appeals to collectivist tendencies, to those who are wishing to escape established organizations, and to founders who want to run a business over which they have control. Often boards drawn from membership are initially made up of founders, and then later incorporate additional members. A few continued to be held by founders for some time.

The two types of boards do not map cleanly onto the decision-making models described above. However, the organizations that preferred collectivism were more likely to draw boards from membership while those that leaned toward more bureaucratic models were more likely to draw board members from the surrounding community. It may be that collectivist organizations are more focused on their interior workings and less on their need to fit into the field of organizations around them. It may also be that those founders more experienced with running organizations chose both bureaucracies and boards that would help them function in conjunction with other organizations.

Each board functioned a little bit differently. Though many boards seemed relatively stable, a few were volatile. One subject reported to me that he felt that at his lab, people came on and off the board too easily. Some community labs set careful structures for their boards with particular duties for each member and highly divided responsibilities. These boards often also

had more extensive rules about how they would operate. However, that was not the philosophy at all labs. One leader notes,

> Other biohackers spaces that I've actually been involved with spent a lot of time wrangling about how the board is going to get elected and who is going to - what they do - and trying to set a lot of rules to keep bad things from happening. And I, uh, I didn't think that that was a good plan. And I don't think anybody with any real experience thinks that is a really good plan.

He notes that organizations with huge amounts of money might need careful discussion of how the board will work "for when you're dead so that the foundation has structure - but then there's also resources to sort of justify those rules. For little organizations it is just too difficult." In his view, instituting structure for board meetings seems to be most useful for organizations that have large amounts of resources that need to be able to withstand board member turnover. The boards also ranged in size a good deal, from as few as two people to as many as thirteen. For the organizations that never incorporated (see the incorporation section below), there was no board at all – though often there were a few officers with vaguely defined duties.

Division of Tasks

The distribution of necessary organizational tasks across members is one way in which distribution of decision-making can occur. Some labs have very clearly defined roles and procedures, like Seattle, which has departments headed by particular individuals and then members within those departments that have particular roles. The majority of labs seem to be flexible in the division of tasks, though – a feature common in collectives. Organizations with very clearly defined roles sometimes run the risk of not including members who would like to do organizational work, depending on whether member's competencies match the defined roles. On the other hand, a lack of defined roles runs the risk of necessary tasks not being completed. Consistent with organized anarchies, the labs often have inconsistent decision-making practices

that are not well understood and managers must wrestle with attention scarcity (Cohen and March 1986).

Several mention the idea of a "do-ocracy," a notion that seems attractive to members of community labs regardless of where the organization falls on the spectrum between collective and bureaucracy. This division of labor relies on informal practices where people adopt tasks that matter to them and then make any necessary decisions. Do-ocracy looks a bit different in community labs than it did in the Burning Man organization (as describe by Chen 2009). Burning Man had too many people to maintain a collectivist form and so centralization was necessary to help coordinate member projects, but community labs usually suffer more from a dearth of people to take up necessary tasks. Instead of a do-ocracy being about members adding elements to the organization as they choose, a do-ocracy in a community lab often means that tasks are forgotten, like filing taxes. And, of course, sometimes tasks fall to individuals not because they want to do them but because they are the person who will do them. One acting executive director tells me that she is about to be formally voted into the position,

> It's not a job that I'm particularly thrilled about, but I think if I don't do it, [the lab] is probably going to go into some kind of suspended animation. We really need to have someone to take care of coordinating all of the different administrative tasks that have to happen in a 501(c)(3).

Even those organizations that have some named roles and ostensibly assigned tasks sometimes miss necessary tasks, like filing reports necessary to maintain nonprofit status.

While who performs which tasks is negotiable in many labs, most do have a few established roles. President, treasurer and secretary are required in most forms of incorporation, though the tasks each position is responsible for varies from lab to lab. Many labs have positions like safety officer (often a member of the board, but sometimes the member of a safety committee). Some have a lab manager type position. A few have chief science officers, members

devoted to coordinating the education arm, and members who coordinate volunteers. A few have art directors or coordinators of art programs. Several have committees of various kinds.

V. Incorporation

Lab leaders made it very clear that a central difficulty in founding the community labs was figuring out what form of incorporation made sense for such an organization. They drew upon many models as they considered options; hacker spaces, start-ups, and incubators were the most central. Community labs selected their incorporation type to match their goals, their funding hopes, and how they wanted to be perceived by the public. Many decided to be nonprofits, though a few decided that for-profit or hybrid status made more sense for their organizations. Several community labs never incorporated at all. Table 11 contains the incorporation type for each community lab.

Table 11: Incorporation Type for Community Biology Labs

Nonprofit	*Incorporation Type*
LA Biohackers (Los Angeles)	501(c)(3)
Genspace (Brooklyn)	501(c)(3)
Biocurious (Sunnyvale)	501(c)(3)
HiveBio (Seattle)	501(c)(3)
Counter Culture Labs (Oakland)	Nonprofit Public Benefit Corporation; filed for 501(c)(3)
The Citizen Science Lab (Pittsburgh)	Under umbrella of 501(c)(3), Urban Innovation21
Indie Lab (Richmond)	Non-Stock (Virginia Nonprofit)
For-Profit	
Berkeley Biolabs (Berkeley)	Domestic Stock - changing to LLC
Hybrid	
Bio, Tech and Beyond (Carlsbad)	Lab is run under a nonprofit Network for Open Scientific Innovation; with LLC
BUGSS (Baltimore)	Tax-Exempt Non-stock (filed for 501(c)(3)); with LLC
Unincorporated	
BossLab (Boston)	Unincorporated
Wet Lab (San Diego)	Unincorporated (though claim to be nonprofit on website)
Container Lab (San Francisco)	Unincorporated
Brightwork CoResearch (Houston)	Unincorporated
Biodidact (Los Alamos)	Unincorporated

Nonprofit

The simplest reason that community labs decided to become nonprofits was because they believed that it would help support the most effective funding model. "We thought that being a nonprofit organization would give us some tax advantages for getting donations, things like that," explains one founder in an interview. Nonprofit status has tax advantages at both the federal and the state level. Nonprofit status also opens up many grant opportunities that are reserved for nonprofits. For organizations that are serving the public in some way, nonprofit status may align nicely both with their goals and with their funding models.

Community labs also selected nonprofit status because the believed it would improve the way that they are perceived by the public. Founders at one lab talked to members at another while they were deciding how to incorporate. They realized that people in the public have an "interpretation about what these home brewer scientists are doing in their crazy zombie underground labs" that created an image that could be problematic for the organization in the long run. "So we understood right away that there was always going to be people ready to decry what we were working on or to do some mudslinging so we wanted to do it right. And, for better or worse, nonprofits are seen as more altruistic." They decided to become a nonprofit in order to ease their way as an organization. Several labs expressed to me this fear of being viewed as doing something dangerous. It is also the reason many labs have safety boards or officers.

Another founder explains to me the thought process as they worked through their options and decided to become a nonprofit:

> The easiest way to go is to set up an LLC, but then that's always stuck to one person so if that person dies or disappears or whatever, then the organization and all the money and everything is gone. So we're like, ok, we should set it up as a C

> corp just so it sort of exists even if people get hit by a bus or whatever.[42] Then we're like, well, this is really more like a cooperative thing. It's not like we're trying to make money off of this. We're definitely not running a business. This is not profitable. So we're, like, if we're not going to run a business, we might as well set it up as a 501(c)(3) so we can actually get donations.
>
> There's a lot more work in getting that. Since the day we sent in our application for the 501(c)(3), it took them almost 2 years to actually get around to looking at the application.

The process of elimination worked for this lab. Several of the other options did not make sense and being a nonprofit opened up opportunities for donation.

A founder at another lab explains the fit with being a nonprofit in terms of the goals of the lab:

> More traditional biolabs that are in educational institutions or for profit research, their goal is to make a profit. And they have research that's dictated by the executive team. You know, it's dictated by the leadership of the company. And that's not how we work. We work to provide the lab space and to provide classes and mentorship and foster a community. And that's much more along the lines of what a nonprofit does.

This lab saw their mission as being in line with their understanding of a nonprofit.

Nonprofit status does take some time to achieve, and it requires renewal paperwork every year. However, the status supports certain funding models, provides a certain kind of legitimacy, and aligns with the mission of many of the community labs.

For-Profit

The nonprofit approach does not work as well for all community labs. Even within labs that are nonprofits, there is sometimes tension between the nonprofit goals of the organization

[42] A C Corporation is all types of corporation that recognizes the corporation as a separate taxpaying entity (IRS 2015). An LLC, if held by an individual, typically is taxed through that individual's income tax, though it is regarded as a separate legal entity (IRS 2015). It is not clear that the subject fully understands what an LLC is, though it is true that in order to be a 501(c)(3), they cannot be an LLC.

and the entrepreneurial goals of some of the members. Recall the discussion at Counter Culture Labs about whether to include an LLC to handle for-profit activities, as Baltimore has done in the past. For some community labs, for-profit incorporation has made more sense. This is particularly the case for hackubators, which focus almost entirely on entrepreneurial aspects of DIYbio. Berkeley BioLabs' funding model includes the possibility of the lab holding stock in the for-profit companies that have worked in the space. Companies sign over small amounts of stock in place of paying some or all of their membership fee. A for-profit model, then, is required for the lab. Additionally, one of the incentives that founders tried to engineer into Berkeley BioLabs, in order to keep members active and putting in the necessary organizational work, is the stock that founders hold in the company. If founders pay into the company and work hard, they can hope to make a profit. The for-profit model of the lab is meant to motivate members who put time into sustaining it.

Hybrid

Two organizations have chosen a hybrid model that involves a nonprofit organization and an LLC. Bio, Tech, and Beyond, a hackubator, is one of these. A founder explains:

> We operate the incubator lab infrastructure under my existing nonprofit. I've maintained that since 2007 actually and previously run various Open Science advocacy conferences and activities through it. We may not show up in most of the registries because our annual budget is low/doesn't cross the threshold until recently (this fiscal year probably the first time). We use the Bio Tech and Beyond LLC for a few commercial joint ventures with entrepreneurs who come to the lab. It has been a long time to get off the ground but we anticipate soon launching a cheap reagents business to sell to local San Diego academic institutions and biotech companies. If that works we're already planning to "franchise" the product up to the Bay Area in partnership with a couple other spaces, probably Berkeley Bio Labs initially.

The hackubator has managed to make entrepreneurial endeavors work under a nonprofit by using an LLC for commercial endeavors. Companies that use the space, of course, can also be

incorporated for profit. BUGSS is primarily a nonprofit, though there is also an LLC under which they hoped to do similar things to Bio, Tech, and Beyond.

Unincorporated

A number of labs never incorporated at all. Two of the labs that never incorporated failed quickly after opening (The Container Lab and Brightwork CoResearch), and they may have never incorporated simply because they never got around to that step. The lack of incorporation of these two may also be an indication of either a lack of planning by organizers or a lack of commitment to taking on the organizational tasks necessary to make these organizations sustainable. However, there are two labs that have persisted that have not incorporated. The Wet Lab and BossLab likely have different reasons for not incorporating. BossLab, which is one of the oldest community labs, simply never wanted a high level of organization. A member tells me that he is glad that they never incorporated because he believes running the small lab would be more of a headache if they had incorporated. He does not want a bureaucracy to deal with or paperwork to maintain.

BossLab is housed in the corner of another organization, Sprout, which promotes science learning. The Wet Lab, which a founder tells me is for now just a Meetup group, is housed in a Fab Lab, a community accessible fabrication workshop. Neither of the community labs requires incorporation in order to acquire space (because joining and getting space does not require a lease) and neither needs an income model that would bring in substantial amounts to support their rent. Therefore, for these organizations, incorporation has not been something that is necessary for them to do the activities that they currently want to do. In order to grow, I suspect these organizations would need to incorporate. The Wet Lab, which is relatively new, may eventually move toward incorporation. It may be at a stage that many labs were at before they

incorporated. (Though many labs incorporated before they had any space, a few incorporated after they had started working in a hacker space, prior to their final space.)

VI. Conceptualizing the Lab's Constituencies

New organizations must identify who they intend to serve. Similar to the organizational feature that Hannan and Freeman (1984) call "marketing strategy," new organizations must identify "the kinds of clients (or customers) to which the organization orients its production and the ways in which it attracts resources from the environment (p.156)." Community labs spend time conceptualizing who to include in their endeavor and what kind of image they want to project to potential participants, regulators, grant makers, and donors. They undertake three big tasks: establishing who they serve, defining how membership will work, and crafting an image. In doing so, they take cues from each other, hacker spaces, and other organizations in their environment. The resulting sets of strategies that they use are often overlapping, but still contain variation. In this section, I address three aspects of the organizations that institutionalize and broadcast the decision about who belongs in the organization: the mission statement, the membership policies, and the lab's image. Community biology labs craft mission statements, membership procedures, and images toward particular audiences that they wish to recruit (or toward external audiences that they wish to make particular impressions on). Community labs vary in the degree to which they are targeted to all members of the community regardless of wealth, the degree to which membership gate-keeping allows anyone to join, and the degree to which the image of the lab invokes particular cultural elements.

The central-most factor in how community labs construct each of these elements is the degree to which the organization is focused on being inclusive. In general, I found that labs fit along a spectrum from being open to anyone to labs that limit who can be members. Along that

spectrum, some labs limit members only a small amount, while others only allow members who are companies, with higher scientific expertise. Some labs have mission statements that emphasize openness but either their pricing policies or their voting procedures on new members likely limit that openness to some degree. Most labs fall to the open end of the spectrum.

On the one hand, many labs try to be inclusive because one of their central commitments is not to be like professional science labs – exclusionary and elite. Most of the labs want to serve those who cannot gain access through other means. However, sometimes labs limit who can join in particular ways, often for practical reasons. The more entrepreneur-oriented labs limit membership to those with more expertise and higher commitment to their ideas because they believe it will help create a more sustainable funding model and easier maintenance of lab space. Other labs limit membership to those who seem to fit with the lab, likely an unconscious attempt to have better control over the lab through recruitment of only like-minded people.

Mission Statements Reflect Commitment to Inclusion

A purpose or mission must be articulated as part of the charter of the organization. Many community labs also broadcast their mission on their websites. The mission ostensibly articulates the main goals of the organization, one of the core features of an organization's form (Hannan and Freeman 1984). For community labs, mission statements often also implicitly direct attention to which groups will be served by the organization.

Patterns emerge in the data I have collected about lab mission statements. Some labs take on vastly more in their missions (Sunnyvale, Oakland, and Brooklyn, particularly). These are the biggest, most active labs. A founder of one lab tells me, "There was one of those mission/vision/values statements on who we were here to serve. And we did this to ourselves." They decided they would accommodate hobbyists, professionals, makers, students – they went as

broad as they could imagine. “We’re toying with the idea of maybe pairing it down a bit [because it is more difficult to serve so many constituencies], but, you know that takes hours of thought and work on our part. And we’re just not there yet in our list of things to do.” These broad mission statements include nearly anyone under their vision.

Others are geared more toward particular ideas of what the lab should be. One set of labs emphasizes openness, citizens, and education (less expertise to participate) while another set emphasizes entrepreneurial endeavors (more expertise necessarily, geared toward business). I will discuss this split in more detail later. For now, note that community labs are not all oriented to serve the same people.

In their filing to become a charity in California, Counter Culture Labs states the following (Counter Culture Labs 2014):

> Our exempt purposes are the furtherance of safe science for peaceful purposes; providing open access to the tools of science; encouraging scientific literacy, exploration, discovery and innovation; transparency of process enabling reproducibility and maximizing public benefit; and respect for the environment.

The lab highlights a few of the most common goals of community labs: to facilitate education in biology, to enable inclusive access to doing science, and to encourage innovation. Counter Culture Labs takes a broad view of who belongs in their lab. It is for those seeking to innovate, but also those seeking to learn. It is meant to promote public benefit. It is meant to be open. Recall from the vignette earlier in the chapter, CCL took a vote among membership about whether they should orient toward professional scientists or hobbyists and determined that they would like to do both, a decision that is reflected in the breadth of their mission statement. CCL’s mission statement, like many community labs, corresponds in part to the DIYbio Code of Ethics, outlined in the next section. CCL, in fact, adopts the code of ethics as it’s value statement in its bylaws.

DIYbio Code of Ethics

Several of the commonalities in mission statements across community labs are similar to sentiments found in DIYbio.org's Code of Ethics (DIYbio.org 2011) and so I will outline these first. Concerned with the need to self-govern the DIYbio community, DIYbiologists convened a series of meetings in the United States and abroad during which they drafted codes of conduct (one for the United States and one for Europe). The Code was drafted in 2011 by members of DIYbio groups in North America, including the labs in Sunnyvale, Boston, Brooklyn, and Los Angeles. Several community labs make direct reference to the code on their websites. The Code of Ethics has been held up as an example of how the community is concerned with being responsible and safe citizens. Indeed, some have made the claim that DIYers have made more effort to be responsible than some professional biologists (Kuiken 2016). The code emphasizes the following values:

Figure 4: DIYbio Code of Ethics

OPEN ACCESS
Promote citizen science and decentralized access to biotechnology.

TRANSPARENCY
Emphasize transparency, the sharing of ideas, knowledge and data.

EDUCATION
Engage the public about biology, biotechnology and their possibilities.

SAFETY
Adopt safe practices.

ENVIRONMENT
Respect the environment.

PEACEFUL PURPOSES
Biotechnology should only be used for peaceful purposes.

TINKERING
Tinkering with biology leads to insight; insight leads to innovation.

Many of these ethics are incorporated into the mission statements of subsequent community biology labs (and those that existed before).[43]

Patterns in Mission Statements

I compiled a list of missions of all community labs from their websites and charters in order to examine commonalities and differences. I included in the mission statements from websites any text that was immediately around the mission statement that served to further explicate the purpose of the lab. San Francisco is excluded because they apparently never got around to a mission statement (or formal incorporation, though they had a physical space). Table 12 includes the major themes. Community labs clearly draw on the shared code of ethics when writing their mission statements. The precise combinations of things that they emphasize vary a bit. The degree of inclusivity is one of these major themes, and it includes emphasizing inclusive access and affordable access (which is usually meant to be more inclusive). BioCurious, for example, espouses this mission: "We believe that innovations in biology should be accessible, affordable, and open to everyone. We're building a community biology lab for amateurs, inventors, entrepreneurs, and anyone who wants to experiment with friends (http://biocurious.org/about/ Accessed 10/2/15)." Not only is the lab meant to be accessible, but they also enumerate people with a range of interests that they wish to serve. Note in the table that labs mention certain groups they would like to serve: those seeking education, entrepreneurs, and citizen science. Occasionally, they seek to help their surrounding community develop. When constructing their lab's image, community labs also project certain audiences that they wish to serve, some of which are more inclusive and some of which are very specific. Inclusive and affordable

[43] One interview subject, however, expressed vexation over what he perceived to be DIYbio's need to reinvent the wheel. He claimed that drafting their own code of conduct was unnecessary because professionals have, in fact, thought about ethical biology previously. Creating their own code, in his eyes, was ridiculous, when they could adopt already existing standards.

Table 12: Concepts in Mission Statements for Community Labs

Location	Education	Inclusive Access	Innovation	Entrepreneurship	Citizen Science	Affordable Access	Community Development	Safety	Transparency/ Openness
Sunnyvale	1	1	1	1	1	1	1	1	1
Brooklyn	1	1	1	1	1	1	1		
Norfolk	1	1	1	1					
Seattle	1	1	1			1	1	1	
Oakland	1	1	1					1	1
Baltimore	1	1			1	1		1	
Los Angeles	1	1			1				
Pittsburgh	1	1			1		1		
San Diego	1	1			1				1
Boston	1			1					
Los Alamos	1						1		
Carlsbad	-1	1		1					
Berkeley			1	1		1			
Houston			1	1					
San Francisco									
Total	**11**	**10**	**7**	**7**	**6**	**5**	**5**	**4**	**3**
Code of Ethics	1	1	1		1			1	1

"1" indicates concepts emphasized in mission statements or immediately surrounding the mission statements on the webpage. (1) indicates that a previous version of the website did include this mission but it does not anymore

access is more commonly mentioned in labs that also mention education as a main goal – and less central in labs that are geared toward entrepreneurship – a pattern that holds true in pricing and membership policies for labs with these different goals.

Designing Membership Policies for Inclusion

The way that community labs construct their membership policies and rates reflects goals they wish to accomplish. Some labs construct membership policies to encourage inclusivity of as diverse a membership as they can recruit, while other labs attempt to recruit only those with more science expertise. The policies that they implement influence whom comes into the lab, whom is approved for membership and whom is turned away, and what kinds of activities will be necessary in the space to support the type of members they have recruited. For instance, labs with open membership policies are more likely to attract amateur biologists who require the education activities much more extensively, while those that support companies take on members who already have some knowledge and ideas. Table 13 shows which labs promote accessible rates and which labs gear themselves only toward more developed companies rather

Table 13: Membership Openness

Location	Accessible Rates	Companies Only
Berkeley		✓
Carlsbad		✓
Pittsburgh	.	.
Seattle	✓	
Brooklyn	✓	
Sunnyvale	✓	
Boston	✓	
Los Angeles	✓	
Baltimore	✓	
Oakland	✓	

Pittsburgh's lab intends to recruit members, but in its initial phase is rolling out the education program first. People cannot yet be members.

than individuals. Essentially, the hackubator labs place less emphasis on serving every constituency while most of the other labs, to some degree, try to set rates and allow members of many constituencies.

Membership Rates and Tiers

Lab membership rates can be designed in ways that make them more inclusive for people who have limited means. Many labs want biology bench space to be more accessible than it is in established science organizations, but they implement policies that make them inclusive to different degrees. Some rates, like $100 a month, are really only accessible to the upper middle and upper class public. However, labs have come up with a few ways to try to provide access for those who cannot afford these fees.

Membership rate structures vary considerably. Some have a set fee for all. Others have tiered rates. One lab has no membership fees at all. The labs with the lowest fees (or no fee) typically involve a small square footage, and most are working out of rooms in hacker or maker spaces, where rent is quite low. These range from $0 a month to $50. One founder tells me that they do not post the rates for their lab on their website because they are afraid it will discourage people who cannot pay from inquiring about their lab. This lab charges $50 a month to most members, though if you have more, they may ask for more. If you do not have money, they will still allow membership without a fee. A leader explains, "I don't want to be like 'screw you poor people! Get out of here!'" A few other labs also have a single set fee of around $100 a month, with 12 months for the price of 10 (a feature that appears in several pricing structures). Both of these labs provide lower rates for those who are unable to pay, usually in return for work, but neither post this on their website.

More recently, the tiered pricing systems as seen in CCL have started to become more common (though neither Genspace nor Biocurious, the largest and earliest labs, use them). For instance, BUGGS in Baltimore has 4 levels of membership: $85 individual membership, $50 + 5 hours of work for teachers and graduate students, $25 + 5 hours of work for high school teachers and undergraduates, and $25 associate membership for those who do not want to use the wet lab (http://www.bugssonline.org/payment.html Accessed 10/5/15). They are the only lab that has formally integrated a set number of hours of work in their pricing structure, though several other labs do have pricing structures meant to encourage less affluent people to participate by giving time rather than money. As one founder tells me, "We've got to become solvent. We've got to stand on our own two feet at some point, but for us its about saying 'Yes' as opposed to saying, 'Sorry you can't come here,' so we try to do everything we can to work with someone that wants to be a member." Sweat equity is one way to make pricing friendlier to members who cannot afford the full rate. Another approach is to graduate pricing by amount of time allowed in the lab. HiveBio of Seattle has taken this approach, laying out a pricing scheme that charges $54 for 4 days/month, $81 for 6 days/month, $108 for 8 days/month, $175 for keyed access that provides unlimited access, and $240 for keyed access along with desk space (http://hivebio.org/join/ Accessed 10/5/15).

While many labs set rates intentionally low in order to include whoever is interested, other labs have significantly higher rates and do not accommodate lower income options. These rates range from $600 to $1000 and are meant to accommodate a different membership model that emphasizes fewer members that pay more money. In the funding models section, I discuss this decision in more detail. Important in this section is the notion that by cultivating higher paying members, these labs hope to recruit more dedicated members who might both stay around

longer and have more investment in keeping the space clean. One founder tells me that they consciously made the decision that they did not want to be "all things to all people," as many of the other community labs have been. Even in these labs, members sometimes pay in kind, usually through the donation of equipment. At one lab, members can pay through equity in their company rather than through monthly fees.

Two labs, which never incorporated, do not seem to have ever had a clear membership structure. A third lab, in Los Alamos, does not list any information about membership on their website and has not returned requests for interview. The Citizen Science Lab in Pittsburgh does not yet appear to have membership. Instead, it is running from funding from its parent organization and income from classes, though its ultimate goal is also to have membership.

Individual vs Organizational Membership

Most community labs cater to individuals who want to join the lab as members. But a few labs actually cater also to companies, and a few labs cater exclusively to companies. Many labs are open to entrepreneurs who are trying to start companies, but individual people are the members of the lab. Berkeley BioLabs and Bio, Tech, and Beyond, however, target mostly companies, some of which may have more than one person in the lab. The companies are often very early phase start-ups trying to do the kinds of proof of concept necessary to get financial backing. More so even than a traditional incubator, the companies at these hackubators are often very early stage. The two hackubators, which focus on companies rather than individuals, are the two labs with the highest membership fees. At Berkeley BioLabs, individuals can become members, though the lab advertises the membership as "Individual Professional Lab Membership" for "select scientists and entrepreneurs" (http://berkeleybiolabs.com/blog/ Accessed 10/5/15), which is written to exclude casual members. The other lab, which at one time

did have more casual members who were trying out ideas but where not necessarily developing products, only offers company membership now. The decision to exclude individuals, along with the decision to have higher membership rates, is a choice that affects what sorts of people have access to these labs. These labs have selected higher expertise members doing "serious science" as their target membership rather than the all-inclusive vision of most of the other labs.

Applying for Membership

Membership procedures serve a gate keeping function in allowing access to the organization. Some community labs make joining easy for anyone who wants to join, while others prefer to do a little screening for good fit before allowing people to join. A few labs have no established procedure for in taking members, but most now require filling out an application form with basic information, the signing of a release (for liability insurance), and many also require a safety training class or presentation before new members can work in the lab.

One lab told me that they employ a verbal approval process for new members where they gather the group together, introduce the new person, and vote on whether to let him do his project at the lab. A leader notes that they are never going to exclude a person based on the merits of the project. Instead, as long as the project is safe and does not take up the entire lab, the applicant will be allowed to join. Another member tells me that they review any project proposals of new members with a safety board, and if the board votes that it is safe, they will allow the member into the lab. Many other labs also mention the assessment of fit to the space, such as whether the lab has the equipment the person will need and whether the projects that they want to do can be done under the safety guidelines of their labs. Most community labs do not require members to undergo ongoing safety evaluation as part of keeping membership.

Usually, membership processes also include informal elements. Many subjects mentioned the attempt to assess whether the potential member fits well with the organization. A founder at another lab tells me that he does "the personality test" to see if the person seems to fit. They do not use a committee to decide who to admit: "We're not awarding NIH grants." Informal practices like this may exclude certain types of members, like those who are not socially clicking with the group. While many groups seem to want to allow anyone into the organization (in theory), informal practices like this may exclude people who are unlike the rest of the membership. Collectives, for instance, are known to recruit homophilous membership because consensus making is easiest when members share a similar vision (Rothschild-Whitt 1979). Many of the informal practices seem to be centered on checking whether the people have a similar vision for the lab.

Many labs have formal application procedures that delineate who is a member and who is not. However, several labs also considered of some people who are not paying members as members of the lab. For instance, they might have people who hang out in the space a lot but are not paying members. Some of these nonpaying members did other things to earn membership, though the lab might not formally have such a membership category. In other cases, the members were really supposed to be paying but had fallen through the cracks. One lab leader told me that, though they had paying members who go through an application process, they also consider members of their Google group members of the lab. While many of the organizations work hard to define and regulate membership, some do not. Even those that do have procedures in place do not always rigorously enforce them.

Demographics

In the end, regardless of their wishes, labs do not recruit just anyone to be members. Location of the labs, price, education, and other factors of socialization will mean that members of many demographic groups will not be represented in the lab even if they are welcome. I have only information given to me by the few members that I interviewed to describe the demographics of the community labs, and so the data are limited by those members' abilities to notice and recall. Unsurprisingly, most labs noted that men dominate their activities, though some labs certain did have female participation. One lab estimates that they have about 30% females to 70% males.[44] Most labs noted that women selected out of showing up to begin with rather than dropping out quickly, at least according to the reports of interview subjects. Participants range in age quite a lot, from rambunctious five year olds (rarely) to retired judges and grandmothers. Several labs notes two clusters of age range – one cluster in their mid to late twenties and another cluster in their forties. Many labs also have a few retirees. African Americans are underrepresented at most of the labs, a phenomenon that corresponds to the dearth of African Americans in STEM occupations. However, two lab founders are PhD holding African Americans, and one of those labs is geared specifically toward engaging African Americans in the community. It is important to note that the demographics were reported to me by members that I interviewed, so my data on demographics is limited by subject recall, which may not be very good. However, lack of female and African American participation in STEM fields more generally is well documented, and it would not be surprising to find that similar trends exist in leisure pursuits.

[44] Women were key members of the founding team in at least seven community labs.

The occupational backgrounds of lab members are fairly diverse, though most lab members are well educated and come from professional backgrounds. As I detail in Chapter 4, labs draw members largely from educational organizations, academic and industry labs, the art world, and engineering, programming, and biotechnology industries. Computer scientists and various engineering disciplines are very well represented at most labs. A few subjects made reference to the idea that biotech is the next big thing, and so engineers of all sorts are drawn to learn more about it because they foresee that that is where to jobs are likely to be in the future, and they have "discovered that biology is engineering." Most labs also have some artists. "People who come from a certain discipline seem to be more open to new things. So we've got the people who identify with the hacker community and the people who identify with the avant garde, cutting edge," one subject tells me. Entrepreneurs are the third major category (though many of these overlap with the engineers). Professionally trained scientists (some of which are also entrepreneurs) are also a big category. Other people served include those who had undergraduate degrees in biology but do not do biology related work professionally, students (high schools, undergraduate, and graduate), and an assortment of other disciplines.

The way that labs design membership policies can influence who their constituents are. While some labs endeavor to build a broad base of constituents, others are intentionally selective. Those geared toward entrepreneurship are particularly likely to implement more selective policies.

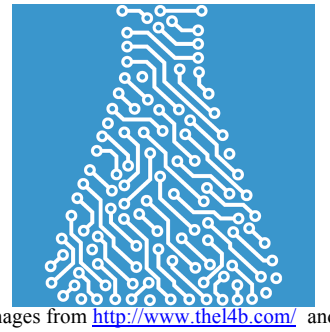
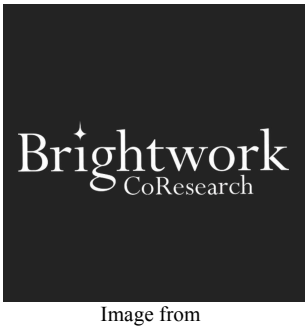
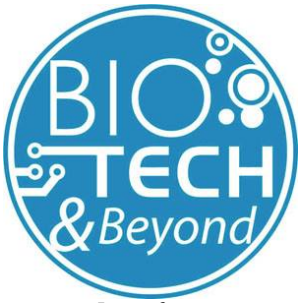
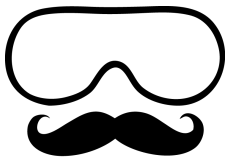
Constructing an Image for the Lab

Community labs construct an image for themselves in order to attract particular publics, associate themselves with known organizations or cultures, and promote legitimacy. Counter Culture Labs, for example, chose the name because it invoked both creative commons licensing

and the "counter culture" embraced by so many members of the hacker community. Creative commons is an organization that promotes open licensing, and it is very popular among computer scientists and the open-source community (see creativecommons.org) CCL, which is devoted to openness, transparency, and citizen science, chose a name that would convey an attachment to open source and to alternative ways of doing science. They also use the tagline "YOUR biohacking & citizen science lab" to convey an attachment both to hacking culture, and their openness not only to biology but to all citizen science in the lab (tagline from https://counterculturelabs.org/ Accessed 10/5/15). The image was carefully constructed to convey inclusivity – using the words "your" and emphasizing an openness not just to the biology community but to any citizen scientists who need lab space. The attachment to the counter culture conveys an opposition to existing institutions. CCL draws heavily on language popular in hacker spaces after which they have modeled much of the organization.

Though Counter Culture Labs makes reference to biohackers and the Los Angeles Biohackers (LAB) uses it in the name, "biohacker" is actually a controversial term in the community. Biohacking refers to doing biology outside of established institutions. While CCL happily affiliates with hacking and counter culture, subjects at many community labs explicitly told me that they do not identify with the term "biohacker." Often, diybiologists associate hacking with negative connotations that are anti-authority or associated with illegal activity. For a community that spends a lot of time trying to illustrate that community labs are safe and that they are not harboring terrorists, many labs desire to distance themselves from the term "hacking" and the cultural baggage that comes with it. Instead, labs use other indicators of openness. Table 14 contains the names and logos for all of the community labs. The lab in Boston is named "Boston Open Source Science Lab" (often shortened to BOSSLAB), which also

Table 14: Community Lab Logos and Names

 Image from http://bosslab.org/?page_id=30	THELAB LA's Hub for Citizen Science and DIYBio [45]  Images from http://www.thel4b.com/ and https://www.facebook.com/TheL4b/timeline	GENSPACE Image from http://www.genspace.org/ bioCURIOUS Image from http://biocurious.org/
 Image from http://www.bugssonline.org/	 Image from https://www.facebook.com/BrightworkCoResearch?fref=ts	 Image from https://www.facebook.com/biotechandbeyond?fref=ts
 Image from https://counterculturelabs.org/	The Container Lab[46]	 Image from http://hivebio.org/
 Image from http://berkeleybiolabs.com/	 The Community Biotech Lab Image from https://www.facebook.com/Biodidact-766169000111497/timeline/	 Image from https://www.facebook.com/The-Citizen-Science-Lab-659860734131985/timeline/
 Image from http://wetlab.org/index.html	 Image from http://www.indielab.co	

[45] (Formerly "LA Biohackers" now "TheLab Inc")
[46] This lab never had a logo (nor did it officially incorporate)

invokes the open source movement but without referencing hacking.[47] Originally called "Community Life Sciences Lab," founders changed the name of the lab in Pittsburgh to "The Citizen Science Lab" to better reflect who they are – a lab that is open to the public. Baltimore Under Ground Science Space (BUGSS), on the other hand, makes vague reference to the counter culture (though the organization is much less so than CCL seems to be). Indie Lab's name invokes alternative culture as well.

Community labs present a surprisingly professional look, for the most part, with websites that are often well designed and logos that are distinctive and catchy. Some are playful, like the amoeba growing out of the petri-dish in Counter Culture Labs' logo or the amoeba with googly eyes in the BUGSS logo. They often allude to science with logos that incorporate DNA, micropipettes, and biological entities. More often than not, the name incorporates "bio," explicitly drawing attention to the biological nature of the lab.

Another part of this outward facing image is the tagline. Genspace, for example, uses the tagline "Remember when science was fun? At Genspace it still is (www.genspace.org Accessed 10/5/15)." Similarly, Biodidact also invoked fun along with education with "Science literacy through fun hands-on science and actual research (http://biodidact.net/ accessed 10/5/15). "A place for creative biology (http://www.bugssonline.org/ Accessed 10/5/15)," BUGSS tagline, invokes both biology and the potential for innovation (or art).

Community labs craft mission statements, membership policies, and images that highlight who belongs in their organizations. The labs vary in how inclusive they try to be, with the entrepreneurial organizations striving for less inclusivity. They draw on models from hacker

[47] Rebranded to Boslab and now uses the hyphen in open-source (Boston Open-Source Science Lab); They also, in October 2015, just released a new, more playful website and logo.

spaces in particular and from the counter culture community when constructing membership policies as well as their images.

VII. Need for Expertise Shapes Core Activities

Community labs have a major hurdle that must be overcome – biology work requires substantial expertise. Community labs must train their participants to an unusual degree, and the core activities of the lab must be shaped around helping members participate. The actual activities that labs undertake are not the same at all labs. The constituencies within the membership shape which tasks are necessary and desirable to undertake.

While many labs wish to both educate and to have independent work conducted in them, some labs have found it difficult to make these two functions coexist. Many labs find that a large number of their members do not have the expertise to do independent work, and so these labs must undertake many of the education-oriented tasks outlined below (like classes, lectures, and group projects). People pursuing instrumental tasks sometimes find it difficult to work in the same space as those who are inexperienced or just pursuing biology as a hobby. One member explains that she left one community biology lab for another because the disorder associated with inexperienced users creates difficulties for those wishing to do reproducible science (see Bio, Tech, and Beyond and Berkeley BioLabs section on page 131). A community lab geared toward educating inexperienced biologists is more likely to encounter issues with cross contamination, people who do not follow procedures, and various mishaps that happen as people learn how to properly care for equipment. In this way, labs with many educators and students may not be ideal for entrepreneurs who need a more stringent scientific operation. Out of this problem rose a slightly different way of making community labs – one that emphasized projects, companies, and entrepreneurs instead of education and access. The community labs fall along a continuum from

those that privilege the educational aspect beyond all else to those that privilege entrepreneurial endeavors. Many labs exist somewhere in between. Table 15 summarizes which activities each lab undertakes.

Table 15: Type of Activities Undertaken

Location	Substantial Education	Substantial Entrepreneurship
Berkeley		✓
Carlsbad		✓
Pittsburgh	✓	
Seattle	✓	
Brooklyn	✓	✓
Sunnyvale	✓	✓
Boston		
Los Angeles		
Baltimore	✓	
Oakland	✓	

Community labs that take on primarily education oriented activities may have trouble recruiting as many scientists as they would like in the space. The presence of scientists dabbling in their own work often translates to additional ways for expertise to be disseminated to amateurs (mentorship and apprenticeship), and it may increase the options available to amateurs once they have acquired their own expertise. A dearth of entrepreneurship options in the lab may decrease the amount of independent work that members are able to do once they have learned about biology. Labs that specialize primarily in entrepreneurship may avoid recruiting members with less biology expertise. Consequently, these labs are less likely to have diverse members from technology, art and other areas of expertise who can bring unusual perspectives to the work. The increased mean level of expertise may increase innovation, but the lack of diversity of experience may hamper innovation that could rise from new points of view. The organizations end up more specialized in what they can accomplish. A few organizations try to have substantial

education programs and substantial entrepreneurship opportunities, and this creates a constant struggle to assign the proper amount of physical and cognitive resources to each task. Below, I develop a typology of the sorts of people found in labs, detail the kinds of activities that labs host to serve the purposes pursued, and describe the factors that lead some labs to move toward one end of the spectrum or the other.

Dimensions of Participation

As discussed in Chapter 4, people become member of community labs for a variety of reasons. Sam, a lab founder, says, "[In the beginning,] we tried really hard not to talk about the long term goal of the group because everybody had different ideas." Some had really "whimsical" ideas of a space for impromptu performances of art. Others wanted something like a professional incubator, geared toward people with prior training who just wanted a space to pursue their own projects without the licensing restrictions imposed by institutions. Still others wanted a cool group of friends who could hang out and do science related projects. Later, some would focus on educating the public.

Through interviews, I have identified four dimensions of participation in community labs: education, instrumental use, pursuit of hobbies, and pursuit of visions. Some people's activities fall squarely into one of these dimensions, but many people do activities in a combination of dimensions. Some labs specialize in catering to one dimension because they must – if their members, for instance, require education to participate. Others recruit members devoted to instrumental use of the lab, like the hackubators that emerged from BioCurious. While a few labs serve the needs of both education and entrepreneurship, there is sometimes tension between the dimensions that require either constant attempts to balance the concerns in each or leads to a split into multiple labs.

Education

People participate in community labs both to educate and to be educated in biology. Educators take a few different forms. The most obvious are those who teach the classes offered at the labs. Many are motivated by supplemental income, but there is also a notion that this is an important site for professionals to engage the public. As one educator puts it, "If people are interested enough to want to do science, I don't think that they should be turned away." As scientists get more specialized and scientific knowledge becomes harder for the public to grasp, some believe that an intermediary space to engage and educate citizens is very important. These sorts of educators teach classes in the space, organize public talks, and create opportunities for public outreach such as doing hands on experiments with children at science exhibitions.

Professionals who advise and collaborate with others in the space in less formal capacities are another form of educator in the labs. Most labs have such professionals, and they often overlap with the more formal educators. At one lab, this mentorship and guidance is provided largely by Max, who has developed individual relationships with a range of people at the lab and who advises them in many ways, including helping them select and evaluate relevant academic readings, helping them plan how to reach their project goals, and helping them troubleshoot when the project does not proceed as planned. At other labs, similar mentoring takes place. Community members also lead study/reading groups. For instance, one PhD recipient leads a group of several members who are interested in plant biology, coordinating discussions, coming up with project ideas, and helping members of the group to develop and conduct their own projects in plant biology. These groups are not a formal entity in the labs but have formed in response to interest by members in a subject known to a professional plant

biologist. Informal education is most common in labs that have both education components and significant numbers of those doing instrumental work.

A number of people also participate at the lab in order to become educated. Often these are people in other fields wishing to make a transition into biology, which many of them say they view as the next field of growth. Hobbyists also seek education through labs. Both of these groups are interested in education, but also in being able to do independent work in the lab.

Instrumental Use

Other activities in the lab are aimed at reaching particular applied goals, including expanding scientific knowledge, entrepreneurship, and creating art. As Christopher, a graduate student in biology, notes, many lab members have a utilitarian approach. People use the lab to accomplish something rather than as a way to encourage public access or education.

At some labs, artists are the primary instrumental users. The artists wish to provoke discussion about humanity and biology, and their lab work universally is geared toward particular art projects designed to do just that. They use established techniques rather than seek to make scientific discoveries. Their interest is not in the biology itself, but in the social and philosophical questions that might be raised when biology is manipulated. Their experiments are a means to an artistic end. At other labs, entrepreneurs are the dominant instrumental users of the lab, often led by people formerly in the software industry. These members often want to develop a particular application of a scientific principle in order to found a startup and produce the good for the market.

Max, a professional working out of one of the labs, draws a sharp line between himself and the visionaries or educators, who spend time thinking about how to further the DIYbio movement. When he goes home, he says, he does not think about ways to make biology more

accessible. He is not passionate about creating a space that empowers the public or emulates a hacker space. Max is interested in doing his projects. He spends his time contemplating applying his knowledge to the projects that he is working on. Kim, similarly, is not interested in participating in the lab's politics or decision-making. "I use it more like a rental lab kind of thing," she says.

Some labs, like the hackubators, are geared entirely toward instrumental use. Even the community labs that are more open sometimes really target instrumental users. For instance, a founder of one lab that is in the process of forming explains,

> We're very project oriented. Not necessarily just kind of coming in to do one-off things. Not necessarily coming in to tinker. But if you have a project idea that you want to carry through, then we'll provide access to the tools and resources. Kind of gearing ourselves toward the gym for science, that kind of thing.

The subset of instrumental users that already have scientific expertise tend to be the entrepreneurs who have difficulty coexisting with amateurs, but also, sometimes, are the ones who provide mentorship and education to amateurs.

Hobbyists

Not all of the people who come into the lab are seeking education or specific instrumental uses in the lab. Some of the participants join with the primary goal of having fun. Some users of community labs, though they take classes or tinker with their own projects, can best be described as hobbyists. Hobbyists are interested in developing their own knowledge and in doing biology experiments, but they are not pursuing these as a replacement for their day jobs, as many of those in the space for instrumental use might be. There are many hobbyists. They are everything from bored programmers to retirees to parents of children in college who want to learn stuff and mess around in their spare time. Hobbyists may have projects that they are working on individually,

but these projects are spawned by curiosity and enthusiasm for biology rather than desire to educate or desire to apply their learning toward other ends. Many of the students who partake in the various educational opportunities are hobbyists (though some are artists and entrepreneurs).

Visionaries

Another dimension of activity in community labs centers is being visionary about do-it-yourself biology, and people who undertake these activities often articulate visions for both education and entrepreneurial innovation. Discussions in community labs, often those that drive organizational decisions, often turn to grand visions of citizen science, some of which may be unrealistic. Visionaries are important in the movement. Many of the people who helped found the lab spend time articulating visions for the spaces that shape policies and activities. These are the people with a vision for what citizen science could be who articulate it to the outside world and help build a community around these visions.

One category of visionaries is made up of those who enable and create the space. Ryan, a major founder of the DIYbio movement, labels himself more an apostle than a citizen scientist. He does not belong to any of the community labs, but he has visited many of them, connected with many members, and continues to invest time in being a proponent of the movement. Similarly, many of the founders of BioCurious are not active bench workers, but they take on the task of community organizing and fielding the politics of the space.

Not all of the people who come to community labs dreaming of better things have expectations that are realizable. In fact, many amateurs in the community labs expressed frustration that their idealized understanding of science did not meet the reality in the lab. Certain professionals also express doubt that many of the visions for community labs are feasible because of limitations on what amateurs can actually do.

Dimensions of Use Interact

At many community labs, all of these dimensions are represented in people participating in the space. Education, instrumental use, pursuit of hobbies, and visionary activity can coexist. In fact, often a single member will take multiple approaches. One woman working out of a community lab tells me, "One of my peers [with professional science background], he has made it a point to split his time between work and doing fun stuff at [the lab] hoping it is going to blossom into something lucrative for him." His ultimate goal is entrepreneurial, but he realizes that pursuing fun projects like a hobbyist, without instrumental goals, often in conjunction with members of different varieties, may spark new ideas. The woman would like to do bench work at the lab on her own knowledge building projects, but her commute to the lab is about an hour, which makes it difficult to do sustained scientific work that often takes regular attention. Instead, she assists less experienced members in their projects, teaches, and mentors when she has time.

However, some of the dimensions do conflict. As discussed in the California Lab split at the opening of the chapter, those wishing to pursue entrepreneurial work sometimes have difficulty sharing space with those who seek biology education. Consequently, some labs have specialized. Labs also specialize in one or the other due to demand or limited resources. As I will discuss in the funding models section, some labs find that their members need education and so they must make that a priority.

Several labs reported to me that they were entering a stage where they had trained the initial set of members in the various procedures necessary to do biology and that finally those people were ready to undertake activities on their own. Indeed, in some cases, those people have stepped forward to train the new members. As more members have more expertise, it may be that community labs are better able to accommodate both new members and entrepreneurial members

more effectively. It may be worth considering that this particular form has a particular challenge to overcome – a community biology lab requires a certain amount of expertise to participate but also wants to engage the public. The earliest phases of this inchoate form may look different from the later phases. In the beginning, most members may not know anything. Theoretically, as more expertise exists among the amateurs, the organizations may be capable of doing different things. The organizations that have henceforth had to concentrate on education may be able to expand into more entrepreneurial work. Entrepreneurs may no longer be tempted to flee to specialized labs in order to accomplish their work.

I have concentrated on the education aspect and the entrepreneurial aspect. My dimensions of participation, however, also include artists as instrumental users of the space, hobbyist use, and the presence of visionaries. Visionaries, it turns out, are at all of the labs. I believe that the founding of a community biology lab requires the founder to be, at least partially, engaged in visionary thinking. Though certainly some people who are members of community labs do not hold grand visions for the potential of citizen science in biology, many people who find their way to these labs do. It might be that the incubator labs have fewer members who are visionaries about the DIYbio movement, but they seem to be present in some quantity everywhere. People pursing biology as a hobby, on the other hand, are much more common at labs that are not geared primarily toward entrepreneurs. Hobbyists do not require the superior cleanliness of the hackubators or want to pay the fees. That said, I have been told that a few members at the hackubators, though they have goals and projects, are really more casual than the entrepreneurs who dominate the membership at hackubators and are participating in order to have fun. A handful of members across the labs seem to be at the intersection of playing around and actually trying to create something new (hobby and entrepreneurial). Still, the people

interested in pursuing biology for fun alone are largely members of the less entrepreneurship-focused labs. It is also worth noting that artists, one category of instrumental users, are not found at the hackubator labs, though they are found at the other labs.

Activities

I want to briefly summarize the kinds of activities that labs undertake. Some of them are geared more toward education while others also support entrepreneurship. Community biology labs conduct a range of activities, though not all of them do all activities. These activities include offering classes, hosting lectures, organizing journal and study groups, hosting group projects, and hosting independent projects. A few labs do unique things, like offering corporate workshops or providing resources for company development. For each activity, labs fall on a spectrum of how central the activity is to the goings on of the lab. Counter Culture Labs sums up some of the activity going on in its lab:

> Over the past year, we've held over 300 free classes and workshops, ranging from the science of our senses, to a workshop on local soil sampling, to an introduction to molecular cloning. Counter Culture Labs is currently home of: the Real Vegan Cheese project (in collaboration with Biocurious), creating vegan cheese engineered from baker's yeast; Fermentation Station, perfecting homebrewed kombucha, beer, and tasty vinegars; and Bay Area Applied Mycology, whose core current research focus is fungi for soil remediation.

CCL has a wide range of activities, though it is concentrating at the moment on the educational ones. Below, I summarize the key activities undertaken by community biology labs and discuss some of the differences between labs.

Classes

Classes are a major component of activity for many labs. They serve as a primary way to educate the less knowledgeable, are a major way to draw in new potential members, bring in

income, and serve as community outreach. They have become less central at the business-oriented labs (the hackubators), but otherwise are very common within labs.

Nearly every lab offers classes of some kind, though sometimes they are referred to as workshops or courses. Classes include things like lab safety[48], basic biology, basic synthetic biology, lab skills boot camps, scientific illustration, neurobiology, dissection of various organisms, and a variety of workshops geared toward building electronics that can be used as tools in the lab or that do something cool with something biological.[49] Some labs feature many art related classes, while others feature very few. Biotech classes are the most universal among labs. Classes vary in length from a single session that lasts an hour or two to a week of sessions that are 3 or 4 hours each. Labs tend to have some internal consistency to whether their classes are structured as single session or multisession classes, but different labs take different approaches to these classes. Classes tend to be held on weeknights or as weekend workshops. A few labs offer multi-week daylong boot camps in the summer, including a few geared toward high school students. While some classes are sequential (you need to do "Build-a-gene 1" before you move to the next level), most are not. The classes range in costs (between labs, instructors, and duration). Genspace offers a four day, 3 hours per day "Biohacker Boot Camp" at a cost of $300 for the community or $150 for students.[50] Their classes tend to be structured as multisession $300 courses, and they repeat the basic courses regularly. HiveBio in Seattle hosts

[48] Some labs offer this as a course for new members. Others do a brief presentation or an informal review of safety guidelines.

[49] "Digitizing Life Using Synthetic Genomics," "Build-a-Gene," "Backyard Brains SpiderBox Workshop," "Basics of Biology," "Introduction to Intellectual Property," "Smartphone to Digital Microscope Workshop," "Sheep Brain Dissection," "The Science Behind Lotions," "Candy Electrophoresis," "C. elegans and Model Organisms," "Biohacker Boot Camp," "Biotechnology Crash Course," "Intro to Synthetic Biology," "Molecular Biology 101," "Parts for Biological Machines," "Plant Biotechnology, Plasmid Design, and Cloning," "Bioinformatics"

[50] See http://genspace.org/event/20151012/1800/Biohacker%20Boot%20Camp (accessed 10/6/15)

one-session classes that cost $15 plus material costs that last about three hours.[51] Variation in class cost and duration make different classes useful for different things. The very cheap classes may be good at drawing in new members, but they usually are of lesser duration, so they may be less valuable for teaching biology expertise. Thus some labs may have higher effectiveness at promoting learning while others may serve larger numbers of people in outreach.

Members of the labs often teach classes, though scientists or artists from nearby organizations also sometimes teach them. At one lab, a high school teacher taught a class in order to fund memberships for some of her students. At some labs, scientists or artists from local institutions teach classes as part of their own interest in science or art outreach or to make money on the side of their day jobs. Many of the classes are taught by founders and lab members who are seeking extra money or who want to build the community. Though many labs allow the teachers to take some portion of the class fee, others accept the fee as a donation to the lab and rely on that money to cover the lab's overhead expenses.

Some labs offer no classes. One lab leader told me that their recruitment to take classes was so low that they are thinking about not holding them anymore. Other labs, however, do classes almost exclusively. Pittsburgh, for instance, is currently doing classes exclusively (though they hope to branch out at some point). Most community labs do offer classes with some degree of regularity.

Journal Clubs and Study Groups

A handful of community labs also have "journal clubs," or reading groups dedicated to various topics of interest among the members. These are modeled off of cooperative learning in other organizations, particular in academic biology. At some labs, this club is led by someone

[51] See http://hivebio.org/class-registration/ (accessed 10/6/15)

with expertise, such as a graduate student or professional scientist, and so they require the presence of scientists in the lab. In one such club, a young professional scientist leads a regular journal club intended to "help people learn, facilitate collaboration and spark project ideas." The journal club meeting centers around a current topic, which the leader provides background information around. The journal club also provides opportunity for discussion of the topic by members and for giving each other project feedback. In other cases, the study groups are made up of a group of members who are interested in helping each other learn about a particular topic, such as molecular biology. At one lab, a group of members took a Coursera class together online and had a study group for the class. Not all community labs have formal regular journal clubs or study groups. They are most common in the organizations that emphasize education. Group learning allows members to pursue their own interests with guidance and assistance from others. It supplements the education available through classes.

Lectures[52]

Many of the labs host lectures on a wide range of topics. Lectures serve to draw in potential new members (who might then be funneled into classes), to engage the public, to raise money, and to explore topics of interest to members. As in an academic department, lectures are a way to bring in expertise that those in the lab are lacking. They also are a way to reinforce connections with other organizations and to promote legitimacy of the lab as a public resource.

Frequency and type of lecture differs from lab to lab. Some labs have regular lecture series. Others have them quite infrequently. Lectures in Carlsbad and Berkeley tend to be

[52] "Medical Devices and the FDA," "Digitizing Life Using Synthetic Genomics," "Design Thinking," "Addressing the Challenges of Building Synthetic Biological Systems," "Difference and Sameness: a talk by genetic artist ---," "Patents 101: Protecting Your Ideas for Fun and Profit," "The Molecular Basis of Alzheimer's and Parkinson's," "Breaking Down the Vaccine Debate," "Intellectual Property Issues for Biotech Startups," "Telomeres in Cancer and Tissue Regeneration," "Drug Discovery on a Budget: A Collaborative, Lean approach"

relevant to entrepreneurs, addressing issues like intellectual property, new technological developments, making a business plan, and other topics relevant to starting businesses. Other spaces tend to have lectures geared more toward a general audience, focusing on biology and its intersection with art and technology rather than business considerations. Still other labs have a mix of both. Lecture topics often reflect the organization's emphasis on either education or entrepreneurship or, sometimes, both.

Lectures are often open to the public, though some charge a small fee or have a suggested donation ($5-$10). They range a great deal in topic, from business issues like copyright, patenting, and working on a budget to talks by artists (both local and nationally known) to new techniques or electronics (like protocols to use in the lab or DIY electronic kits) to knowledge areas in biology or electronics that members have requested. They are taught by a range of specialists (lawyers, scientists, professional artists, entrepreneurs) and sometimes by community lab members. Attendance ranges, of course, from quite small attendance by lab devotees to fifty or sixty people in some cases, as was the case in one art related lecture that I attended. The lectures are often advertised on the group's Meetup page, which often include large lists of biology enthusiasts who are not lab members. They are also advertised on the lab websites and through their mailing lists. Sometimes lectures are cosponsored by other groups, who will also put out advertisement – as is the case with San Diego's Wet Lab, which often cosponsors events with a public library.

Group Projects

Lab endorsed group projects are common in many labs. Counter Culture Labs, for instance, has a group devoted to making vegan cheese and has recently taken on a project to

make open-source insulin.[53] BioCurious has an inkjet printer that a group of members adapted to print with biological material. Group projects are a way to engage members in community activity, allow experienced members to teach new members, give new amateur biologists a project to work on, and combine forces toward solving a problem. Group projects are also visible to external parties and get mentioned in news write-ups, crowdfunding campaigns, and recruitment attempts. Counter Culture Labs wanted to come up with group-project ideas even before they opened the lab because they believed these projects were key to recruiting new paying members.

Individual Projects

Most community labs aspire to have members with individual projects in the lab, and many are successful in that goal. Individual projects range from members developing technologies to make biology more accessible to members trying to engineer new organisms to accomplish some particular task. Many of the individual projects are oriented toward having fun – members want to try something out. However, many projects are aimed at creating marketable products, like Glowing Plant, which is mentioned at the beginning of Chapter 4.

Though the idea of putting out new scientific knowledge and products is a central dream at most community labs, it is more prevalent in some labs than in others. A founder of one lab notes that they may have been ambitious in terms of what they thought they would be able to accomplish in the community lab when they started out. He has been disappointed in the types of projects that they have actually been able to accomplish. One of the reasons he thinks they have not been able to do as many projects is because it takes a lot of time to get people "up to speed" in biology knowledge and procedural knowledge. Individual projects require a high level of

[53] The media has been a bit taken-aback by this one.

expertise that many members do not have. This sentiment is echoed at other community labs as well.

Summary

The need for expertise shapes which activities a particular lab undertakes. Because some members will need education, some labs must offer it. A few specialized labs have emerged that focus on serving entrepreneurial ends instead. Most labs have some education and some entrepreneurship and the balance between the two must be constantly negotiated.

VIII. Funding Models

Identifying the appropriate funding model to sustain a citizen science lab was far from clear for most lab founders, even several years after founding. Members hold different philosophies about what funding model is likely to sustain the lab, and all of the labs have had to make changes to their models as they attempt to create a financially viable organization. “In the past, all of the community labs are struggling with their financial model. You know, what's the sustainable model for independent science?” sums up one lab founder. While many labs might shape a funding model based on those they see in other organizations that seem aligned with their goals (hacker spaces, incubators, start ups, nonprofits), perhaps more than any other feature of the organizations, the funding models have to be flexible to be shaped by the pragmatic need to sufficiently fund the organization even if the new funding sources do not necessarily line up with the initial vision of the lab.

Two primary funding models exist: one that relies heavily on membership fees and another that relies more heavily on revenue raised through educational activities. Most labs will raise money both through membership fees and through education, but they often find that one or the other is more central to their financial stability. The labs supplement their primary income

through grants, sponsors, donations and a hand full of other revenue streams that are unique to particular labs. A few labs have unique funding models, which I will discuss below. The data for this section comes from interviews of members of ten community labs for which I had sufficient information on their funding models.

Table 16 provides an overview of the funding sources mentioned to me in interviews. Community labs that are geared toward entrepreneurial endeavors tend to emphasize membership-derived income (and sometimes do not have education income), while those labs that emphasize education as a central activity use a variety of models.

Table 16: Funding Sources by Lab

Location	Membership Heavy	Education Heavy	Education/ Membership Balance	Grants	Sponsors	Donations	Other
Berkeley	✓				✓		✓
Carlsbad	✓				✓		✓
Pittsburgh		✓					✓
Seattle		✓		✓		✓	
Brooklyn		✓		✓	✓	✓	
Sunnyvale			✓	✓	✓	✓	✓
Boston		✓*					✓
Los Angeles	✓					✓	✓
Baltimore		✓		✓			
Oakland	✓					✓	✓

* Boston uses a class heavy funding model in that it has classes but does not have membership fees. However, at the time of the interview, classes were also very infrequent.

Those labs that lean heavily toward the education related sources of income tend to serve members with lower expertise, who need classes in order to do biology projects in the lab. The labs that operate on mostly membership-based funding models include those in which there is a very high mean expertise level, as well as some of the labs that serve a variety of people. Many labs fall somewhere in between class and membership-based funding, and nearly all of them augment these methods with other sources on income. Very few labs have come up with models

that are able to eschew classes and memberships entirely. The one that has is one of the smallest and least active labs.

Choosing the funding model is based on many factors. For labs that are targeting high levels of expertise (like science companies), classes are not necessary. For these labs, higher membership fees are attainable because companies tend to invest more in lab access than individuals can. Some organizations leaned heavily toward classes because that was their mission – to educate the public and to be cheap and easily accessible. Others planned to rely on both membership fees and education revenue, but were pushed toward education revenue because their membership base was small and the need for learning was larger or were pushed toward membership because the demand for classes was small. The intention of the organization was not always what was attainable for the funding model. Recently, organizations have also been attempting to derive more of their funding from external sources such as grants.

Each model has pros and cons. The funding model that relies heavily on education works well in labs with many members who need to learn and have the money to do so. Classes are quite necessary in some community labs, where expertise of members is low. However, they require quite a bit of attention to plan and host, and some labs found that they could not manage or were not interested in using classes as a basis for income. Many labs reported that hosting courses ebbed and flowed according to the amount of time members could put into coordinating them. Consequently, revenue streams in organizations that rely on education revenue can be unstable or, at best, difficult to maintain. The membership-heavy funding model requires less time be spent on coordinating education endeavors. However, membership-based models require a larger number of members, and those members must sustain interest in participation over a long period of time. Classes, which are often important points of entry of new individuals into

the labs, can help refresh the membership – if the lab holds classes. Below, I give more detail about how particular funding models work.

Education-based Funding Model

An education-based funding model is employed in five labs. Below, I illustrate how Genspace (Brooklyn) and HiveBio (Seattle) cobble together funding that relies on education revenue as the largest component of the model. They also pull together other sources of revenue that are available in their local environment. Education revenue is a large part of their funding model not necessarily because that is their ideal, but rather because education is in demand at these labs and, in the case of HiveBio, external funding is available that pushes their activities in that direction.

The three biggest sources of revenue for most community labs are donations, class fees, and membership fees. In 2013, the last available year of tax documents, Genspace's income included approximately $26,000 in donations, gifts, and grants, $57,000 in program revenue, and $20,000 in membership fees. About one quarter in income comes from donations, one quarter from membership, and half from classes and other money raising endeavors. Of all of the community labs, Genspace is probably the most well known, so it may receive more donations than many labs. It also has the most active class schedule. At $300 a class, classes are offered very regularly. Partnerships and sponsorships are another way that labs augment their funding. Genspace, for instance, partnered with Assay Depot, a company that is out to change the pharmaceutical industry by networking researchers and suppliers of services. Together, they launched a "Tri-State Open Science Challenge," where Assay Depot donated three $5000 grants to fund three ideas plus a one-year membership to Genspace for each grantee (PRNewswire 2012). Other labs have subsequently also received small grants from Assay Depot and other

sources. Cobbling together revenue from multiple sources is very common in community biology labs. Genspace ended up with a revenue model dominated by classes, but it certainly has income from other sources as well.

Other organizations that go with a class heavy model do so for different reasons. For instance, HiveBio originally planned to fund the lab on approximately half membership fees and half income from classes. However, early income actually looked quite different than anticipated. They had one member of the organization who was quite motivated to get the courses under way, "but it also then coincided nicely with the fact that we needed income right away in order to support the organization. So the membership, in terms of people who pay to use lab space, is extraordinarily low. Like, there are very few." Many community labs run into difficulty getting the necessary membership numbers to sustain the lab in the beginning. As part of HiveBio's initial income, they were able to gain money from the outreach portion of an NSF grant by teaching and providing access to underprivileged children in the community. One member explains, "That's a steady source of revenue so that's really good to, kind of, provide the basis for this lab, and so that stability will also help us grow in other areas." The organization also developed a protocol for entrepreneurs in the space to give a certain amount of money, but at the time of the interview, entrepreneurship did not seem in high demand in the area (Seattle), which has many incubator spaces. HiveBio is one of the only community labs that has noted that fundraising endeavors to secure income were planned from the beginning of the lab. Though some labs did use Kickstarter, an online fundraising platform, to launch the lab, few seemed to organize a sustained fundraising effort as part of the funding model at their inception (though many would later approach fundraising more methodically).

Membership-based Funding Model

Membership-heavy funding models are utilized in four of the community labs. Membership-based models have less fluctuation than education-based ones, as noted by BioCurious during their near failure. In June of 2013, on the Google group devoted to BioCurious, a board member posted a note titled "BioCurious Cash Crisis – I need YOUR help." BioCurious was in danger of becoming insolvent. It needed to recruit more new members to bring up membership income. Classes had fallen in frequency because of difficulty sustaining enough teachers and because of conflicts in the schedule with group projects, which took up lab space on many evenings but did not bring in income. Several pieces of equipment had been broken and needed to be replaced, which was expensive. Many community labs believed that BioCurious was going to or had closed. However, they were able to pull themselves back from the brink of bankruptcy. BioCurious (Sunnyvale) ultimately went with the only balanced education and membership model. They came to believe that diversified revenue streams were preferable.

The founders of the labs in Berkeley, Carlsbad, and Oakland all witnessed the struggles with revenue in Sunnyvale (as noted in the vignette at the beginning of the chapter). They became convinced that membership-heavy funding models would be more stable than models that relied on education. Each of these labs then implemented membership-based models. In Oakland, they did try to keep the rates down to similar rates from Sunnyvale, tried to supplement membership income with other revenue, and carefully set costs according to the number of members they anticipated. The other two labs opted to go for much higher membership rates, which they hoped would allow the labs to be stable with fewer members.

Other Options

A few labs have tried funding models that do not emphasize classes or membership. A few labs have funding models that are in flux. Substantial external funding is also an option that organizations have tried, like BUGSS and The Citizen Science Lab, described below. Several labs were interested in bringing in income from entrepreneurial work in their spaces. A few organizations have such tiny membership and activity that their funding model is ad hoc.

The Citizen Science Lab is unique among community biology labs for now. It exists under the umbrella of an organization call Urban Innovation21, which is a foundation that promotes entrepreneurship in Pittsburgh to assist underserved communities and their residents. The Citizen Science Lab, which shares the mission of reaching underserved communities through teaching and access to STEM, is funded entirely through Urban Innovation21. The long-term goal is for The Citizen Science Lab to be self-supporting, and for this they do plan to have membership fees. For now, however, they exclusively offer classes. Their revenue stream is largely external, but they are working on making education their primary revenue stream.

Baltimore's BUGSS initially pursued a revenue stream that heavily involved contribution from for-profit entities in the space, and they were not alone in the desire to use businesses that spawn in the labs as a source of revenue to support labs. Several organizations have attempted this, but so far this method has not supported lab spaces in substantial enough ways (membership fees are still necessary). "A lot of places are member-based [funded], and I think our feeling was members would never be – wouldn't really give us the robust financial stability that we hoped it would have," a member told me. Instead, BUGSS tried a different model. One of the founding members had an NSF grant for work that he was doing out of his for-profit company, which needed space to do the project. In order to get the lab off the ground, the company rented the

space for its work and BUGSS also set up in the space. The approach cut costs to sustain the lab because a business within the space took on major costs. The original vision for the lab also included more entrepreneurial work. They had an LLC that they hoped to use for any spinoff work, which could be a source of income to sustain the lab. However, one member informs the that the entrepreneurial aspect never took off:

> That was one of the things that we had in our original business model, that we would try to serve as a little bit of an incubator, but that, I'm not sure if the people don't know about us or if there are other resources [in the area] but that hasn't really panned out.

Expertise was one issue at BUGSS – many people who were interested in the space did not have science backgrounds and needed substantial learning in order to do work. Though it may change in the future, the lab was not able (at the time I talked to them) to do as much entrepreneurship as they had hoped.

Unfortunately, the nonprofit coupled with a for-profit approach only worked for about two years, until the funding ran out for the company, at which point they had to shift tactics. Though BUGSS actively avoided sponsorships and partnerships when they started out because they wanted the lab to remain independent and uninfluenced by external stakeholders, they later came to the conclusion that they would need to pursue these lines of income in order to sustain the lab. Thus, in later phases of their model, like several other community labs, BUGSS has undertaken fundraising. One member notes to me that now that they have been around for a few years, they have been noticed by local groups and have had inquiries from philanthropic organizations that are interested in supporting them. In the summer of 2015, the Robert W. Deutsch Foundation awarded BUGSS $189,000 in funding to be distributed over 2.5 years to hire a full-time lab and program manager (Babcock 2015). The employee will take pressure off of the few member volunteers who were running the space, allowing the lab to be open more

hours and coordinating activities that can bring in additional money. BUGSS will be one of the very few community labs to have a full-time employee.

A few labs are so minimal in structure and activity that they simply do not need much revenue to survive. These labs tend to hack together money as needed in whatever way seems desirable to them. LA Biohackers, which does have membership fees, also relies heavily on donations as a primary source of income, making their 501(c)(3) status vital to their funding model. The funding model fluctuates from month to month, depending on donations, whether they offered classes, and whether they were able to buy excess equipment off of ebay and sell it for a profit. The donation model seems to work for them because they have fairly minimal costs compared to some of the other labs. Bosslabs, which occupies space very cheaply in an educational space, has a very unusual funding model – one that is nearly nonexistent. Though they have discussed whether to have membership fees "over and over," they have always decided that since they have few overhead costs, they do not want to have membership fees. One member concedes that if they gain more people, they may need to rethink the membership fee in order to help control demand for the space and time in the lab, or they might require blog posts to serve the same purpose. For now, they make enough money through classes to buy the supplies that they need. However, they have been having some trouble sustaining the classes. Classes have typically run around $200, but they were not recruiting many participants even after they dropped the price. When I interviewed the member, the lab was considering discontinuing classes and trying to raise small amounts of money through projects instead. "We don't have to be like every other lab," the member explains.

Each of the labs in this section is unique. Some are dominated by grants or donations. One exists under another organization, and so it has not yet established a sustainable funding

model. One exists on practically no funding at all. Each lab is experimenting and reaching for whatever funding they think they can acquire. All of the community labs, whether membership-based, class-based, or cobbling together other funding, are constantly in flux.

IX. Challenges and Changes Over Time

Any new organization will encounter challenges. Leaders in community labs acknowledge that the organizational models continue to undergo change as they learn how to run them better:

> I think that we're grounded enough to realize that community labs were still new. We knew when we opened our doors that it wasn't a guarantee that this was going to be successful or that this was going to be around for a while. The model still needs tweaking and we're still relatively new.

Organizations that are experimenting with new forms encounter a few additional challenges rooted in issues specific to their tentative form, but they also encounter challenges that are typical for small new organizations. In this section, I first outline the challenges that community labs are facing that are common to many new organizations. I then outline a few unique challenges that community labs likely face because they are experimenting with organizational form. The organizations use a trial and error process by which they learn new lessons about the best way to run their organizations, a method of organizational learning common in cases where the organizational environment is difficult to analyze (Choo 2001). Community labs change over time (as many new organizations do) as they attempt to solve issues that arise.

Surviving without Particular Leaders

Many organizations struggle to move beyond early leaders to institutionalize in ways that help the organizations survive turnover. One community lab member describes to me the ongoing struggle to maintain the organization:

> It's definitely still a work in progress. I think there's some things we're doing really well. Like I said, I think there are some things we aren't doing so well and we're trying to work that out. I think the real challenge of these things [community labs] is not the starting. Getting them started is actually the easy part. Its maintaining them, and keeping them viable and fresh [that is the hard part].
>
> Especially if you have just a few people who are doing most of the work, well if the burnout – that's one of the reasons we decided to go down the route of, you know, trying to raise some money to hire some people – that some of our volunteers were, you know, just carrying too much of the load.

Many of the labs survive because a very small number of leaders put in a very large amount of work in setting the vision, searching for funding, solving problems, and making any other decisions necessary around the lab. The organizations can only survive as long as the leaders stay in place. Many interview subjects expressed frustration at how hard it is to spread the workload over enough members than there is no member in the lab without whom the lab would fall apart. The subject quoted above believed one way to solve this problem was to hire an actual individual to take on the various tasks necessary in the lab – a dream that several labs' members expressed, but only one lab has yet achieved. An employee can relieve current leaders who are donating tens of hours many weeks to run the lab on top of working full-time jobs, which labs hope might be a more sustainable model.

Other labs have taken steps which are likely to help them transition from original leaders to new ones without jeopardizing the organization. Seattle, for instance, outlined a very clear structure and has managed to replace some key figures without issues. Berkeley BioLabs has transitioned completely from the original founders to a new set of members on the board.

Surviving Membership Turnover

Membership turnover is a major issue at nearly every community lab. Members sometimes burn out (particularly if they are taking on organizational responsibilities in the lab), move away, have life events that take away leisure time, or lose interest in the community lab.

High turnover creates problems. It makes it difficult to budget at labs where membership fees are a large portion of the funding model. It also means that sometimes necessary tasks are not taken care of properly. At several labs, the person who put together the web page left the organization and did not leave behind the necessary information for those who remain to be able to update it. At one lab, the treasurer left and taxes were not filed that year.

Starts and Stops

Partially as a result of membership turnover and partially as a result of the organizations being difficult to maintain without tireless leaders, several of the community labs have experienced death and rebirth. Both BossLabs and LA Biohackers experienced times when they no longer had any activity, followed by reopenings as leaders either stepped forward or stepped back up to organize events. Other labs do not go so far as to close down but still experience lags in activity. For instance, BioCurious's financial crisis was brought on by a decrease in organizing classes and not enough member recruitment. Though it did not close, it did come very close.

Losing Nonprofit Status

At least two community labs, had their 501(c)(3) status suspended for a time because the proper paperwork was not filed with the IRS. Completing and keeping up with necessary paperwork is challenging, particularly in volunteer run organizations like these. As with the labs that start and stop, one of the big challenges for community labs is maintaining their status as a 501(c)(3).

Challenges Due to Stage of Organizational Form

The challenges enumerated in the previous section are common to many organizations that lack resources when they are starting out whether they take a new form or adopt an existing one, like a hacker space. However, community biology labs have additional uncertainty that they

deal with when they are young organizations. A founder of one of the earliest community labs explained to me,

> Community labs are awesome. They should exist everywhere. We all struggle so heavily and invest so much of our passion and our time in it and what we need to achieve is a sustainable model for these labs to exist without compromising the goal to help the greater community and to continue to expose people to the excellence of science and the excitement. And that's what I see as the biggest challenge in the next couple of years.

The search for a sustainable model is a difficult one. Most of the labs note that they struggle to understand how to marry the goal of doing citizen science in a community space with a model that can sustain it. Though they draw on hacker and maker spaces, and sometimes incubators, community biology labs are slightly different from what has come before. The range of ways that they have tried to organize around the goal of creating a public biology lab illustrates how unobvious the right way to organize is to them. They differ not just in their approach to funding, membership, and the distribution of power – they also differ even in the basic type of corporation that they form. The appropriate features to adopt are not obvious. As organizations that do not have a recognized and legitimized form, community labs also encounter unique challenges in acquiring insurance (as detailed in Chapter 3) and interacting with realtors. Recall the experience of the founder in Norfolk, VA, who told me that he and his cofounder believed that creating a new lab was particularly difficult because there were not any instructions they could read about how to go about founding the lab. When they wanted to create bylaws and documents for incorporation, there were no existing templates for community labs. Nowhere does there exist a comprehensive list of equipment that you need. For him, the struggle to figure out how to go about making a lab was compounded by the lack of resources suggesting best practices for this particular form. The range of features adopted by community labs underscores this point; community labs could look many ways. The factors that push them in different directions are

many. The outcomes likely to result from particular choices impact who will be included, what activities the labs will ultimately undertake, and what will be required to make the labs sustainable.

Change in Community Labs

Community labs continue to change as needed. One leader describes, "We're still continuously adjusting. Actually, we're making some changes right now on how we operate. It's a big experiment. Some things work really well. Some things do not work so well. So we keep doing the things that are working well and stop doing the things that aren't working well." Many community labs have changed over the course of their lifetimes in response to what members have learned from their experiments with organizing. Some of the changes are small, such as changing membership prices, trying to offer more classes, or offering summer boot camps. One lab retreated from a previous stance where they refused to take sponsors in order to maintain independence when they experienced funding problems. They moved, instead, toward active fundraising endeavors seeking donations and large (for the lab) grants.

Other changes are larger. For instance, Berkeley BioLabs was originally a domestic stock corporation, a form of for-profit incorporation in California in which owners own stock in the company. In 2015, the founding members of the lab left to found a biotech accelerator in San Francisco, turning the lab over to a leader of one of the companies in the space. On the brink of bankruptcy, the new leader moved the lab from a 4000 square foot facility to a 1000 square foot facility. He noted in an interview that the proximity of CCL to Berkeley BioLabs meant that biohackers already had a local place to do their work and BBL did not need to cover that angle, so when they downsized, they got rid of the open lab spaces and discontinued allowing the community into the lab. They created a new LLC, which they hoped would allow investment to

be brought more easily into the space, and purchased the domestic stock corporation from the original founders. They do still have workshops aimed at the public, but anyone using the lab must be a trained scientist or must be supervised by a trained scientist (and they must be part of a company). In their attempts to survive, Berkeley BioLabs has transitioned from a community biology lab to a very inexpensive version of a standard biotech incubator.

Another lab told me "we're getting ready to reset the lab as we speak." Some of the tenants in the hackubator were not a great fit for the culture that the founders wanted to cultivate. The lab has a very cheap rate because they expected members to share their equipment. Some members were getting territorial over their equipment, which did not fit the model of cooperation. In the new attempt, the lab would stop bartering for equipment and try to distribute some of the organizational tasks to some of the companies in the space. BioCurious revamped their bylaws and their funding model in the face of near collapse. In the California vignette, I described how sometimes members of a lab, rather than seeking to change the lab's organization, split out and create entirely new community labs with radically different organizational structures.

New organizations trying out an inchoate form encounter both the typical challenges of starting new organizations and challenges surrounding the uncertainty of the best way to organize. They experiment and make changes in response to what they learn as they go along.

X. Conclusion

Throughout the chapter, I have illustrated the ways in which community biology labs vary in how they structure and run their organizations. In terms of the core features model of organizational form forwarded by Hannan and Freeman (1984), the organizations differ with respect to their goals, the forms of authority and extent of authority within the organization, and

the kinds of "clients" that they hope to serve. With all of these core aspects varying across each lab's form, it is clear that the community biology lab is in a stage of organizing that is characterized by variety and experiment. While all of the labs draw on ideas about independence and openness from the technology culture, some incorporate these ideas more directly into their organizational structure while other labs adopt features toward more pragmatic ends.

Community labs' forms are also often changing. While Hannan and Freeman (1984) note that when an organization changes one of its core features, it is more likely to fail, community labs do sometimes change their features. They may be more adaptive than many organizations because they are minimalist organizations, which require low initial cost, relatively low maintenance costs, have the ability to mobilize reserve structures (like a member's back room) when they encounter difficulties, and are adaptive because they have very few sunk costs (Halliday et al. 1987). As organizations, they should be able to avoid structural inertia to a greater degree than less minimal organizations, and so they have greater flexibility than some organizations. Still, in the case of the California lab split, we also see new organizations breaking off in order to pursue different structures than those that had previously existed rather than adapting the existing structures. This was necessary because there were conflicting ideas about who the lab should serve, how they should serve them, or whether particular ways of organizing promote the necessary behaviors to sustain the lab.[54]

For the time being, community labs are still in a stage of organizing that is inchoate. As Karin, a lab leader explains,

[54] Though the California labs are the only labs that appear to have formed new entities due to such divisions, many labs have had members that have departed due to differences in opinion about running the labs. Some seek to work in other spaces (like hacker spaces). Others work alone at home. Some choose to no longer do lab work at all.

> There have been times where, you know, we struggled, and it's worth questioning again whether not 'Will we survive?' but 'Should we survive? Is this model right?' And the answer to that came about through surveying the landscape of options. Through answering that question, like, who is similar to us? Who provides these resources? Who are the people whose needs should be served?

Creating a community lab is difficult work. Founders have searched for models that they think make sense for bringing biology to a community accessible lab space, and they continue to experiment with their organizational form after the organization is in operation. I have argued that there are five organizational features that labs have recombined in different ways: whether power is distributed or concentrated in the hands of a few members, the type of incorporation, the degree to which they wish to serve a wide audience, the degree to which they are geared toward educational opportunities versus business opportunities, and whether the funding structure leans more heavily toward classes or membership dues. Each of these areas – how authority works, the organization's legal form, who participates, what they do, and how they create sustainable income – are centrally important to the form of an organization. While some patterns have emerged among community labs, they do not yet have a clear picture of what might ultimately be a sustainable model. The would-be-founder I mentioned in the opening of the chapter, is in the process of creating a new lab, but even after the last seven years of community labs experimenting with form, a clear template is still being created.

Though she was not sure if the organization would survive, one founder told me that when she and her cofounders looked around at the other organizations in the environment, they came to the conclusion that exposing people to the life sciences is a noble goal. In the end, she asserted, "Something like what we do should exist."

Chapter 4: Community Labs Negotiate a Place

The Glowing Plant Project

In 2012 and early 2013 Kyle Taylor, a cell and molecular biology PhD fresh out of graduate school at Stanford, was working out of BioCurious[55] in his free time trying to make his own kind of postdoc studying of things he was interested in without having to compete in the depressing and low-odds world of academic or industry biology labs. A very active member of the lab, Kyle soon met two more scientists – Omri Amirav-Drory, a biochemist PhD who had given a talk at BioCurious and Antony Evans, a mathematics MA, who Omri had met at Singularity University, a local corporation aimed at education, innovation, and acceleration of technology related projects. Anthony talked Omri into taking a synthetic biology course at BioCurious, where the three men started to collaborate. They teamed up to start a project called Glowing Plant, which they crowdfunded through the online crowdfunding platform Kickstarter in the spring of 2013.

Glowing Plant's mission is to create sustainable natural lighting by engineering plants to make them glow. The project was eventually featured on *Wired*, *The Wall Street Journal*, *The New York Times*, and more. Though the original goal was $65,000, Glowing Plant raised $484,013 from 8,433 backers to fund the beginning of their research (Evans 2013). The funding was meant to support the project's costs, including necessary supplies and some income for the scientists to support themselves. The plan was to conduct the work from BioCurious. As incentive for investing at least $40, backers were to be rewarded glowing plant seeds so that they could grow their own glowing plant.

[55] A community lab in Sunnyvale, CA.

Many in the do-it-yourself community considered the campaign a huge success for DIYbio, particularly community laboratories. The press attention was extensive. Glowing Plant demonstrated that it might be possible to attract nontrivial amounts of money into real science projects in an amateur science space. Innovation outside of traditional science institutions, a dream of founders at most of the labs, was finally happening in a visible and exciting way. However, the success of Glowing Plant also brought to the fore tensions in the community lab, which were discussed at length on the BioCurious Google group and mentioned in interviews of a few of my subjects. Glowing Plant wanted to introduce genetically modified organisms (GMOs) into the environment, and the lab members were split on the appropriateness of lab policy on the release of GMOs.

On the one hand, proponents of the project noted that the genetically modified glowing plants include "non-pathogenic, non-toxic, well categorized genes" (Evans 2013) introduced to a plant that is well understood by biologists and that plants that glow are unlikely to survive well in the environment because 1) they use a lot of the energy that they collect to glow, 2) this use of energy stunts growth relative to naturally occurring organisms that do not glow, and 3) they are very visible to organisms that might want to eat them. Furthermore, though the project falls under no regulations of the USDA, EPA, or FDA, the researchers planned to comply with all NIH guidelines on recombinant DNA research, and the project qualifies as Biosafety Level 1 (BSL 1), the safest of biology work. Both sets of guidelines apply only to labs that get government grants – but the researchers (and many community labs) had chosen to adopt them nonetheless. The proponents of allowing Glowing Plant to do work in the lab did so under the argument that 1) the organisms released were not dangerous, 2) the regulations allowed it and the lab itself should not limit people from doing something that is not illegal, and 3) Glowing Plant

would be able to solve some of the financial issues of the lab by making contributions (this was discarded by many).

Those who opposed allowing the Glowing Plant researchers to do their work at BioCurious presented concerns about the safety of GMOs and the wisdom of release into the environment, though the concern was also undergirded by a desire to avoid some of the negative attention that they had received from the press. They worried about the environmental impact and that the project leaders had not fully evaluated the possible downsides. They noted that just because GMOs are not well regulated, that does not mean that they are safe – several members believed that the lab should hold itself to a higher standard of safety. While the temptation for many community lab members is to not regulate action within the lab – to be free and open to anyone to do anything – many community members believed self-regulation was important. One member expressed the following concerns:

> Beyond that, any company operating in this field, including BioCurious, has to be aware of and concerned about potential liability for damages from the release of GE organisms, whether accidental or intentional but negligent.
>
> And [their] liabilities go beyond just being sued for doing something stupid. Potential downsides include increased scrutiny or regulations that would come from an accident, or unintended consequences. Just the perception of not working with the proper caution could have chilling effects on what has been an otherwise fairly self-regulated field. ("BioCurious Cash Crisis – I need YOUR help" 6/15/13)[56]

Self-regulation in the lab was seen as a way to preserve their ability to keep doing DIYbio by preventing an incident that would encourage more regulation.

As media coverage of Glowing Plant and environmental groups drew attention to the possible hazards of do-it-yourselfers engineering and releasing new organisms (see Pollack 2013), BioCurious started emphasizing its relationship to existing standards in science. In a

[56] See footnote 34 for information about how I chose to cite these excerpts.

message to the group asking members to forward any media solicitation to the committee that handles outreach, one member writes:

> Safety rules at BioCurious are based on academic and industry best standards for working with genetically modified organisms. Much of our safety framework exists to minimize the chances of accidental release. We explicitly make the distinction between the genetic manipulations of substantially weakened model organisms that could not survive in the wild -- allowed in the lab -- and actually releasing and distributing such organisms -- currently prohibited ("Media Questions about Glowing Plant & BioCurious" 5/14/13)

The safety rules that they adopted were, indeed, conservative, and did not allow the release of GMOs. The appeal to established lines of thought continued in other communications:

> There seems to be a tacit assumption among some of the contributors to this thread that, because this is the first *DIY* bio project, we have an opportunity to create new standards and practices from scratch. I don't think that's the case; there's already a long history of thoughtful consideration on these matters (Asilomar etc.) that should be taken into account. IMHO, I think it would be hubris to throw that all out the window in favor of some sort of quick popular vote (mostly among relative newcomers to the field, I would note). (("BioCurious Cash Crisis – I need YOUR help" 6/15/13)

Adopting existing standards associates the community lab with the practices of respected scientific institutions, thereby conferring legitimacy on the organization, and it deflects negative attention from community labs that might spur regulation that would make do-it-yourself biology impossible. BioCurious wanted to have thoughtful oversight practices such as, perhaps, a safety committee responsible for reviewing the safety of projects, as would be common in academic institutions.

Kickstarter ended up banning the release of GMOs as a reward for future projects as a result of the controversy in the media over the Glowing Plant project. In the end, Glowing Plant withdrew from BioCurious, then proceeded to do work at a few other community labs (many of which did not seem nearly as concerned with GMOs) including the short-lived Container Lab in

San Francisco (McDede 2013) before eventually establishing its own space, where the company has produced very slightly glowing plants and is working to produce a more pronounced glow. They will release the seeds to investors as promised in their Kickstarter campaign.

The Glowing Plant controversy at BioCurious centered not just around trying to be responsible human beings. It also shows how a community lab works to situate itself within a field of organizations, including regulatory bodies and institutionalized science. Community members understand that they are part of a larger world of science – and they take steps to engage with that world on its terms. BioCurious adapted safety regulations found in industry and academia, including adhering to BSL guidelines (even though they are not required to) and safety oversight and policies that reflect the conversations in science more broadly. Science, however, is just one field that BioCurious and other community labs operate near. This chapter focuses on how community labs interact with a range of fields that their organizations abut.

I. Introduction

Emerging organizations are shaped by the organizations in their environments. Emerging forms also are shaped by the context of the early organizations of the form. In Chapter 2, I discussed some of the geographic and technological factors at play. In Chapter 3, I discussed some of the models from organizations around them that community labs draw on to create their organizations. In this chapter, I focus on how community labs relate to existing organizational fields and the organizations within them. I am adopting the definition of organizational field used by DiMaggio and Powell (1983) – "those organizations that, in the aggregate, constitute a recognized area of institutional life," including the suppliers, consumers, regulatory agencies, and other organizations that produce similar products or services (p. 148). An organizational field is an abstract concept that directs our attention to the totality of organizations operating

together over some domain of institutional life and the established connections operating between the organizations. Each organizational field has distinct rules and forms of social control. While many new organizations emerge within a single field, I argue that community biology labs emerge at the interstices between four adjacent fields: professional biology, education, art, and technology. Education, professional biology, art, and technology are all fields that are very different from each other. I reference them broadly to draw attention to the breadth of types of organizations with which community labs interact. However, community labs tend to interact with subsets of the organizations in these fields.

Organizations emerging at the interstices between fields have been shown to encounter a diverse set of interests, competing frames, and entrenched sources of resistance from the different established fields (Rao et al. 2000). New organizational forms seek to differentiate themselves from existing forms, and the degree to which they are successful is shaped by the environmental conditions in the surrounding fields (Chen and O'Mahony 2009). The environmental conditions include degree of competition, degree of opposition to the form, and whether the new organizations depend on other organizations for resources. At the same time, interstitial organizations draw on organizations in the adjacent fields by recombining physical, informational, financial, legal, and legitimacy resources derived from the organizations (Bátora 2013). In this chapter, I demonstrate how community labs negotiate a place within and between fields by creating narratives that differentiate the labs from organizations in education, professional biology, art, and technology. At the same time, they also align themselves with organizations in these fields in order to secure resources and legitimate their endeavor. I examine the factors that shape how community labs relate to organizations within the four adjacent fields.

Community labs relate to organizations in each field in different ways. First, I examine these relationships. Labs attempt to differentiate themselves from organizations in each field by constructing narratives about the ways in which they fit into the field. In each field, lab members identify gaps in what the established organizations can accomplish, and they outline niches that community labs fill within education, biology, art, and technology. At the same time, the labs are networked with organizations within those fields, and draw particular kinds of resources from education, biology, art, and technology organizations.

The subsequent section examines some of the other ways in which labs attempt to align themselves with or differentiate themselves from existing organizations in order to claim space for amateurs in the fields, some of which are usually exclusive to professionals. I suggest factors that explain why organizations within particular fields relate to the labs in different ways. In fields where community labs provide biology expertise to professionals, less work is required to prevent conflict than in fields like professional biology, where community labs spend considerable effort trying to establish the legitimacy of amateurs to do biological work.

At the end of the chapter, I discuss the development of a field for community labs situated between the four fields with which they are adjacent. The development of a field is an important step toward the institutionalization of the new form. Often, forms emerging at interstices of fields must construct their own new field-wide environment in order to survive (Rao et al. 2000).While community labs have not developed a field of their own, they have begun to discuss and make early movements toward developing some of the elements necessary for a community lab field.

II. Gaps, Niches, and Resources

Community labs must negotiate a place for themselves in their organizational environments. On the one hand, new organizational forms often try to differentiate themselves from established organizational forms in order to maintain their divergent goals and identities (Rao et al. 2000). They do this by comparing themselves to reference groups that they believe hold different values. On the other hand, organizations have incentives to align themselves with existing organizations in order to acquire resources and avoid conflict. Members of community labs create narratives about the function of the labs relative to existing organizations that simultaneously differentiate the labs from existing organizations while also helping to avoid conflict by laying claim to functions that existing organizations do not undertake. They critique other organizations but rather than replace or revise them, they create a new organization that seems mostly to complement existing organizations by filling functional gaps.

Community labs develop niches in existing fields that fill gaps that members identify in those fields. Many members at the community labs coming from art, biology, or educational organizations provide narratives to explain why community labs are necessary and useful. They highlight shortcomings that they perceive in the established organizations in their fields, allowing them to express dissatisfaction and promote a lab identity that is defined in contrast to existing organizations. In this way, they differentiate the lab form from existing forms. The narratives themselves are specific to the fields with which they are contrasting the labs. They tell me that educational organizations do not provide enough hands-on time, art organizations cannot provide access for bioartists and professional labs will not either, professional biology organizations (labs in industry and academia) are restrictive, the career opportunities in professional biology are depressing and scant, and engineers and programmers in the technology

industry have few ways of easily acquiring the expertise to break into biotechnology short of going back to school. For instance, one lab founder describes to me how he perceives problems in both biology education and in professional biology.

> The response from the scientific community has been overwhelming. It's been great. We get probably an email a day from somebody saying 'Hey I want to join' or 'Hey I want to help out' or other things like that from the different events we do around.
>
> Something like that just kind of shows how broken the system is - where it's very much a hierarchy. There is very much a seniority to it. And so for each step along the way we offer a different kind of value proposition that still is from our cohesive message of open access to science.

He goes on to explain that for high schoolers, community labs offer the chance to do hands-on work in science, enhancing their education. For undergraduates, students have the opportunity to actually work on their own ideas rather than doing menial work for graduate students, enhancing both their education and providing a place for them to do biology work of their own. For graduate students, labs can provide a space to create and work in which activities are not dictated by an advisor. Postdocs also can pursue their own work. Professors and biologists in industry can get around the huge amount of bureaucracy required to do a project in a professional lab, and can also pursue their own ideas while preserving their right to intellectual property based on the ideas. He sums up, "Everybody in the system is doing something that they don't necessarily want to do, and I think that is a huge problem." A different experience can be provided both in biology education and in bench work by community labs. In this section, I detail all of the gaps that members tell me exist in their fields and the ways in which community labs serve to fill these gaps. Community labs have developed ways to serve members trying to fix these problems – and in doing so, they have claimed a small place in each of the fields.

The various narratives can be viewed in two ways: as actual descriptions of what community labs do or as rationalizations that members offer to explain why the new organizations should exist and why they are participating. As I note throughout the section, some narratives seem more based in reality than others. Barley and Kunda (2011) note that technology workers who opt to exit firms in favor of contract work often cite reasons like burn-out, a desire for flexibility, a wish to avoid work politics, and higher pay as the reasons they choose contingent work – even when workers did not choose to become contractors. The researchers argue that the contracting work can promote freedom and be a result of choice or that it can be quite disadvantageous. Similarly, community lab members report narratives that make community lab participation sound like a choice – one that promotes freedom. However, the narratives do not all appear to be realistic for all participants. All of the narratives, however, are geared toward attempting to negotiate a place for community labs in the organizational environment. In developing niches within existing fields, community labs claim a small place in those fields. Many narratives also justify resource acquisition.

Though community labs try to differentiate themselves from other organizations, they do establish relationships with other organizations. Labs are related to other organizations through the flow of people, funding and goods, and expertise from organizations like high schools, colleges, industrial labs, academic labs, art schools or studios, suppliers from biotechnology, and more. People from each field work in the community labs, though the types of relationships labs and organizations have vary across organizational fields. Organizations (and people) provide monetary donations, grants, and donation of equipment. Knowledge about biology, organizing, art, and more come to community labs through members who are affiliated with each of the four

fields. In addition to discussing the niches that community labs claim in the four fields, I also discuss how they are connected to organizations in each field.

Education

Of all of the narratives that community lab members offer to explain why community labs are necessary and useful, the narratives around education are some of the most common. Many members at the labs note that biology classes at educational institutions often lack sufficient hands-on experiences for students at both the high school and the college level. Moreover, there are almost no opportunities to learn through independent work for all but the highest level students, usually in graduate school or beyond. Community labs develop a niche in education by offering access to laboratory space, classes, and mentorship opportunities to those who are otherwise underserved.

Community labs are able to establish their niche in education because educational organizations do not provide sufficient resources to students or the general public to do wet-lab work. Schools often lack resources for biology labs. At the primary and secondary education level, schools may lack labs themselves, in addition to the consumable materials necessary to do biology work (glass wear, reagents, biological material, and certainly the more expensive pieces of equipment). At colleges and universities, educational organizations usually have biology labs, but they do not have the resources to open them to all students. Often lab time is carefully allotted to particular projects, and expenses are covered under project budgets that do not have extra room for independent student experiments. Liability concerns may also prevent organizations from allowing students to do projects on their own time. Several students and professionals that I interviewed (discussed in the next section) note that bureaucratic restrictions on projects, which require approval to be done on university property, makes it very difficult for

students to do self-initiated experiments in the lab. The restrictions imposed to protect the organization from legal issues and to ration resources restrict access for most students and restrict the kinds of learning that students have access to through labs at educational institutions. Community labs provide the hands-on lab work that many students are missing, which is particularly helpful for people who learn best through hands-on application. Community labs are able to serve some of the educational needs of students and the public, giving them a niche in the field of education. Providing additional educational opportunities is very widespread in community labs. Many people take advantage of it. Filling this niche is a central goal in many labs. As far as the narratives go, educational supplementation seems to be based on real programs at the labs, not merely talk.

A Different Way to Learn

The executive director of one community lab is a professional biologist and also teaches classes at colleges from time to time as an adjunct. She notes that while an undergraduate education is much deeper than anyone can get at a community lab, it seldom involves much practical experience in lab work because most colleges have few resources for undergraduates. The classes that they offer at the community lab teach practical skills that students will seldom get in a university class. Practicing those skills through work at the lab is one of the only ways that people can really learn to do the necessary techniques well. A cofounder at another lab explains to me that his own experience working in a biology lab as an undergraduate involved almost exclusively washing glass wear and organizing lab supplies. For undergraduates who do want to get their hands dirty, a community lab is a better bet. One subject noted that often students must take years of biology courses before they get to actually do anything hands-on. For

those wishing to explore options, a community lab is a way to see if a person enjoys the mechanics of biology without investing years specializing in it first.

Some of the labs also supplement secondary education. At one lab, for instance, mothers pushed for access for their children, who were unable to get wet lab experience in middle and high school. The lab developed classes and tutoring for kids, and allowed some kids to participate in the lab's gene transformation class along with their parents. Another lab seeks to train high schoolers in biology to prepare them better for college based on a PhD student's observations of undergraduates in his teaching experiences at a university. He explains, "Even when I started teaching undergraduate biology, I noticed that even some of the students from the well prepared school districts didn't seem to be as exposed to some of the things we do in biology as far as hands on experimentation." Through community labs, he hoped to remedy the missing experience. Community labs also provide space and expertise to teachers at the high school level who are trying to develop biology experiments for class. The labs provide both educational opportunities for teachers and also a space in which they can work out experiments to do with their students with help from experts or through classes. Community labs produce development opportunities for biology teachers and provide hands-on education for students in the secondary education system. Serving the secondary education system is less common in labs than offering general classes. Only a few labs allow minors to join as members. A few more allow minors in classes. Only a handful of labs have partnerships with teachers.

Another dimension of hands-on learning afforded by community labs is that it complements learning styles that are often served less well by lecture classes. One man, who is working on a bachelors degree in a science field, tells me that he thinks we have "inherited an

educational legacy that doesn't necessarily satisfy the most curious of us," particularly those who do not do as well with conventional learning techniques.

> Categorically, I'm a person who's interested in DIY because I believe that the way to learn how to master something is to do it yourself. You can learn from books and having people tell you about the subject…but eventually you have to do it. So I'm a big fan of skipping over the whole reading a book and telling someone how to tell you to do it in a classroom and going straight to doing it.

Many lab members agree with his assertion that actually doing rather than reading is universally useful for all sorts of people. Others note that they really learn best in a traditional classroom, which is not replicated well by community labs. Even so, a lab leader states that community labs do not need to fill the need for traditional biology classrooms because existing organizations already do.

The narrative about learning styles seems to be more of a rationalization that people offer when asked what community labs are good for, and it is a less frequently offered rationale than some of the other education-related narratives. No doubt some people learn better through hands-on learning, and many people who come to community labs do learn the physical processes of biology. However, community labs do not, as yet, offer very extensive curriculum. While students may learn more about the physical processes involved in research, it is unlikely that many really learn more about biology than they would in a class. One indication that skipping straight to doing is not wildly effective is that at most labs, leaders tell me that they struggle to get their members up to speed enough in biology for them to be able to do their own work. When those who espouse the narrative tell me what they are actually doing in the lab, they often express frustration at obstacles that they encounter when trying to figure out how to accomplish work or they tell me about getting caught up in learning extremely basic processes but note that they have not gotten as far as they need to in order to do their work. While actually doing lab

work may be a useful tool for learning, there is little evidence that skipping straight to doing has accelerated the learning process for many of the members. For students who have learned in traditional settings, however, the lab space may be a promising supplement for that learning.

Another lab member, Greg, tells me that he thinks that community labs are a good way to learn about biology without having to go back for a masters degree or PhD. He had researched graduate programs, but found them daunting because he had not taken biology or chemistry classes since high school, a few decades ago. He was interested in other ways he might go about learning biology for his entrepreneurial endeavors. At the lab, Greg works on a number projects and helps others learn what he has already mastered in the lab, a feature that he values highly. Everyone in the lab has different backgrounds, so they are able to teach each other different types of things (biology, hardware, software, business acumen) as needed while they are collaborating on projects. He says, "It doesn't matter what you do there. If you are there for 10 minutes or you're there for 10 hours, you're learning. So it's just that kind of immersive environment, which is very different from the educational system." He believes that the environment, which immerses members in biology, is a productive way to learn that is different from universities or high schools. While he might pick the brains of those who have training in biology, they can pick his brains about business (he has had several very successful technology startups) and fundraising. In this way, he feels he can learn about what he needs to in order to do his biology projects in a way that seems more achievable for him and also helps those with biology expertise develop their own new skills. As with hands-on learning, the notion that community labs can replace graduate education seems to be a rationale for participating in the lab instead of undertaking an actual graduate program. Greg has put substantial efforts into learning, and he may well realize his goal of learning enough to create new biotechnology – but

using the lab as a graduate program replacement is very difficult. No doubt, labs do offer an alternative way to learn for people who do not have time to return to school, but practically it is hard to realize the goal of learning at this level in a community lab. Community labs may be more practical for retooling a skill set toward biotechnology, where those with existing expertise in technology can combine that expertise with limited, specific new knowledge in biology.

Community labs also service people who would not seek education from traditional institutions because of financial constraints or time constraints. A typical class might cost at most $300 and last a handful of weekends – a financial and time commitment that is much easier for many to bear. Even should people choose to pay $100 for monthly membership and learn on their own, the cost of participating is much lower than a course at any community college or university. As long as members are able to teach classes cheaply and membership rates can be kept low, community labs may offer limited kinds of education to those who have less income.

Community labs also offer a different sort of experience for teachers who teach in them. One community lab member who leads a reading group and also had taught at top tier universities tells me,

> It's a different type of teaching. It's so much fun. I mean, the type of people that go to these meetings who just, like, show up at [the community lab], are very passionate. And they want to learn something new. And it's different from teaching students who are there because they have to be there.

She adds that having students who are enthusiastic and self-motivating is really motivating, and it keeps her be engaged and enthusiastic. There are, of course, limitations – like students constantly cycling in and out so that it is difficult to strike a balance between exploring something new for the group veterans and keeping the new students in the conversation. As a teaching experience, however, she finds community labs to be invigorating.

Relationships with Educational Organizations

Thus far I have discussed the niche that labs have carved out in the educational community – the kinds of education that they provide that fill in the gaps in the biology education offered by traditional institutions. However, the relationship between labs and education is not just in the niche that the labs have developed. Community labs are also networked with educational organizations in a variety of ways, which connects them more directly with the field of education.

Community labs are connected to educational organizations through the flow of resources, even in the absence of formal ties. For instance, community labs almost always include students from local educational organizations, including universities, community colleges, and sometimes high schools. Community labs also often include professional scientists who teach at universities or community colleges. Through the personal connections of members (including these members who are connected to educational organizations), community labs often receive equipment from university labs that are updating their equipment. Most of the community labs reported receiving donated or very reduce priced equipment from either university labs or industry labs.

Community labs are also more formally tied to educational organizations. Multiple labs have working relationships with the local school systems, including partnering with teachers to promote community lab classes, partnering with the school system to provide access to students, and including members of the school system on the community lab's board of directors, in a few cases. In some cases, universities also provide lab board members (one lab had board members from both the education department and the biology department) and partner with a few labs. For instance, one lab funded education programs for underprivileged kids through an NSF grant to a

local university professor. Community colleges in particular have shown interest in partnering with community labs. Several community lab professors have expressed the need for more resources, some of which can be met through community labs.

In a few cases, community labs are networked with unique educational organizations. For instance, Boston's lab is housed within Sprout, a 501(c)3 devoted to science education and outreach. It is affiliated with many schools and universities in the surrounding area, and provides a place for many kinds of outreach including seminars, classes, and learning opportunities led by professional scientists. The lab in Boston, which is less active than many and hosts few classes, is thus networked with many educational organizations through its contact with Sprout. Though Sprout is not a part of the main educational apparatus (universities, primary and secondary school systems), it does have a certain legitimacy as a collaborator with such organizations.

Summary

Education at community labs does not replicate the same experience as established educational institutions. The scale of instruction, the time put in attending classes, and the types of topics that they address are very different. However, community labs have established a niche in biology education by providing opportunity and hands-on exposure to biology knowledge to members of the community – both those involved in traditional biology education and those who are not. They offer a way for community members to explore biology and gain expertise through instruction. While the education is on a lesser scale, community labs also do it for less money and without restrictions on who can attend. And these classes, though providing fewer instruction hours and thus less overall instruction, require less time commitment from those who have less time to spend or who wish to dabble more casually.

Professional Biology

Labs have also developed a set of niches and connections in the field of biology, enabled in part by pressures in professional biology over the last ten years. Beginning in 2003, the real increases in NIH funding for research in biology ended and spending began to fall behind inflation (Federation of American Societies for Experimental Biology 2015).[57] Additional pressures were added in 2008 with the great recession. The amount of funding available for the number of trained biologists has fallen, causing sharp declines in the rate of approval of funding applications for professional scientists (Alberts et al. 2014). In addition to decreases in revenue, the way that science has traditionally been structured creates an oversupply of qualified biologists to supply the demand of academia, government, and industry; professional biologists rely on the labor of their graduate students and post docs, incentivizing the training of vastly more scientists than are needed to replace those that are employed. As Alberts et al (2014) explain, the current system of biology produces an oversupply of scientists competing for limited opportunities, which creates hypercompetition that is unattractive to many in the field. The average PhD recipient in biomedical research begins her first tenure-track job at 37, after years of post doctoral work (Alberts et al. 2014). Hypercompetition and funding restrictions also limit creativity in research because the system favors guaranteed results rather than risky but potentially break-through projects (Alberts et al. 2014) One professional biologist who founded and runs one of the community labs describes how the circumstances in industry biology led her toward participation in a community lab.

> Unless you're working on really cutting edge, well-funded research, it's not that much fun out there right now. Funding is very competitive. Only 10% of grants get funded. You can't really explore very much. You have to do what you promised to do in the grant or it won't get renewed. And there is a great deal of

[57] Funding has been increased in the 2016 budget.

> pressure to get results. You know, universities don't have a lot of funding so most professors are on soft money. They need grants. And in industry – the job market is very tough in industry right now. There are a lot of people graduating and looking for jobs. There are a lot of companies that have downsized.

In 2010, the subject was laid off because of downsizing due to the recession.

> It didn't make any sense to me to start looking for another job right away, and I started having a lot of fun doing the [community lab] stuff. And also, you know, you get to a certain point in your life and you figure you want to make some sort of a lasting change for the good, and it just seemed like being another brick in the wall of biopharmaceutical research – it's very rare when you get to participate in something that's really ground breaking. Most science is pretty much just adding a little bit of knowledge to the database.

Professional science was not fun to her anymore. It was stressful. It did not live up to her notion of what she thought science would be. Though some might hope to make big discoveries in labs, for her, labs were not really about this either. A community lab would be a place where she could at least have fun again.

Those professionally trained scientists who begin working in community labs report that they do it for three reasons: they lost their jobs in the recession and are unable (or unwilling) to secure a new one; they are disheartened by the career opportunities in the field and they opt out of traditional paths in favor of trying to make their own way; or they seek a place where they can do the creative, exciting kinds of research that they often cannot do in their professional settings. Of course, it is difficult to tell the degree to which the narratives are post-facto rationales to explain how members ended up in the lab. Several noted difficulty in the job market. While they might frame the option as a choice, in many cases they may be rationalizing the choice to do work outside of a typical organization. In addition, the narratives that they offer vary in the degree to which they are practically realizable given the limited time and supply resources in the labs. Practically, the labs likely appeal most to professionals who have issues with institutional

labs (like unemployment or politics). Still, community labs clearly seem to be filling a gap for professional scientists. Working in community labs allows them to pursue biology research on different terms, though labs seldom provide the income necessary to support scientists.[58] Some live off of savings. Others cobble together income through teaching or other jobs and pursue their biology research in their spare time. Still others attempt to crowdfund or acquire grants to support themselves. Some are still working full-time at their professional labs, but use the community labs in their spare time to pursue different goals. Below I explore the niches that community biology labs serve for biologists from industry and academia who choose to work there. I then describe how the labs are networked with the professional biology industry.

Members of community labs seldom network through means used by professional biologists. They tend not to have access to professional conferences and do not present at them. They also are not able to publish in scientific journals, which makes it difficult to do reputation building and knowledge dissemination. In part, the lack of ability to participate in conferences and journals may be because they are not doing the right kind of original research. It also likely results from the scientists not being affiliated with recognized science institutions. However, community labs do establish relationships with professional biology organizations.

Unemployment Problem

Like the founder described above, many members with professional biology backgrounds who make their way to community labs do so because of unemployment. A leader from one of the hackubator labs tells me that they receive resumes and requests from people looking for part-time work with the companies in the space regularly. In part, it is the nature of the workforce in the particular location. There is a lot of biotech near the lab, and those businesses have been

[58] Scientists and entrepreneurs do sometimes receive grants or investment but not on the scale that scientists might within professional labs.

affected by the recession. "We've just become the refuge for the underemployed, or everybody is getting laid off. I'm not sure how we bootstrap our way out of this!" he says with a nervous chuckle. Underemployed or unemployed scientists are common to many of the labs. A few turn to the lab as a way to keep their skills sharp for when they are able to reenter industry. Others decide to take up entrepreneurial endeavors. Many do both of these and also teach classes at the lab for a small amount of income as well. Community labs have developed a niche as a place where some of the surplus of trained biologists can go to do bench work. The majority of the labs have some unemployed or underemployed professional scientists, particularly those in California. Some have many.

Make Your Own Postdoc

While many community lab members have become unemployed, other professionally trained biologists have actually opted out of academia or industry intentionally. While I heard the unemployment narrative most from biologists in their 40s and 50s who had been employed at some point in professional settings, the opt out narratives tended to come from much younger PhD recipients. These men and women received their PhDs during the great recession from December 2007 through June 2009 (Public Information Office n.d.) or just after and entered a job market that was particularly bleak. Several of them told me that they were still excited about the science and they want to pursue biology, but they found themselves severely disillusioned with their career prospects. Bob,[59] who received a PhD from a top program, told me how he came to eschew a traditional science career path in order to make his own alternative career path out of a community lab. He says:

> Without sounding too much like a jaded graduate student – so I was looking around and as I got towards the end of my – once I transitioned to a senior grad

[59] Pseudonym

> student, I was looking around at like career prospects and it kind of scared me – terrified me. In biology, you basically have to do a postdoc – at least one, if not two or three. And then you have the opportunity to apply to a faculty position that everyone else is applying to for this mythical thing of tenure that I, and this is my opinion: I am of the opinion that tenure is dying or at least radically changing. And I was not very comforted by the prospects of what I was looking at. About that time [the local community lab] and the whole DIYBio proper came onto my radar and I thought, "Oh, this seems interesting." And if it's going to succeed anywhere, it is going to be in a place like the Bay Area, where you have a critical mass of people. Where you have people thinking about very innovative and exciting things. And so, what I did, kind of consciously made the decision of "I'm going to forgo doing a postdoc."

He also noted that the postdoctoral researcher at his graduate lab had been doing the postdoc longer than Bob was a graduate student because the job market was so tough. Bob decided that he would make his own postdoc, on his own terms, using a community lab space. He got a job elsewhere to pay the bills, and gave himself a year to try to do some research on his own through the lab. Bob notes that the community lab is "definitely not an academic lab, definitely not an industry lab, definitely not perfect. But it's new and exciting and people I've met are very worthwhile." He notes that the members are more diverse than in a university lab. While universities try to foster interdisciplinary work by having departments cohabitate, he believes that the community lab are able to this more easily and more successfully for way less cost.[60] In particular, Bob has found it really helpful to be around people with software/hardware experience. Bob also tried to make some money teaching classes at the community lab, but found that there are not enough people taking classes at a lab to support him full-time. He continued working his full-time job.

Making his own career path is not without its own stress. Bob laughs nervously as he explains, "I am acutely aware of this, potentially, being a horrible, horrible career move, and I

[60] At least, he felt he had much more contact while working with people from different fields in the community lab setting than in his previous academic setting.

feel a fair bit of pressure trying to make something happen out of this long term, sort of career success." Bob also notes that now that he has been out of academia for nearly a year, he realizes that marketing oneself professionally is built in to the academic setting, but it is difficult at the lab. They do not have the infrastructure at the community lab for self-promotion that is institutionalized in academia (publishing papers, being on grants, attending conferences).

While the lab has additional limitations on how easily projects can be accomplished, Bob finds that his outlook on the future has improved.

> What I've done, essentially, is flipped what happens. Because in the academic and to a lesser extent, the industry setting there was an army, for better or worse, of PhDs and postdocs fighting for a very small number of faculty positions or research positions. Now I'm in a space where my technical expertise is in high demand.
>
> The career prospects left me incredibly depressed, and now it is completely flipped. It's now much more exciting. It's now much more engaging. I'm able to collaborate with a lot wider range of people in different expertise. And I'm also able to help direct and help lead things.
>
> To me, implicit in the academic model was, you know, you work your butt off as a PhD student, a grad student, and even the first part of your faculty position, and then you get tenured, right, and then you can have a life.
>
> You hold off on all of your ideas – all of your crazy, out of the box innovative ideas, until you get tenure, and then that's when you can do these crazy things…I don't have to wait! I can do it now![61]

Community labs are able, for a few scientists, to offer an alternative option to use their degrees. In Bob's case, he was eventually able to crowdfund a project that kept him employed for a few years. He also adjuncts at a local community college.

Bob is one of the few people I met who intentionally tried to create his own postdoc. However, several other disillusioned young PhDs told me that they were also tired of academic

[61] It is true that members of the labs are unusually free to pursue project without the red tape or external pressures of academia. Of course, the reality is that they are much more limited by resources.

labs and were looking for alternatives. Often, they were dabbling at the labs as part of the search for alternative employment. It is difficult to know the degree to which they chose to do this and the degree to which it is the result of underemployment and unemployment. For many, the alternative career path narrative may be a rationalization to help explain their current career trajectory. Not all people who try to make community labs work as a career option are able to do so, but several that I have tracked over the last few years have managed to keep themselves afloat on projects or become part of startups either emerging out of the spaces or with people who they connected with through the spaces.

Community labs have managed to create a small niche in biology for biologists who are not employed. The degree to which this narrative is truly viable is not clear. Though the labs are probably effective as a space to incubate early ideas for biotech,[62] the lab seems to be less viable for basic research or replacing an academic career. They do not have reliable income flows, struggle with cleanliness, often are missing the latest and most expensive equipment, and do not have the same access as professional labs to journal articles, conferences and publishing opportunities, or legitimacy as a scientific career path. It is unlikely that community labs will ever provide a significant outlet for the numbers of biology PhDs exiting professional biology organizations. But for the community labs, the availability of these professionals seeking lab space and a community is vital. Scientists that have been laid off and professional biologists that choose not to work in industry and academia provide the backbone for many labs. Sometimes they are founders, and always they are important in advising the less expert members of the organizations on biology. None of the organizations I have come across could exist without a handful of professional biologists at least participating in their spare time. Many of the

[62] Indeed, there have been several successes on this front.

organizations depend on scientists who have more than just evening hours to devote to the spaces. The niche community labs have developed for the underemployed serves a small number of professionals, but exploiting that niche is central to the labs.

Freedom and Intellectual Property

Community labs have also developed a niche as an outlet for fully employed professional biologists who have a different set of reasons for wanting to do experiments outside of their professional institutions. Employed scientists sometimes seek freedom to pursue projects that are not supported at their professional organizations. They say that they believe that the freedom to tinker with less commercial, more uncertain experiments is the key to reinvigorating creativity. If they are going to pursue projects in their own time, they also want the right to own their work – something most do not have if they do the work in their professional lab spaces. As Alberts et al. (2014) note, hypercompetition and dwindling funding for science provide incentives for professional labs to pursue the projects that are the most certain to yield results rather than the projects with the most interesting long term potential (but more short-term risk). Professional scientists who are doing side work in community labs tell me that they feel a lack of freedom and creativity at their day jobs, as did the woman quoted at the opening of the section. Another scientist agrees, "In academia, it's very focused on something that's going to be high impact or whatever, and I feel this limitation on just odd, cute quirky fun things. So that I really love [about community labs]. It's a whole other space of thinking." Creativity, many of the members believe, comes from being able to dabble more freely, without worrying about achieving something publishable or marketable. Community labs are a place where this seems more likely to happen both because they do not have to deal with the bureaucracies at their professional institutions and because the atmosphere of the lab makes them feel more open to trying more risky (in terms of

results, not danger) projects. Of course, limitation of resources means that they cannot pursue any but the cheapest ideas.

Scientists also sometimes run into red tape at their professional organizations that make them search for new places to do projects. One community lab founder wanted a community lab because he found politics at his community college were stifling, and he was having trouble getting college administrators to approve the college hosting an iGEM[63] team one year. Frustrated at the bureaucracy, he decided he wanted another place to work on biology that would be more open to atypical activities, like allowing students time in the lab to work on an iGEM project. Another biologist's project was rejected at his organization, which had a previous experience with a genetic engineering project that had not gone well. They subsequently would not allow any projects in that area of biology, so the member used a community lab as a lab space for the project he had devised.

Several scientists and graduate students using community labs noted to me that they were pursuing projects that they could not get funded through professional organizations. A member explains, "They find the intellectual property issues at their schools can be too onerous, and they'd just kind of like a neutral ground to do science and to do entrepreneurship." Instead of using their professional labs, they opt for using community labs for their off-hours, unfunded work. "If you're paying for your own research costs, you shouldn't be giving the IP [intellectual property] to your university," they explain. A similar rationale is also a popular reason that some programmers use hacker spaces.

Community labs are able to offer lab space that can be used for purposes that scientists cannot use their professional spaces for like being able to avoid departmental politics, freedom to

[63] The International Genetically Engineered Machine competition, discussed further on page 254.

do lower impact or less certain work, a place to take on projects that they believe in but cannot get funding for in a competitive grant market, and a way to maintain rights to their own intellectual property for work that they are not pursuing under the auspices of their professional institution. Community labs have developed a niche as alternative labs that give professional scientists control over their work that is not possible in the current professional settings.

The narrative that freedom will lead to creativity in the lab seems to be more aspirational than practical. Though scientists do sometimes pursue projects that they have been wanting to do at their professional organizations, few of these projects have yielded significant results. It is not clear that scientists have the resources at the community labs to do many of the projects that they might want to do, but it is clear that they would like to develop these spaces to have the capacity to serve more fully as alternative lab spaces.

Niche for Amateurs in Biology

Community labs have also developed a niche in biology for amateurs not just to be educated in biology but also to participate and do lab work of their own. The sections below on art and technology elaborate some of the ways in which the lab is important for biology amateurs from these fields. Important here is the notion that community labs enable many more people to have access to biology work. A college dropout with a passion for biology explained his frustration to me at trying to gain access to a lab in which to try some of his own ideas: "The catch-22 is that if you want to do science you need to get into a lab, and if you want to get into a lab, you have to have skills - and you cannot gain skills to get into a lab unless you're in a lab." Community biology labs are one of the few access points to do independent lab work for those who are not professional biologists. Interestingly, after he gained some skills in lab work through intense participation in a community lab, the subject was able to start working in a professional

lab as a volunteer technician and later as a paid technician. Still, while lab technicians may be able to gain access to biology labs, few of them will be able to pursue independent research in the professional lab context.

Professionals in the space note that amateurs are limited in what they can do in a community lab, and so are professionals. For the time being, one member tells me, community labs are not data-gathering powerhouses "like a university where you can afford your $300 mill mass spec machine" or "a lab with 50 post docs all focused on one problem." The interests of members are too eclectic. Another member explains that biology is a niche science, where people specialize in specific systems in specific organisms, which makes collaboration in the community lab sometimes challenging for even professional members.[64]

Though amateurs are limited, professional scientists also note that some very important but simple work could potentially be accomplished in community labs over the next few decades, and amateurs will probably contribute to the work. For instance, a professional describes to me his vision of where biology is likely to be important in the coming decade. Many manufacturing processes could be improved using basic biological engineering that does not require massive innovation. These sorts of projects will take intelligence and creativity, but will still be doable by a lot of people. The work will not require big theoretical breakthroughs at which professional labs may be more adept. Instead, much of this work will be more akin to quilting – that is, applying known processes through manual labor that does not require a high level of research skill. Community labs may be one way to harness less expert biology enthusiasts into doing this basic biology work. Only a few labs are pursuing the niche for amateurs doing basic work. At a few labs, specific professional scientists have farmed out basic

[64] More on perceived shortcomings of amateurs on page 268.

tasks on their own projects to nonprofessionals in the space. A few other labs have group research projects that harness the participation of amateurs. For example, at Genspace one of the scientists who helps lead the lab has collected plant samples from Alaska. During regular "Open Barcode Nights," members of the lab and the public can help to process the samples and add the knowledge gleaned to a database.[65] The DNA barcoding technique is a way to help develop taxonomies and many plants have not yet been sequenced. Biology enthusiasts with low levels of expertise can assist with the process, helping build scientific knowledge while using very basic processes. Several labs have started projects that are similarly geared toward engaging members in contributing to science in small ways. For many other labs, the possibility of using nonprofessionals to add to the scientific body of knowledge is currently an aspiration (and a justification for continuing to run the labs).

Relationships with Organizations in Professional Biology

As they are with educational organizations, community labs are connected to a range of organizations in biology in indirect and direct ways. One of the big ways is through donation of equipment and supplies. Several community labs told me they either received donations or bought equipment cheaply from biotech companies that were going out of business. A few labs also acquired equipment from companies that were upgrading, like a therapeutics development company, a biopharmaceutical company, a scientific equipment vendor (who donated all of the equipment, reagents, and supplies), and a few academic biology labs.

At least two of the labs have partnered with Assay Depot, a "pharmaceutical marketplace for life science research services," that states on its website that it seeks to revolutionize how pharmaceutical research is done by helping connect researchers to suppliers

[65] See http://genspace.org/project/Alaska%20Barcoding%20Project

(www.assaydepot.com accessed 11/2/15). Assay Depot and each of the two labs that it partnered with hosted an "Open Science Challenge" where winners who submitted ideas for research projects received $5,000 in funding and a year's paid membership in the community lab. At BioCurious, much of the prize money was required to be spent on services provided by Assay Depot. Kevin Lustig, the CEO of Assay Depot, also went on to help found Bio, Tech, and Beyond, the community lab in Carlsbad, CA.

Several community labs have members of the board who come from professional biology including either biotech companies, life science companies, or academic labs. They often serve as safety officers on the boards as well as advisers on projects. Informally, community labs are linked to many university labs and biotech companies through membership in the lab by employees, but, of course, this kind of affiliation is seldom an endorsement, particularly given the fact that many of the members of the community labs are there because their professional labs cannot meet some of their needs.[66]

One lab has managed to become affiliated with local professional organizations. The lab partnered with a local association for biomedical research to host a summer camp and also received fundraising advice from them. A member of the lab even spoke at the association's fundraising gala. The same lab also received support from a global biomedical and biotechnical association, which helped raise awareness about the lab's work and helped its organizers to network with groups that gave them equipment. Of the labs that mentioned affiliation with local professional biology associations, two of them were geared largely toward outreach and education. A third was a hackubator, which was a member of a local biomedical and manufacturing association. I believe that the first two were affiliated because they were a kind of

[66] Though some of them are there because they enjoy the outreach component of participation.

outreach activity for the associations and the third was affiliated because its leaders wanted to be part of the biomedical and manufacturing industries in the area to network their members with those organizations.

Community labs also have to network with the same suppliers that are used by professional biology labs. Only a certain set of suppliers can provide certain types of chemicals and strains of bacteria. Since they are not professional labs, sometimes community labs have difficulty getting suppliers to ship to them. Usually they have to undergo questioning by the supplier about what sort of organization they are and what they do with the supplies. One member told me that they had to send in pictures of their lab. Many also told about safety procedures. To my knowledge, none of the labs has been unable to create a relationship with a vendor, but some had an easier time than others. Individuals cannot order from these vendors, so the lab itself must handle supply ordering.

Summary

Community biology labs have developed a few niches in the field of professional biology in response to circumstances affecting industrial and academic biology labs. Community labs provide alternative places to pursue biology for those unemployed in the recession, provide alternative career paths for those disillusioned by the tough biology job market, and provide a place for biologists to pursue intellectual freedom and maintain rights to their own intellectual property for projects pursued on their own time. Community labs were able to develop these niches in response to current circumstances in professional biology including a recession that has closed many industry jobs, a decrease in science spending and perverse training incentives that flood the market with PhDs that outnumber available positions, and an incentive structure within academic organizations that prioritizes the pursuit of certain projects but not others.

Though community labs are unlikely to make a large impact on professional biology, the state of professional biology has made a big impact on community labs. The recession has afforded a surplus of cheap equipment from failing businesses, and cheap equipment has afforded lab building. In addition, the recession freed up professionally trained biologists for membership in the lab. Professional scientists turn out to be important assets in community labs. One community lab member asserts that she thinks a successful lab must be seeded with a certain number of professional scientists because they tend to be the people who make the most successful projects, who teach classes, and who mentor the less experienced members in their projects. Professionally trained scientists bring with them important skills that they can impart to the other members, and so the ready availability of them in the last ten years to pursue unconventional spaces like community labs is likely a vital component to the success of these early labs.

The recession has now been over for a few years, but the oversupply of biology PhD's continues to create hypercompetition (Alberts et al. 2014), and professionals who found themselves unemployed during the recession and recovery may find themselves competing with fresh PhDs for any new jobs that appear. Surplus and disillusioned scientists will likely continue to be available for community labs for the time being. Fewer biology businesses are closing than were closing during the recession, which may make cheap and donated equipment harder to acquire. However, community labs also receive old equipment from professional labs that are upgrading, so a better economy with more money for lab upgrades may still include ample equipment access.

Art

Community biology labs serve a niche community in the art field – bioartists. Bioartists are artists who use biological material as their art media. Artists at community labs have worked on quite a variety of projects. One woman took hair samples from public spaces and created reconstructions of faces based on the information that could be extracted from DNA. She wanted to draw attention to the amount of data about ourselves that we leave in public places.[67] Another bioartist developed a biofuel cell battery that was meant to make people want to care for their "friendly energy" source.[68] A third grew art in Petri dishes aimed at highlighting the complex patterns that bacteria create as they self-organizes.[69] Each of these artists required access to biology equipment and lab space and expertise.

Community labs serve bioartists in part through education. Bioartists often need to learn basic techniques in order to do their art. Community labs also provide bioartists inspiration through immersing them in a biology lab and a scientific way of thinking. One artist described this way of thinking as the "visual language" of biology, which is often what bioartists want to comment on with their work. Most importantly, community labs provide bioartists with much needed access to the tools they need in order to do their art. In the art field, community labs fill a very particular niche. In both education and biology, community labs fill niches that are lacking at the heart of the fields: access to education for a wider variety of people, alternative work option, and freedom over projects. In art, however, community labs are more like a tool for a specific set of artists. They do not solve a problem general to the field. They provide resources to artists working with particular media.

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[67] See http://deweyhagborg.com/strangervisions/
[68] See http://cargocollective.com/nelramon/BactElecTric-Master-s-Thesis
[69] See http://www.nuritbarshai.com/objectivity/

Guidance

Bioartists in community labs nearly always reported to me that community labs were helpful places for them to obtain guidance in their projects. A bioartist as one of the larger labs says of professionals, "Show me which are the right paths and I'll walk them, but I need your headlights." Many of the bioartists in the labs have transitioned out of other areas of art (largely computer, media, hardware, or technology related art) and know very little about biology. While they have no trouble coming up with ideas, they often have no understanding of how to approach growing, engineering or building their project. "I didn't even know what I needed to know to do the project," explains one bioartist. Classes to learn techniques and then more expert members to provide advice and help troubleshoot become an important resource. A bioartist explains the sorts of trouble she had when she started trying experiments in the lab.

> You don't know how to debug things. An experiment fails. Why did it fail? And how do you even set up a proper experiment? You know, when I did my first experiment, I didn't have any control! And [one of the professional scientists giving her advice] was like 'A control!' and I was like 'Oh, a control! I remember from 8th grade.' You know, there are just all these things you don't think of.

Artist get help assessing which articles to read, understanding what articles mean, troubleshooting projects, and evaluating what the most promising paths are to follow in their projects. For some bioartists, help with these issues was the most important part of working out of a community lab.

Unconditional Access

Community labs also provide much needed access to lab space for artists. Bioartists encounter similar issues to nonprofessional biologists when it comes to finding a place to do wet lab work. One bioartist told me that she went looking for benches at local incubators, but the prices were prohibitive. She could not get into any other labs because she did not have biology

credentials. Other artists also report difficulties trying to find space. One, who had started a graduate program in art at a university, was trying to gain access to a biology lab on campus. "It really makes me appreciate how amazing [the community lab] is because I've been trying now for, like, two months, to get into the biotech lab here at [the university], and it continues to be, like, this administrative and bureaucratic struggle." She had spent a lot of time negotiating for access. When they finally decided she could do it, there was a lot of paperwork and she had to take a test. Funding and supplies turned out to be a special challenge too. "At [the community lab] you go there and everything is there. The pipettes are there. The tips are there. The gloves are there. Here [at the university], each grad student, each professor brings their own stuff that they have from their own grant. I don't have [that]." At the university lab, she must figure out where to get her supplies, and how to pay for the fee for using the lab, which is usually paid for by grants when the biologists use the university lab. Her art department is not set up to pay lab fees within the university. The fee for the university lab access turns out to be higher than what she would pay at the community lab she had previously been working in, and she spent quite some time considering a multiple hour commute so that she could do her projects in the community lab. Many bioartists that I interviewed reported similar reasons for seeking out community labs. They are affordable, and they are open to artists.

Moreover, community labs provide access that is not conditional on the scientists in the lab approving of the project. One artist who does work that is often critical of biology ethics explains her experience at community labs:

> As biologists go, [the biologist at the community lab] are incredibly open-minded. And, I was shocked when I went in and went to talk about the project. I was like 'Uh oh, I hope that they don't get offended or concerned, or something like that.' Because I've spoken with other – you know, I've tried to work on this project in the Netherlands. And I was in these lengthy discussions with scientists in a genomic center there, and there were lots of concerns that those scientists raised.

> And basically they wanted me to change the language of my proposal, and all of this stuff, which was pretty concerning to me as the artist. And so when I went to [the community biology lab], I expected to encounter the same thing, and so originally I was trying to temper my language a little bit. But they were totally open to it. You know, [the scientist cofounders] are just really open-minded and really interested in the critical aspects. And I think that's how they end up forming a place like this. Because they are more open minded than a lot of other scientists.[70]

Other artists expressed similar concerns about their interactions with biologists. One told me that every time she encountered a scientist, it was always as the scientist as the instructor and the artist as a recipient of knowledge. She liked that at a community lab, she was not treated as a lesser expert. Even when she got advice from professionals in the space, she felt like she had control over her project and that she was respected and allowed to make her own decisions.

Connections to Art Organizations

Community labs are networked with art organizations in a few ways. They occasionally receive funding, for instance. At one lab, a member collaborated with a professor at a major art school who had received project funding from the school. Community labs receive little equipment and not as many donations from art organizations as they do from science and education organizations, however. While community labs tend to receive experts and expertise from educational and scientific organizations, community labs actually provide expertise to art communities. Some of it is done through mentorship of artists as described above. However, classes are offered by lab members for local artists at several labs. At one lab, members who taught at the lab also taught biology courses for art departments at two different local art schools.

[70] The artists who noted this imbalance of power often were concerned about scientists shaping the message that the art was meant to evoke. This was particularly concerning to artists who may be raising ethical questions about genetic engineering or DNA research, though it was concerning to all artists because their point of view is so central to their work.

Community labs have also organized art shows at local galleries and hosted an array of lectures from bioartists.

Technology

Community labs have developed a niche in the technology field geared toward providing access and knowledge, similar to the niche they have developed in the art field. The labs have become a refuge for members of the technology community (programmers, engineers, and hardware builders) who want to transition into biotechnology. Programmers and engineers are able to take advantage of the niches that community labs have formed in education and biology bench access in order to transition into new career opportunities. Community labs also serve as particularly cheap spaces from which to launch biotech startups.

Transitioning to Biotech

Programmers and engineers seldom want to return to school in order to transition from technology to biotechnology, perhaps a sentiment that results from being a part of the programming and engineering fields, which require constant learning and adaptation and involve quicker learning opportunities like boot camps and certifications as common ways to become proficient in new areas. Though a few of the programmers and engineers who become part of community labs are unemployed, most of them are learning biology or pursuing projects in their spare time. Most often, they believe that biology is the next big field of economic growth, and they want to become proficient in it so that they can be part of that growth. Community labs are a place where they can take classes and have hands-on experiences, as well as work on project ideas and develop their skills. Some programmers and engineers have developed hardware in the community labs to support biology work.

Cheap Startup Space

Programmers and engineers (and trained biologists, as well) find community biology labs to be very cheap options for bench space for launching companies. A founder of one of the hackubators explains, “Everyone views R&D as a cost. From our perspective, I think we're the most efficient way of doing that given the kind of overheads we have. It's pretty incredible that we can support the amount of research that we do on this limited budget.” Many of the startups that have launched out of community labs are technology related and run by people with technology backgrounds (though the other half come from trained scientists seeking alternative career paths). The startups that are technology related most often focus on developing innovative equipment to bring down equipment costs and make biology even more accessible.

Connections to Technology Organizations

Community labs are affiliated with organizations in computing, hardware, and other technology areas in a few ways. The majority of community biology labs have links to hacker spaces. Some started out meeting in hacker spaces. Others used them as models for founding the lab. Several community labs were founded by people who had previously founded or worked at hacker spaces. Many have co-hosted events with hacker spaces. Local hacker spaces may be the most common affiliation that community biology labs share.

Community labs individually have a few other affiliations with organizations in technology fields. Autodesk, a software company, sponsored Genspace’s 2013 “Summer Synbio Program” (Summer Synbio 2013), which included grant money for several projects. As mentioned in the opening vignette, BioCurious is affiliated with a somewhat atypical educational organization, Singularity University. Singularity University is founded on the notion that man and technology will eventually merge, and it is really run by members of leading technology

companies, not people typically associated with education. Many of its activities (classes and workshops) are well attended for large sums of money by CEOs and others in the tech field (including Google and NASA employees), and it tends to focus on the cutting edge of technology (Vance 2010). Singularity University is geared toward post-graduate education through specific short-term courses. Though it calls itself a university and draws from many well-known professionals in the tech field, it is not an accredited institution. BioCurious, and likely Counter Culture Labs and Berkeley Biolabs, are connected to Singularity through shared members and crossover of teachers. In Silicon Valley, affiliation with Singularity University may be helpful in drawing positive attention from the tech elite, but it may not drawn positive attention from education organizations. Members of software companies and engineering companies seldom sit on the boards of community labs, but members of biotech firms sometimes do.

Additional Relevant Organizations

Community labs are networked with organizations in the four fields described above. They have developed niches that situate them in gaps that members perceive to exist in existing fields. They differentiate their organizations from existing ones through narratives and action to comply with many of these narratives. At the same time, they claim membership within the four fields, though in slightly different ways. However, there are a few more organizations and relationships outside of these four fields that are important to understanding the context in which community labs are situated.

iGEM

The International Genetically Engineered Machine (iGEM) Foundation has been a shared focus of many (but not all) community biology labs (see http://igem.org accessed11/2/15 for

more information). Each year iGEM hosts a competition in synthetic biology in which each team is given a set of standard biological parts with which they must build something to improve the world. The standardized biological parts, called BioBricks, are part of an effort to develop compartmentalized biological parts that can be mixed and matched to make biology easier to engineer in a manner very similar to the way electronic engineering was advanced by the development of black-boxed electronic components. Historically, iGEM teams were required to be affiliated with an institution of higher education.

Founders at many labs have competed in (as students) or advised (as faculty) iGEM teams, and most labs seem to have one or two members for whom participation in iGEM was a big formative experience that got them interested in finding a space in which they could do their own synthetic biology work. iGEM has been tied up in the DIYbio community since the beginning. Mac Cowell, one of the two men who coined the term "DIYbio," then subsequently founded the Boston lab and the San Francisco lab and the international Google group, was a director of iGEM before his involvement in DIYBio. At least one lab was founded explicitly to support an iGEM team that was having trouble getting support at a local community college. Many labs have hosted iGEM teams. Usually teams are made of students from a local college. Lab members provide mentoring on the project and assistance fundraising for the team fees, and the lab provides the space to work. Community labs began to lobby to be able to send teams of their own members (rather than local college students). At first, there was resistance among leaders at iGEM, apparently because the term "biohackers" made the community uncomfortable. However, as labs established themselves, iGEM eventually decided to allow a category of community labs, including any non-academic organizations that want to put together teams.

iGEM is not affiliated with any community labs, but it has been a gathering place for community lab members. Members from different labs often make contact at the iGEM competition. It also has serves as inspiration and a starting point for some members at the labs, who bring from iGEM a fascination with synthetic biology and an interest in accessibility and engineering of biological parts. iGEM is an ongoing focus in at least five labs, which host teams every year or every few years.

Government

The second major influence outside of the four main fields is local and federal governments. For the most part, there are no regulations the limit the existence of community biology labs, particularly since most labs take care not to work with biohazardous materials. However, labs do sometimes interact with local governments. For instance, local leaders, who did not care to have do-it-yourselfers in their county discouraged founders of one lab. The founders subsequently chose a location in a different county. When Counter Culture Lab was searching for a location, they did extensive research on zoning laws to determine what sort of building they should have (because it is a lab, it falls into a very specific category of zoning). They experienced relatively positive interaction with the government officials with whom they spoke, though the zoning restrictions did make finding a space difficult.

Sometimes the local government embraces community labs. In the case of Carlsbad, the community lab won a bid for a local building. For $1 a year, they rent the building from the city. The city hopes that the hackubator will draw in companies and help build the local life sciences sector. Unlike Silicon Valley, where local government was less welcoming, Carlsbad does not have a booming biotech industry, so the government is interested in encouraging more, even if it starts out with a new atypical organization.

The federal government has become involved in community labs in two ways: through the Federal Bureau of Investigation (FBI) and through the Defense Threat Reduction Agency (DTRA). Early in the founding of the first community labs, lab leaders were contacted by the FBI, who wanted to check out what the labs were doing and make sure they were not a threat. Many community labs have chosen to inform the FBI when the start up in an area, and one lab member told me that a representative from the FBI showed up at their grand opening to take a look at the space. Most community lab leaders report a friendly working relationship with the FBI. "It's not in the way that most people think when they hear about the FBI, because it's typically known as a law enforcement agency. So this is a group that is trying to be more of a proactive and outreach group," one lab leader explains the FBI's interest in DIYBio. Several times, the FBI paid to fly the leaders in the DIYBio movement to participate in a two-day seminar in which representatives from the labs described the types of projects that they do and the types of safety procedures that they have in place. They then talked through scenarios about how they would handle particular kinds of situations. A leader of one community lab tells me that the conferences were really helpful for the labs. Many founders put a lot of money into the labs, and they do not have the financial means to visit other labs. The FBI conference helped members of the labs network with each other, while also helping the FBI be more comfortable with the labs. In the last few years, the FBI conferences have ceased (the particular agent who had spearheaded the effort moved to a different job), and most of the labs do not appear to have had much contact with the FBI since then.

The Defense Threat Reduction Agency, part of the Department of Defense, is tasked with preventing spread of weapons of mass destruction and planning for how to react in the event of deployment of such weapons. They were also in attendance at the FBI conferences. The DTRA

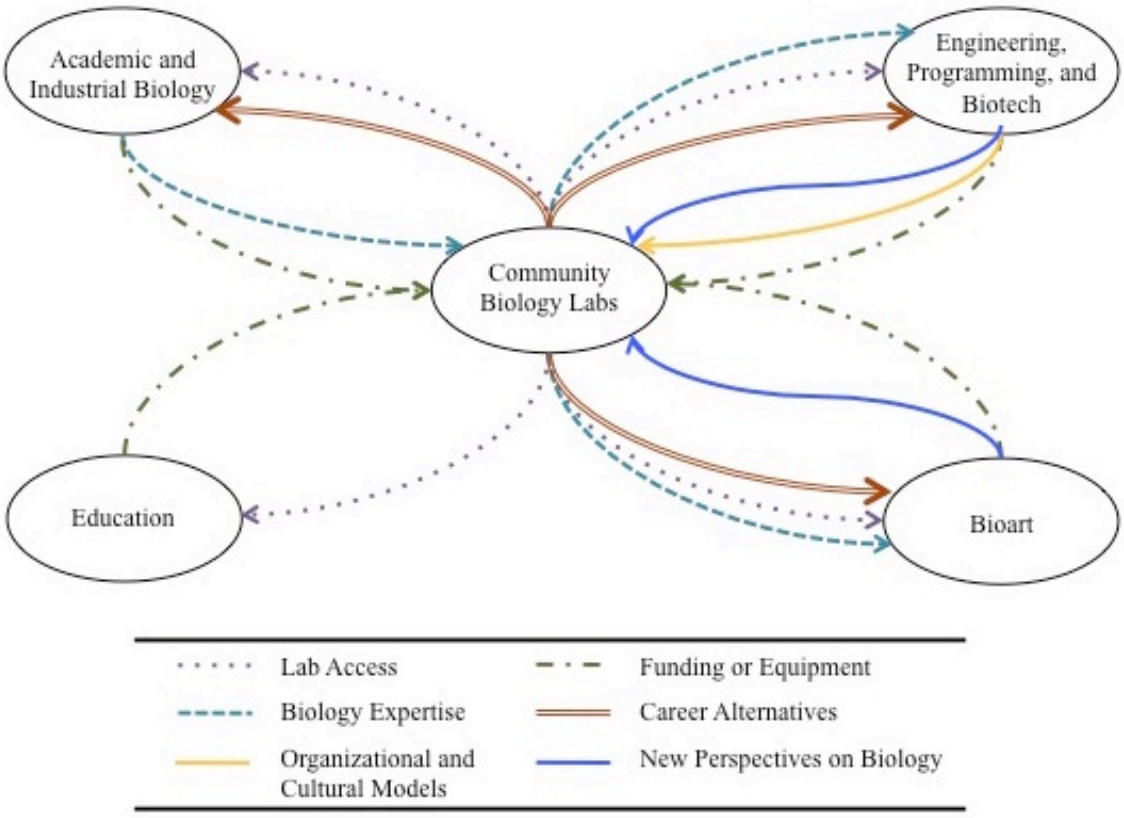
funded several education oriented projects through the grants made with Assay Depot in the open science competitions hosted by the labs, described above. One of those grants was for a project to build a biological sensor for detecting arsenic. Another was an education-oriented program.

Occasionally, representatives from governmental agencies will give lectures at labs when projects emerge that are relevant. For instance, at one lab the FDA and the USDA have given talks. Local and federal government agencies have provided some funding and networking opportunities for community biology labs. They do not provide or take expertise from labs, unlike the relationship that community labs have with the members of a number of other organizations. Labs have not developed a niche in government. Instead, the government interacts with labs in a largely top-down regulatory way.

The Flow of Resources Among Organizations

Resources flow between community labs and organizations in their communities. Different types of resources flow between community labs and different fields, as show in Diagram 1. Community labs provide access for lab space to members of organizations in all four fields, and organizations in all four fields have provided funding and equipment, to varying degrees, to community labs. Biology expertise flows from members trained for professional biology through community labs to engineers and programmers in biotechnology and to artists entering bioart. The labs are a resource for academic and industrial biologists who seek alternative career opportunities. The labs also can help retool the skill sets of programmers and engineers to help move them into biotechnology and artists to help them transition into bioart by providing workspaces and expertise. Community labs draw on organizational and cultural models from the technology field. Artists and those from technology backgrounds bring new perspectives on biology to community labs.

Diagram 1: The Flow of Resources Between Fields



Some of the niches that labs fill are overlapping. They provide biology education to those who would like education without traditional organizations – and some of that education goes to programmers, engineers, and artists. Community labs provide bench space outside of industrial and academic labs, which are used by professional biologists for a variety of purposes, but are also used by people from programming, engineering, and art backgrounds, and by people from a variety of other backgrounds as well. Labs provide access to alternative career options for biologists and also for artists and technology professionals who want to gain the expertise necessary to transition to bioart and biotech. Community labs help transfer biology expertise from professional biology to art and technology and to students in the education system.

III. Aligning, Differentiating, and Laying Claim to Expertise

Developing niches is one way that community labs negotiate their relationship with organizations in different fields. In their narratives, they do a lot of differentiating between labs and other organizations. They do additional work in negotiating their place by attempting to align themselves with other organizations. They sometimes try to align themselves with other organizations in order to become identified with them, which can blur the boundaries between community labs and existing organizations. Below, I describe three ways in which labs shape their external identities by aligning themselves with other fields: 1) they adopt features from professional biology in order to project an image of responsibility and legitimacy (similar to the way that fertility clinics and sperm banks adopt features from medical organizations as a way of promoting legitimacy (Almeling 2007)); 2) they construct narratives that liken their endeavors to the electronics revolution as a way both to understand what they are doing and to project a particular image to external audiences; and 3) they adopt particular categorizations when they file to be nonprofits. Each of these actions shapes the identity community labs develop among themselves and the identity that external entities associate with them.

The attempts at aligning with various organizations can lead to push-back from the organizations, which can lead to differentiation. In order to secure resources, lay claim to a unique authority over science, and protect professional boundaries, professional scientists work to delineate between scientists and nonscientists (Gieryn 1983). In many ways, the recession was an exogenous shock that allowed non-experts a unique way to get a foothold onto the edge of the biology field by freeing up supplies and collaborating experts. This put professional and amateur biologists into an unusual amount of contact. Professionally trained scientists within the lab spend time differentiating community labs from their professional settings by outlining what the

community lab does well and what it does poorly and by explaining how community labs are different from professional labs. The non-biology experts in the lab also spend time differentiating between community labs and professional labs, though they are not defending the boundary of professional biology in the way that professionals do when they speak of differences. Though the defense of professional boundaries can be seen in other contexts, organizations in technology, education, and art seem to experience less tension with community labs, possibly because the labs are already more well-differentiated from organizations in these fields. The degree of tension between community labs and organizations in other fields seems to be dependent on the degree of niche overlap between community labs and other organizations.

Adopting from Biology

In some cases, there are incentives for community labs to align themselves with existing organizations. The opening vignette about the Glowing Plant project illustrates some of the reasons that community biology labs adopt features of professional biology labs. One reason is for legitimacy. Community labs wish to appear to be a legitimate place to do scientific research, not just a place for amateurs and hobbyists. An entrepreneur at one lab expresses this concern, "Most scientists look at us and think we're just playing with toys, so we need to move beyond that and we need them to recognize that we can do real science. It's still citizen science, but it's real science." The desire to demonstrate that community labs can be similar to industry and academic labs has led community labs to adopt safety procedures and ethics similar to those espoused within professional labs.

Members are aware that some scientists, journalists, members of the government, and members of the public who are aware of the labs have concerns about whether community labs

are safe, and they have taken specific steps to associate themselves with the safety procedures common to professional biology as a way to manage these fears.

> If you look at the historical media response to citizen science and DIYBio, it's crazy! People are like 'Oh my god, they're gonna create the zombie virus!' and all kinds of crazy stuff. There was - I feel like that isn't so much the case anymore - there was a lot of public fear around non-PhD individuals practicing biosciences. And I wanted to make sure we had all of the tools in place to be able to assuage those fears.

Leaders of community labs took early measures to help calm the fears by adopting safety measures originally designed for professional biology labs, the Biosafety Levels (BSL). As mentioned in the Glowing Plant example at the opening of the chapter, most of the community labs have chosen to become certified as Biosafety Level 1 labs. BSL protocols were established by the CDC for labs receiving government funding. They specify safe practices for labs at four different levels. For the most part, community labs have adopted BSL 1 guidelines, which stipulate that they will work only with "well-characterized agents not known to consistently cause disease in immunocompetent adult humans, and present minimal potential hazard to laboratory personnel and the environment" (Chosewood and Wilson 2007). They also agree to a set of practices, safety equipment, and facility requirements. A few labs are interested in branching out or have already become BSL 2 labs, which allows work with a wider array of organisms in exchange for a more thorough set of safety practices and equipment. There is an internal debate in some of the community labs about whether community labs should take on the more risky organisms (BSL 2 allows pathogenic bacteria – and though BSL 2 still is not considered super risky, it is more risky than BSL 1).

Some labs (though not most) have also adopted safety review procedures for projects, as discussed by members of BioCurious during the Glowing Plant disagreement at the beginning of the chapter. Professional biology organizations implement review boards and procedures to

ensure the safety of projects conducted within the organization. A handful of community biology labs have decided to adopt either an application procedure that goes to the board of directors or a particular leader, or have instituted a committee that reviews applications for projects in the lab, similar to the way an institutional review board might work at a professional biology organization. Review committees or procedures are less common than adoption of BSL levels, which is nearly universal in community labs.

Notably, community labs are not required to adopt these standardized practices. It is not law. Biosafety levels are usually implemented by professional labs because they are required for institutions receiving government funding. BSLs have been implemented in community labs for three reasons: the hope for grants, the desire to be safe in the lab, and the desire to appear responsible despite the amateur status of many of the members. Other review procedures are also optional, but they are considered best practices within most professional biology labs.

Community labs also attempt to manage liability by adopting BSL measures and project review procedures. If they do everything to the same degree of safety as professional scientists, it is harder to criticize them for being irresponsible or amateur in their way of handling biological research should something go wrong. Leaders at a few labs expressed to me the concern that a single accident at a community lab could jeopardize the very existence of all of the community labs because an accident could lead to regulation that might make it impossible for them to do anything they would want to do. Self-regulation, then, is the answer. “I think it’s pretty clear, mostly from the viewpoint of academic professionals, that some sort of regulation needs to be in place, so at [our community lab] we’ve implemented our own regulations because we’re aware of the need,” explains one subject. In fact, some members of the lab wish to hold themselves to a higher standard of safety than professional labs, perhaps recognizing that community labs may

be subject to more scrutiny and hold fewer resources for defense against the worried public. The debate over the GMO release in the Glowing Plant project is one example. Though GMOs can legally be released into the environment, under many circumstances with very little restriction (Acosta 2014), and industrial labs have produced many GMOs that have been released into the environment via the food supply (Johnson and O'Connor 2015), some members of community labs thought they should hold themselves to a higher standard of responsibility. The Glowing Plant project obtained the necessary approval to release their plants, but debate raged in the lab about whether the lab should follow the letter of the law or whether they, as scientists, should follow a more cautious approach.

When community labs adopt procedures from professional labs, they are not necessarily trying to transgress the boundary between the organizations. Rather, they are trying to minimize risk and acquire resources that might be available to organizations seen as legitimate scientific organizations. However, in doing so, they may challenge some of the boundaries that scientists have used to demarcate science organizations from non-science organizations. They do so because they want to be seen as legitimate science producing organizations and because they seek a way to manage their image as safe organizations. Of course, some of the adoption of these standards may also be the result of 1) the transfer of best practices through the movement of professional biologists from industry and academic labs to community labs and 2) the genuine belief that biology should be done in a particular way, which includes safety procedures and responsible practices.

The Computing Revolution Analogy

In community labs, there is a widespread use of an analogy between the computer revolution of decades ago and the biotech revolution that they envision for the future.

Community labs, they say, are like the garages of old where personal computing was born. They theorize that, as with electronics, biology will become increasingly accessible to more individuals – in part through cheapening of components, in part through the creation of modular components that can be combined and recombined by people with less expertise, and in part by the creation of kits where amateurs can build their own biotechnology. The proliferation of cheap, black boxed parts that can be manipulated by many individuals in their garages and through clubs, as happened at the birth of personal computing, will be the beginning of a biotechnology revolution that will shape the way we interact with the world in profound ways – or so the narrative goes. Participants find the narrative powerful and inspiring. It is something that they believe in and use to make sense of the organizations that they are creating.

In aligning themselves, in many ways, with the software and hardware industries, community labs associate their own endeavors with a field that experienced tremendous success and growth at least in part through the participation of amateurs in their homes. By adopting this narrative, lab members also associate community labs with a successful example of amateurs in technology interloping into a professional domain. The use of the analogy is a discursive strategy that gives people a framework within which to understand what community labs are – a framework that is particularly powerful because digital technologies have become so pervasive. Developing a discursive strategy that positively influences the public's interpretations of new technologies has been shown to be an effective way to make customers comfortable with technological change, as evidenced by IBM's strategy in marketing its first computers as continuous with preexisting adding machines (Kahl and Grodal Forthcoming). By describing a potential radical change in public participation in biotechnology in terms of the familiar and nonthreatening electronics revolution, community labs may be able to influence the public's

understanding of and support for community labs. The analogy helps deflect critics of the labs that are skeptical that amateurs can accomplish any meaningful biological research.

Community biology labs are further aligned with the programming and hardware industry because biology labs have chosen to use as patterns for their organizations primarily hacker spaces and incubators, two organizational forms that are extremely popular for programmers, engineers, and technology builders. Members value open-source projects, a value central in many programming communities. Lab members have also discussed the possibility of offering certifications, a popular practice in the software industry because it allows people to rapidly develop expertise and then acquire a credential to certify that expertise. Each of these similarities reinforces the analogy with the computing revolution.

Official Categories of Nonprofits

Another time one can observe community labs aligning themselves with existing kinds of organizations is when they select their nonprofit category. When an organization files for 501(c)3 status with the federal government, the organization must select a National Taxonomy of Exempt Entities (NTEE) code. In the IRS documentation, organizations are cautioned that the selection of the NTEE code should be done carefully because NTEE codes are sometimes used by donors to identify potential grant recipients (Department of the Treasury 2015). Each of these categorizations begins with a letter under which a whole range of types of organizations fall. The number indicates a particular type of organization.

Of the four labs that have been approved for 501(c)3 status, each lab selected not only different organizational number, but also completely different categories (see Table 17). They fall under the categories: “Medical Research,” “Education,” “Science and Technology Research Institutes and Services,” and “Environmental Quality, Protection, and Beautification.”

Table 17: NTEE Categories of Community Biology Labs

Place	Category
Los Angeles	H92 (Biomedicine, Bioengineering)
Brooklyn	B80 (Student Services and Organizations)
Sunnyvale	U99 (Science and Technology Research Institutes, N.E.C.)
Seattle	C99 (Environmental Quality, Protection, and Beautification)

The labs chose to align themselves in very different ways with education, professional biology and technology. Seattle, which had an artist founder who was quite central, went with environment and beautification. None of the labs chose category W, which is for nonprofits that are "Public, Society Benefit" organizations. The W category contains a subcategory (W24) for "Citizen Participation" and a subcategory (W99) for "Public, Society Benefit – Multipurpose and Other N.E.C." Though these categories might more closely describe the organizations, I suspect being aligned with science and education meant more opportunities for grant funding.[71] Being described as a member of a particular field is a way to align the organizations with resources in that field, particularly for emerging forms, which may not obviously belong to a field of their own.[72]

[71] The same reason they probably did not go with category Z99, for organizations of unknown category.

[72] One community lab reported to me that they did not remember selecting the NTEE code – in fact, they believed the IRS assigned them a code. However, the form 1023 required for becoming a 501(c)(3) clearly states that organizations must select a code based on their organizational activities. Given that nonprofits often must revise paperwork, I suspect that the IRS also sometimes requests changes to the NTEE codes given their own understanding of the organizations and the categories.

Amateurs and Professionals

Community labs are a space in which amateur and professional biologist come into contact through both traditional outreach activities in which professionals maintain authority and through activities in which amateurs are also able to have independence in doing biology work. Lab members discuss the boundary between amateurs and professionals in science in three ways: 1) they construct notions about how amateurs and professionals have different competencies, allowing professionals to lay claim to some kinds of cultural authority and status within the lab while amateurs undermine certain claims to authority by declaring their own competencies; 2) professionals outline the limitations of community labs but also emphasize why the labs are appealing, a process that simultaneously reinforces the boundary between professional and community labs while also allowing professionals in the space to save face and justify their participation; and 3) amateurs express the belief that boundaries between them and scientists are altered within the community lab relative to their experiences with scientists outside of the community space.

Amateur and Professional Differences

In community labs, discussion of the boundary between professionals and amateurs in biology largely reaffirms the difference of approach and capability, but it also gives amateurs a chance to articulate what they believe to be their own contribution to biology. Scientists and amateurs alike note the difference between the ways in which untrained and trained biologists approach work in the lab space. Professionals, for example, have much more training and know how to go about asking questions and which questions to ask, how to design projects to approach those questions, and how to troubleshoot their projects. Amateurs and professionals agree that amateurs find these tasks noticeably harder. One amateur told me he wanted to go back to school

in order to learn how to go about building a project and to acquire knowledge about these shortcomings.

Amateurs in the labs often are oriented differently toward science. As one member told me, amateurs often just want to accomplish a task once not create new reusable scientific concepts. An artists in one space explains the difference to me:

> Even now I'm in these discussions. I'm trying to take my DNA and send it to a lab to have a really thorough analysis of it, and they keep saying that I need to have at least 16 different samples. And I'm like, I just want to have this one sample analyzed. They're like 'No! That's not going to be statistically relevant. You need to at least run that same sample, like, 10 times!' I don't have a thousand dollars per sample to run that 10 times. $10,000! So there's kind of these different perspectives, also, that come out. Where I might just want to say, well I just want to get the result. I just want to do it once. But from Science's perspective, you can't, like – just doing it once isn't scientifically valid.

The artist claims that her goals are different. Other amateurs claim that they bring unique perspectives to experiments and that sometimes they are not bogged down by the same preconceptions as professional scientists. It is not clear that this actually works out to be an advantage, however.

How Professionals Think about Community Labs

Professionals inside the lab offer various explanations about how community labs are different from professional labs. Professionals say community labs offer a different value proposition than professional labs. One professional scientist who did projects in a community lab told me that he thought the gap in what professionals and amateurs could accomplish in the lab would likely never close. While labs are good at the education component, he said, he did not think that "great science" would come out of community labs, unless professionally trained scientists produce it. Another professional notes that community labs take on some of the easiest kinds of biology (like synthetic biology) but much of the work to be done in biology is way too

complicated for what the community labs are ready to handle at the moment. It requires more equipment, expertise, and there are too many regulations.[73] Others note that, while amateurs and professionals in community labs may not be able to take on the same tasks, they can take on many basic but impactful projects nonetheless.

Several professionals in the labs note that they think community labs are helpful and important. By bringing amateurs into biology, there are more minds approaching a problem from different angles and they are, hopefully, able to "explore the solution space a lot better" with extra people working on a problem.

> It brings together people of extremely diverse backgrounds, like people that just have expertise in all different areas, and you get this - there's no barrier. You get amazing ideas between people because everyone thinks a little differently and everyone has a different goal and that's totally different from anything you will find [in an academic lab] – it's like constant collaboration because everyone has a different background than you. And that's really awesome.

In addition, professionals believe that amateurs are helpful in collecting data in a distributed approach, like tracking the progression of a virus across a country. Though the idea of crowd sourcing seems to be popular in community labs, there have only been a few projects in which community labs have really been able to demonstrate that they can do it.[74]

Professionals who work in the labs spent time in interviews differentiating between professionally trained biologists and amateurs, and professional biologists outside of community labs also react to news of community biology labs by questioning these boundaries. In the course of my research, I interviewed a few professional biologists who were not members of the labs,

[73] There are laws that regulate research with certain kinds of hazardous materials and for any projects involving human subjects, and community labs are unlikely to be able to meet these standards.

[74] By highlighting certain forms of less skilled labor as a way that amateurs are helpful in community labs, professionals in the space are doing what often happens within professions – handing off routine tasks to less skilled people outside of the profession (as noted in Abbott 1988).

and their reaction mapped closely to what my lab member subjects reported to me when I asked them about how professional biologists outside of the community labs react to them. Once they get over the shock of hearing that amateurs are doing biology and come to understand better exactly what types of projects are going on in the labs,[75] many biologists are interested and enthusiastic. "The response from the scientific community has been overwhelming. It's been great," reports one lab member. Another lab founder reports that scientists have been very generous with their ideas on open-source biotechnology projects. He believed that this was because scientists were supportive of efforts to bring down the cost of equipment, which is a major financial drain for lab budgets.

Though some professional scientists are enthusiastic about community labs, not all are supportive. One of the earlier members of community labs noted that when he started attending synthetic biology conferences in the early days of DIYbio, he encountered "snobbery" from professionals at the conference about how people in a garage or community lab could do the same things done in professional labs. Some scientists immediately worried about the consequences – something many lab members have mentioned in encounters with professionals, and which has come up when I discuss labs with biologists as well. Other members note that professionals sometimes roll their eyes about the DIY community because biology is hard to learn and do. DIYers often get attention even when they are not really doing anything impressive yet. One member tells me that some biologists resent them because they spend their whole careers optimizing one process or investigating one little piece of a system and never get any attention, but community labs get in the news for doing something "totally ridiculous" half of the time. Such professionals are challenging the value of community labs.

[75] For instance, that amateurs are not trying to engineer mammals.

Amateurs Construct Boundaries in the Community Lab

Amateurs also construct boundaries between themselves and professionals in community labs. In conceptualizing similarities and distinctions, one artist told me that she thinks scientists and artists are similar because they are always asking questions and exploring. The difference is in the end product that they produce. Where scientists need to quantify, artists do not. "The results that artists can afford to have that scientists can't are questions. They might start with questions, but they need to answer them," she explains, whereas artists "need to create a platform to ask those questions." Within the lab, artists and scientists are often really trying to accomplish different things, though that does not necessarily mean they are at odds.

While some members of community labs reinforce the boundary between amateur and professional biologists, others feel the boundary is lessened. Artists in particular seemed to feel that community labs promote a different relationship between amateurs and professionals in biology. For many artists, the scientists in the space are helping to advise them in how to execute their projects, which is often quite different from experiences they have had with scientists outside of the labs. In the section on art above, I outlined some of the differences in access to lab space. Another artist also articulated the difference in the boundary between art and science in many industry and academic labs versus in community labs. She noted that her art school had attempted to create a space for artists to work with biologists, but it ran into similar problems to those recounted in the earlier section. Biologists still maintained authority, and the artists sometimes felt that rather than being collaborators, they were relegated to the role of illustrators or documenters for the scientists. Other artists reported similar loss of control when trying to work in science spaces or with scientists. Artists reported that in community labs, they felt like they had their own autonomy. Scientists became advisors with real and helpful expertise, but the

work was independent. As long as the work was safe, scientists did not try to limit or shape it, according to these artists. The account of the artists seems to show that attempts are made within community labs to break down or alter boundaries between art and science that exist outside of the labs. The alteration of the boundary allows bioartists greater access to expertise.

Amateurs from other backgrounds also want to reshape their potential relationship with biology. One community lab that is working on founding met with architects and decided that rather than creating a standard lab, they want to design a space that is more like an art studio in order to encourage creativity and openness. The decision highlights the desire to be something other than a traditional lab – something more innovative and accessible, which reflects the ways in which community lab members believe that their organizations differ from traditional biology labs. The same lab founder wants to break from the tradition of the length of a lab coat expressing status in a lab. He notes that lab coat length in traditional labs is used to indicate status. The longer the coat, the higher the status of the wearer. Because they do not want hierarchy in the lab, they want to each create and tie-dye their lab coats. It is a very explicit act to express that this lab is not like professional labs. It is open and everyone is equal. They are targeting a symbol of professional science and altering it to express an alternative identity. Most community labs do not instantiate the relaxation of boundaries in such a physical sense, however.

Tensions Shaped by Niche Overlap

Throughout the chapter, I have indicated some ways in which community labs are at odds with people in other fields. Now, I analyze some of reasons that labs appear to have more tensions with organizations in particular fields. In some cases, such as with art organizations, tension is minimal. In other cases, like biology professionals, there is considerably more tension. The degree of tension seems to be related to the types of things the lab actually does that

intersect with the existing organizations in the field and the reasons that professionals from those fields enter the labs. Greater niche overlap in activities and end product corresponds to higher tension. Professionals in each of the four fields participate in the community biology labs, but professionals from each field seem to have slightly different reasons for being in the community lab. Different levels of tension may also be the result of different professions having different degrees of desire to dominate all practices within their jurisdiction (Abbott 1988). Art organizations may have less desire to have sole jurisdiction over the production of art than professional biologists desire to have sole jurisdiction in the production of knowledge about biology. The way that members of the field are oriented toward the activities in the lab may be different as well. In other words, the degree of tension seems to be centered around the degree to which boundaries have to be renegotiated. The education and art taking place in community labs is seldom competitive with the activities done in professional institutions. The biology and technology building conducted in community labs, on the other hand, does try to be competitive with the professionals in those fields.

Education

The educational tasks pursued by community labs do not heavily overlap the tasks that are prioritized in high schools, universities, or community colleges. Classes are more minimal. There is no established curriculum. The education arm provides supplemental lab work that is not competitive, but rather largely is complementary to the existing education system. Moreover, many types of organizations provide educational activities. Colleges and universities do not have a monopoly on educational outreach. Community labs do not need to convince members of the public that they can responsibly educate because the public already is comfortable with the idea that educators might exist in organizations outside of high schools or higher education. No one

has ever expressed surprise to me about community labs offering classes or about their educational goals. Members of labs have not relayed stories about negotiating a place in education or tensions with educators. Labs have successfully partnered with educational organizations to teach classes or provide access to students. In part, the lack of competition between labs and other educational organizations may be because labs do not seek to grant degrees.

Bioart

The art community is also largely on good terms with community biology labs. As noted in the section above on amateur and professional interaction, artists have had trouble carving out their space in biology when they interact with professional biologists in their own labs or even coming into art schools to give lessons. Community biology labs have provided significantly better access to the tools of biology on terms that give artists more control over their work. One participant does report that in the beginning of community labs, art students had a difficult time convincing their academic advisors to let them work in the space because bioart was fairly new. After a few years of exciting and successful work in the space, art students were able to get approval easily. Community labs provide access to the tools of biology, but they also provide a safe space to do biology.

Community labs also help artists manage risk in doing biology work. Several artists directed me to the case of Steven Kurtz, a professor in art history, who was arrested when police found DNA extraction and amplification equipment that he used for his bioart in his home after his wife died (The Associated Press 2008). Though his wife died of natural causes, Kurtz was held on terrorism charges for a time. He was eventually released, but the art community (and do-it-yourself biologists, as well) was shaken by the event. Community labs provide a place to do

bioart that may seem less risky after a case like Kurtz's because community labs have things like biosafety certifications, approval to order experimental supplies directly from suppliers, and, in many cases, have already made contact with local law enforcement about their activities.

Artists tend to use community labs in order to facilitate their art in ways that do not compete with their other institutional affiliations. For the art field, community labs are not competitive. They are a tool that can be used to reach certain ends. In one city, an art school and a community lab have an ongoing relationship because the school regularly sends artists to the lab to do their work and members of the lab teach biology classes specifically for the art school. The relationship between art and community labs seems to be characterized by cooperation rather than tension.

Biology

The most tension exists surrounding the biology aspect of community labs. Many of the objections raised by biologists may be the result of a defense of professional jurisdiction. Professional biologists from academic and industry labs often express skepticism about the safety of the labs and the ability of members of the labs to produce scientific results. Journalists and other external audiences also express concern about amateurs venturing into work with biology, potentially the result of external audiences buying into the strong jurisdictional claims made by biologists. The tension that exists as community labs venture into biology work (which does not exist when they venture into art and education) might be the result of 1) the potential of physical danger, 2) high status of scientists and strong professional boundaries and claims of professional jurisdiction, and 3) the degree of niche overlap with biology organizations that is not present in education and art that places scientists in a more adversarial position. Community labs are not trying to replace educational organizations or the art industry. Instead they offer

tools for members of these communities. Community labs *do* often want to be able to do the same kinds of things as professional biology labs, though they seldom are actually able to do so. The relationship, then, between community labs and industry or academic labs is more adversarial because it transgresses boundaries and challenges stronger claims to professional jurisdiction.

The potential for physical danger is the accusation that community labs face most often, and it is the one that they have taken the most steps to assuage, as noted on page 261. Previous journalistic accounts included the titles "Amateurs Are New Fear in Creating Mutant Virus" in *The New York Times* (Zimmer 2012) and "Hacking the President's DNA" in *The Atlantic* (Kotler 2012). Members of community labs tend to downplay the danger that they pose by emphasizing the difficulty they have in doing complicated projects in the lab – professionals and amateurs in the spaces both offer such explanations. Resources and member expertise are too low to undertake many projects, they note. Cleanliness and sharing a space with amateurs prevents certain projects from being viable for professionals. If professionally trained scientists struggle to do projects in the spaces, amateurs hardly seem able to create projects that would be competitive with professional labs. In emphasizing their shortcomings, they also emphasize that community labs are not really competitive with professional biology labs in many tasks. Community labs downplay their ability to intentionally create dangerous products. At the same time, they also emphasize that they seldom do tasks that could render dangerous their outcomes because they are limited in the processes that they undertake. Such attempts at assuaging worries about safety have been partially successful. Members of labs note that they get less negative press than they once did. Indeed, they have recently gained positive press in several popular platforms like Nature (Gewin 2013; Kuiken 2016) and the BBC (Hanno, Friebe, and Karberg 2013), though

they do sometimes still receive negative press. Community labs have aligned themselves with professional biology by adopting similar safety measures, but they also have reaffirmed the boundary between professional labs and community labs by deprecating their own potential to do scientific work.

Not all labs have chosen to cultivate the same kind of image though. Counter Culture Labs has taken on a project to create open source insulin – something that has professional scientists (and members of the public) a little more worried. According to experts quoted in a NPR article, creating insulin at home could actually be done but the process is complex and errors would be easy to make, yielding a potentially harmful product (Tucker 2015). Members of the DIY community believe that by working together in the lab through a platform for coordinating open source biology projects (Arcturus BioCloud: https://www.arcturus.io/) they will be able to eventually develop safe practices that can allow diabetics to produce insulin in their homes for less expense than it can be bought in the pharmacy.[76] When labs undertake projects like this one, more conflict shows up between the labs and professional biologists, much as it did for the Glowing Plant project, when scientists and journalists raised concerns about GMOs. When labs push to do substantial scientific endeavors, they encounter more resistance than when they focus on education, art, or technology.

Technology

While industry and academic biologists and members of the public many have more concerns over citizens becoming involved in biology research, community labs are probably the most evenly competitive with biotechnology developers. For instance, one community project at

[76] I imagine the pharmaceutical industry will not be pleased with this.

BioCurious, where participants converted an inkjet printer into a bioprinter,[77] was well publicized. It was a PR victory for the lab. More substantial contributions have been made by do-it-yourselfers to biotech, however, like OpenPCR, an open source project that gives directions (or you can buy a kit) to create one of the most basic pieces of equipment for a biology lab, the polymerase chain reaction (PCR) machine. This machine provides a way to replicate DNA, which can be used selectively to help detect the presence of certain genes in samples of DNA. It can be used in detecting infections, genotyping, preparing DNA to sequence, monitoring food safety, and manipulating DNA when doing genetic engineering. PCR machines can cost $30,000, but OpenPCR can be fabricated based on open plans from the website or a kit can be purchased for $649 (openpcr.org accessed 10/23/15). OpenPCR was created by one of the founders of BioCurious, an engineer who cobbled together his biology expertise through individual study and classes available on the web. Biotech seems to be an area where DIY biologists are particularly able to make meaningful contributions. In many ways, these activities in the lab are really technology with a biology flavor. The lab is a resource for technologists learning about the biology side, and serves as an incubator style space for technologists inventing new biotech.

Biotech organizations and biologists do not appear to object to amateur biologists (or amateur programmers or engineers) innovating biotech equipment. Instead, people in biotech and in industrial and academic labs seem excited about the potential for biotech innovation in community labs. Dropping the cost of doing science, of course, is exciting to anyone running a lab. However, I argue that the tech field also has a different culture than many of the sciences, probably a result of the comparatively recent history (relative to biology) of people creating

[77] For their first experiment with it, they printed a pattern with arabinose, which they then overlaid onto a plate of E. coli. The arabinose, a sugar, causes the E. coli to grow green under UV light (Patrik 2013)

important technologies in their garages (such as personal computers). Hacking together technology outside of formal organizations is already part of the culture of the tech field, and so community labs are just a new space that affords hacking together technology for biology. Novel organizational forms that fit within preexisting cultural beliefs and typification are more likely to be legitimated (Ruef 2000). In addition, many of the people making new technologies at community labs are from technology fields professionally, so they are not outsiders to the industry. The result is that there seems to be less tension between members of the technology field and community labs than there is between biologists and community labs.

IV. A Field of Their Own

While community labs have developed niches in a number of other fields, Rao et al. (2000) suggest that forms that emerge at the interstices between fields must construct a new field-wide environment in order to succeed. A field of their own will help community labs defend the boundaries that they have been building, coordinate resources across labs, implement more effective organizational learning, and possibly help in the event that regulation of labs occurs. It will also help the labs institutionalize the organizational form. DiMaggio (1991) asserts that in order to understand the institutionalization of organizational forms, we must understand how organizational fields are institutionalized and structured. "Structuration" of organizational fields involves the emergence of a collective definition among a set of organizations that they are a common industry, formal and informal networks linking the organizations, and the development of organizations that support and regulate the new industry ((DiMaggio 1991, p.267). Below, I describe the degree to which community labs have begun developing a field. I begin by articulating the degree to which community labs have established a collective definition of themselves as being part of a common endeavor. I then describe the ways in which the labs

are networked, which at the moment is limited. I describe the flow of resources from lab to lab, and the attempts to establish field-wide organizations.

Collective Definition

In order to create a community lab field, labs will need to establish a collective definition of themselves as undertaking a common endeavor. This prerequisite for a field is perhaps the one labs are closest to achieving. As part of the interviews that I conducted, I asked members at each lab what organizations they thought were similar to themselves. Community labs often identified each other, particularly the bigger, older labs like BioCurious and Genspace. Even hackubators were identified as something similar, though often with the caveat that they were also a little different. While community labs recognized that each lab has a different approach and different character, they did note that they are generally trying to do something similar. Members of community labs certainly understand that they could benefit from using each other as models and a source of organizational learning, and subjects mentioned drawing charters, funding plans, and other expertise from each other, and following the success and failure of other labs.

A few activities have also begun to help shape this collective definition of community labs. In 2013, a reporter and cofounder of Genspace named Daniel Grushkin collaborated with the Woodrow Wilson International Center for Scholars (Wilson Center) to conduct a survey of do-it-yourself biologists and produce a report about do-it-yourself biology (both in community labs and outside of them). The survey examined the backgrounds of do-it-yourselfers, the kinds of projects that they do, and their understandings of their own values and potential contributions. In part a response to worries that DIYers are creating dangerous organisms, the report is meant to ground the expectations of the public in actual data about the projects that DIYers are undertaking (Grushkin et al. 2013). Among other things, the report makes the claim that DIYers

are pro-transparency with a "culture of responsibility (p.16)," facilitate innovation and creativity, and do not currently require regulation because they are not capable of very much yet. The report makes the recommendation that the government should fund a network of community labs, both because labs cover a gap in US science education and because they believe the open access biology in the lab will be a key source of future innovation. The survey data collected should be considered with caution because the methodology was opportunistic and would certainly have missed some the type of people the authors argued did not exist (those doing dangerous projects would not have been likely to fill out surveys about their work). However, we can see this survey project as an attempt to manage the way the public understands do-it-yourself biology participants, as well as an attempt to create data about who precisely is involved and what they are doing. Though the survey did not focus just on those in community labs, this is a first effort to gain an understanding of the players in the field. Grushkin et al.'s report is also a first attempt to create a small amount of shared knowledge.

Another project that has created broader consciousness among DIY labs and the public is DIYSECT, a documentary film series about DIYbio and bioart (see diysect.com), created by an artists and a documentary maker with an interest in bioart. Several of the still-founding labs have used this documentary series as a starting point for thinking about community labs because it is one of the few resources comprised of collected information about several labs. The new labs look to the series for inspiration and for any information that they can glean about how the labs work and what sorts of projects they might do. People outside of DIYbio produced the series, and several of the established labs noted that they declined participation because they did not think the series was really about community labs. Members of one lab told me that they thought the documentaries were more about a particular kind of biohacking that involves self-

modification[78] – something that is not really common in community labs. Even so, a handful of labs did participate and some of the newer labs have looked to the series for inspiration.

Connections Between Labs

While community labs are developing a shared identity and understanding of themselves as a type of organization, for the time being the connections between the community labs are informal and relatively inactive. Community labs rarely make contact. Most often, they are in contact when they are founding. Genspace and BioCurious in particular get many inquiries from founding labs, and they are in contact with these founders a few times while the latter are getting their labs running. Contact tends to be minimal after the labs are open. Members at labs report that they occasionally exchange phone calls. Sometimes when members visit a city with another lab, they will drop by the lab. Community labs also are networked informally through people outside of the labs. For instance, there are a very small number of people who are not lab members but who participate in discussions on the Google groups. At least one of these Google group members has participated not just on the international DIYbio Google group, but also on at least three local Google groups, though he is not a member of any of the labs. The man shares what he knows about other groups, DIYbio, and sometimes his own archives of useful resources. For the time being, inter-organizational contacts between labs are shaped by inquiries at the time of founding, by occasional opportunities to meet up at iGEM or past FBI conferences, and by travel. Of course, the labs in California are a little more networked since the founders of each coexisted in BioCurious for a time. Counter Culture Labs has some continuing overlapping

[78] Self-modification includes everything from modifying your body through diet to using cybernetic devices for recording biometric data.

membership with BioCurious. The rest of the labs sometimes communicate, though not with great regularity, according to the reports from interview subjects.

The labs do have a small degree of information flow between them. In part, informal connections facilitate the flow of knowledge. Information about charters, bylaws, challenges in opening the labs, funding strategies, where to get insurance, and other founding issues are often handed down through brief contacts between existing labs and forming labs. Additional information is gleaned by reading postings to each other's Google groups (or the international Google group). For instance, when BioCurious was going through its financial crisis, members at other labs were aware of the issues because they were following the discussion happening online. Similarly, other labs noted the Glowing Plant debate over GMOs in community labs, which they often learned about from reading the online discussion.

Shared Resources

Community labs have begun to create (or at least contemplate) a few shared resources. At the most basic, there are two maintained lists of DIYbio groups and labs (neither is complete and both include interest groups that do not have lab spaces as well as those with labs). One list is maintained by DIYbio.org and the other is by a DIYbiologist who is not affiliated with any of the labs (the same man mentioned above). The lists of labs are helpful for new labs looking for models and contacts. However, these lists provide only minimal resources.

Counter Culture Labs has an open wiki where they have collected some materials relevant to founding and running a lab as part of their commitment to being open and transparent. The resources include founding documents, meeting notes, and information on the committees that they have within the lab. It contains some documents from other labs, but is not a systematic centralized source of information on all labs. Genspace has also started a website,

openlab-blueprint.org, that provides information about how to start a community lab, including things to consider when choosing spaces, reasons for safety training, information about building interest and maintaining interest and more information relevant to creating a community lab (accessed 11/12/15). At the moment, the website appears to draw exclusively from Genspace's experience. The website is a first attempt to articulate fully the information necessary for starting a lab similar to Genspace, and it is a resource shared with the public. Possibly in the future, it could be a resource that is built off of the experiences of multiple labs.

Two publications have emerged. One is *Citizen Science Quarterly*, a journal intended to publish findings of all sorts of citizen scientists. It was not have been specific to DIYbio or community labs. The journal did not last long. Another publication, a quarterly newsletter for DIYbio called *Biocoder*, was established in the spring of 2014 and seems to be on track to continue. It is published by O'Reilly Media and is available for free download. *Biocoder* is not specific just to community labs; it is for DIYbio more generally. However, one of the editors is active in multiple community labs. The newsletter prints articles about projects, tools to buy and build, key people in the community, and the labs. It also includes information about events that are relevant to the community. *Biocoder* is one of the few field-wide resources available at the moment that makes a substantial attempt at gathering and disseminating knowledge within the community.

Field-wide Organizations

Field-wide organizations that constrain, regulate, and represent the field are developed as part of the structuration of a field. At the moment, community lab members have differing takes on the utility of field-wide organizations for community labs. One lab leader tells me, "There's no central organization for DIYBio, which is a *good* thing in my opinion, because every DIYBio

organization is part of an individual, very unique community because they're in many different places geographically." However, a leader at another lab believes that a consortium of community labs is an inevitability.

She notes that if you look at any other dispersed types organizational forms (her example is environments for seniors that are not quite retirement centers), once there is a critical mass of such organizations, they are constantly contacting one another to field basic questions, a process that has been happening among community labs. She notes, "All of this stuff that has been covered to death. It's only natural for them and for us to share those resources. It is sort of the model of open source. You sort of build on what's been done." She thinks a consortium is an obvious answer as a way to centralize this knowledge.[79] A consortium could also provide resources, establish relationships with potential funders and regulators, and employ full-time advocates for the labs. So far a move toward a consortium has not happened, and she suspects that it is because it would take a vast about of work to coordinate the resources of all of the labs, recognize what is unique to each lab, and identify best practices.

Neither of these leaders mentions DIYbio.org, an organization founded just before community labs started opening up in 2008. DIYbio.org uses the tagline "an institution for the do-it-yourself biologist" (diybio.org accessed 11/6/15). Founded by Jason Bobe and Mac Cowell, the two men who coined the term "DIYbio," the organization seems like it would be a central organization but does not appear to have established itself as such. It maintains one of the lists of community labs. It also offers a service called "ask a biosafety expert," which allows anyone in the community to ask a biosafety expert for feedback about their projects (whether you are affiliated with a lab or not). The feedback is then posted publicly. The service has not posted any

[79] She even asked me if I would like to organize one.

responses since 2013, and appears to have been short-lived. In 2011, DIYbio.org also hosted a congress of regional DIYbio groups in North America to draft a code of ethics for the DIYbio community (outlined in Chapter 3). Ultimately, DIYbio.org does not appear to be a viable central organization, though it has provided a few community-wide resources. It is currently inactive. I suspect that it came into being too soon, before community labs were ready to contribute toward sustaining such an organization. It also did not emerge from the labs, but rather emerged before the labs.

At the moment, figuring out how to organize and run a community lab requires significant amounts of time and attention. Field-wide organizations that can collect and disseminate knowledge and facilitate communication between labs would greatly decrease the time costs of starting a community lab. At the moment, no one speaks for the community lab field centrally, though leaders at a few of the bigger labs sometimes do by default. For now, there are not any centralizing organizations or events that would impose a move toward centralization. For instance, if foundations begin giving more to the labs, we might expect those foundations to push for central organizations like a consortium because foundations often seek to help organizations become better able to sustain themselves. Central organizations that facilitate organizational learning are a common way to attempt this.

Future

As the field continues to develop, I would expect to see additional ways for labs to be connected through personnel and more formal ways to move knowledge between organizations. For the time being, community labs are so new and so underfunded that they do not have any paid employees. However, that is changing. In the fall of 2015, BUGSS secured funding from a grant making foundation to hire its first employee, and many other labs are also working on

acquiring employees. As there become employees who specialize in running community labs, I expect to see 1) more communication between labs enabled by employees with time to network, 2) more shared resources, also enabled by employees with an investment in creating knowledge about their organizational endeavor, and 3) occasional flows of personnel between community labs.

In addition, the emergence of common funding sources and professional organizations is likely to shape which visions labs continue to pursue. Funding from sources that prefer educational outreach will encourage organizations to focus on those endeavors, as has been the case with the Citizen Science Lab in Pittsburgh, which has not yet developed the open-lab oriented features at all. Member funding might privilege a more varied vision. Sponsorship by particular organizations also will promote the visions of those organizations. At the moment, there are no field-wide funding sources, but if some do emerge, they are likely to promote a common shared set of constraints that shape the labs.

Increases in connections between labs as well as shared resources will help build and define the organizational field for community labs. In turn, building a field will help labs with organizational learning and also help shape how community labs are perceived by the public. It is also possible, of course, that community labs will fail to establish a field and there are no guarantees that community labs will find ways to stably employ directors or sustain their activity. Because community labs are at a stage of forming in which it is not yet clear what will emerge, we cannot know for certain whether a field will emerge at all. It is also possible that community labs will, in the end, be subsumed by existing organizations. One lab, for instance, is currently associated with a public library, which has built a lab on its premises. If community labs become part of other organizations, they are less likely to create their own field.

V. Conclusion

Organizations with new forms must find a place among existing organizations. Community labs find themselves situated in a rather complex space, negotiating boundaries and forming niches within four different adjacent fields. They draw upon the resources of and interact with organizations from a wide range of fields in part because their foundings have left them with a diverse set of stakeholders. In part, community labs interact with people from several fields because people from these fields are currently interested in biology. Interaction with multiple fields for community labs matters because 1) organizations from each field provide the labs with different resources and 2) labs can carve out multiple niches across a range of fields, giving them a diverse set of functions.

Community labs differentiate themselves from existing organizations as part of the process of staking a claim on a particular set of functions and in part as a way to develop their organizational identities. Community labs collaborate with and align themselves with organizations in order to accrue legitimacy, acquire resources, and help their external audiences make sense of what they do. As an emerging form, the community lab is shaped by its relationships to organizations in four separate fields: biology, technology, art, and biology education. From some of the fields it draws expertise. From others it draws organizational patterns or analogies. Organizations in some fields provide equipment and teaching staff. In turn, community labs serve various functions that supplement what can be accomplished in organizations in each field. Community labs are also a site in which amateurs and professionals in biology come into contact and negotiate the boundary between them. Tensions between members and professionals in the other four fields are lower because niche overlap is more minimal.

In this chapter, I provided an overview of how community labs, members of an emerging organizational form, are relating to other organizations in their environment. They differentiate from and align themselves with other organizations as they attempt to justify the labs, promote their legitimacy, and gain access to resources. The importance of this organizational context can be seen in both the founding and the organizational structuring examined in Chapters 2 and 3.

Chapter 5: Conclusion

I. Contribution to Emerging Forms Literature

I argue that before new organizational forms become recognized and standardized, there is a phase of organizing in which individual organizations struggle to structure their organizations in such a way that they both meet the goals of their various stakeholders while they also are sustainable. Variation is the rule during this nascent stage, as organizations draw different resources from the environment, use slightly different organizations as models, pursue slightly different goals shaped by variations in identity, and encounter different obstacles. Indeed, there is so much variation in the early stage of new forms that it may be more helpful to think of the organizations as being part of a pre-form or inchoate form that may or may not develop into an organizational form at all.

Throughout the dissertation, I helped to explicate the processes and mechanisms that shape the emerging organizations in a potential new form. Like Powell and Sandholtz (2012b), I found that disparate networks being brought together are at the center of the emerging community lab form. Professional biologists, academics, technologists, educators, artists, and general biology enthusiasts from myriad backgrounds come together around a shared desire to create a wetlab space in which to learn and do biology work. The result is fifteen community biology organizations that have been cobbled together in various ways out of component parts of organizations that members have seen in their work or leisure environments. My work illustrates a stage of a new form in which founders are reaching blindly for potential models and then are modifying their new organizations as necessary in response to outside pressures and

organizational failures. Certain circumstances lead some people to split from these new organizations and try yet other ways to run a community biology lab.

The literature suggests many processes at play in shaping new organizational forms. Conditions of founding, particularly the characteristics of founding teams and pressures from organizations in the immediate field, are one area of study. The importance of identity and boundaries is part of the founding process that is often emphasized. The structuring of the new organizations, often through processes of recombination of features of existing organizations, is another area of study of emerging forms. A third focuses on the ecology in which the organizations emerge. The dissertation weaves together these various lines of thought. I highlighted many relevant factors shaping the emergent organizations during founding, outlined how ideology and identity shape structure during the recombinatory process of structuring the organizations, and showed how resources flow from and to organizations in four surrounding fields.

Though analyses of new organizational forms often emphasize particular narratives about what shaped an organizational form or, post facto, identify factors that influence success rates of new organizational forms, they seldom analyze the origin of variation and degree of variation in the early stages of the form. Some of the variations of a new form, should any survive the nascent stage, will be replicated by new instances of the form as a way for subsequent new organizations to establish legitimacy and manage uncertainty regardless of the efficiency of structure (DiMaggio and Powell 1983). I showed factors that shape those early structures in the beginning and illustrated some of the reasons for variation.

I also examined the emergence of a new form from an unusual number of angles: I examined founding conditions and founding choices, the adoption of structural features through

recombination, and the properties of the fields surrounding community labs. I examined each of these areas using as many of the organizations about which I could collect information rather than focusing on one or two case studies. I incorporated failures as well as successes. The dissertation is an unusually complete analysis of the earliest stages of an organizational form.

Founding

I focused on factors that influenced the founding of organizations across the entire nascent community lab form. I identified two ways in which founding groups came together for this form – through processes of emergence grounded in networked technology and through intentional recruitment, which also sometimes included networked technology. While previous literature has examined how founding groups come together (Forbes et al. 2006; Ruef 2010; Ruef et al. 2003) and how characteristics of founders matter for organizational success (Baron, Burton, and Hannan 1996; Baron et al. 1999; Baron and Hannan 2002), few researchers have connected the process of founding group emergence to the founding of new organizational forms. Those that have suggest that the joining of disparate networks are the origin of truly novel organizational forms by bringing together people with different ideas and experiences (Powell and Sandholtz 2012b). I suggest that founding group emergence through communally run internet-based groups may give voice to a larger number of stakeholders and allow a greater number of visions to emerge than in groups that form out of a common experience (like working in an existing lab together) or individuals who have a specific goal. The processes through which founding teams emerge seem to shape the degree of focus of nascent community labs, which may explain why some labs seek to do outreach, discovery and business, while others are only interested in one vision.

I also examined how the founding of community labs are shaped by the availability of certain resources including resources associated with particular geographical contexts (cities with science and technology industries), the viability of obtaining funding resources from various stakeholders (members, the public, or private organizations), and the availability of appropriate spaces and cheap equipment. Unsurprisingly, I found that organizational context does matter. Community labs are constrained in where they can be founded, and the surrounding organizations shape how many donations of equipment they receive. Organizations, however, vary a great deal in how they choose to fund their founding depending on member resources, whether they are well known and networked enough to have a viable crowdfunding campaign, and whether there are organizations who wish to contribute toward the lab's goals. The viability of each funding source is shaped in part by the organization's reported goals. Early funding choices can place community labs on a trajectory that emphasizes particular stakeholder priorities.

Community labs vary in the processes through which they are founded and in founding decisions that may shape the way the labs are subsequently structured. Indeed, even among organizations that take established forms, there is likely to be variation in founding. Founding decisions in community labs, however, are characterized by uncertainty over the best ways forward. The different trajectories that organizations take based on the characteristics of founding teams and founding conditions will shape what the organizations look like in years to come. If organizations survive and become reified as new organizational forms, subsequent organizations are likely to take their cue from these surviving organizations as a way to manage uncertainty (DiMaggio and Powell 1983). In years to come, an understanding of early variation

in the form and which organizations eventually survive will help to continue to flesh out theory about emerging organizational forms.

Structuring

Community labs are an emerging form that recombines elements seen in other organizations in the labs' local contexts. I showed how recombination is combined with ideas about identity in order to choose or justify the adoption of particular organizational features. As Chen (2009) did with Burning Man, I found that community labs adopt both collectivist and bureaucratic features from their environment to meld their desire to be open and accessible with their need to practically govern the organizations. I went beyond Chen by analyzing the adaptations of multiple examples of a new form to the struggle between collectivism and bureaucracy and detailed factors that influence the tendency to develop toward one end of the spectrum or the other.

The five features that I examined were whether power is distributed or concentrated in the hands of a few members, the type of incorporation, the degree to which the members wish to serve a wide audience, the degree to which they are geared toward educational opportunities versus business opportunities, and whether the funding structure leans more heavily toward classes or membership dues. Each of these areas – how authority works, the organization's legal form, who participates, what they do, and how they create sustainable income – are centrally important to the form of an organization. While some patterns have emerged among community labs, they do not yet have a clear picture of what might ultimately be a sustainable model. Like many emerging forms, they are experimenting with possible ways of organizing around a particular type of activity.

Like founding choices, the structure of community labs is likely to be mimicked as the form moves from the early stage into a more established stage. In fact, some of the labs being established now are modeling off of earlier community labs. A central tension for this form is how to handle collectivist practices while still maintaining a sustainable organization. For the time being, community labs vary from incorporating largely collectivist practices to having strong bureaucratic practices. Where on the spectrum between collectivist and bureaucratic subsequent organizations fall may shape how much individual members have a say in how the organizations are run. Furthermore, if organizations move more toward bureaucratic practices and away from their hacker space roots, the organizations may lose the counter culture emphasis on individual member freedom to do as they please. For members who have chosen community labs due to limitations imposed by bureaucratic organizations from which they came, the organizational structures that evolve and survive may determine whether the labs serve the purposes that they seek.

Environment

Any emerging organization is shaped by its organizational context. I demonstrated how community labs create narratives to situate themselves within four fields of professional biology, education, art, and technology, carving out niches that serve purposes not well addressed by other organizations in the fields. They simultaneously differentiate themselves and align themselves with particular organizations, movements, or ideologies in order to carve out a separate space for their organizations while still securing resources and recognition as legitimate organizations.[80] The flow of resources between labs and organizations in the four fields involves a flow of expertise from biology to the other fields. Art and technology professionals input

[80] A project not yet complete.

supplies, funds, and membership. Technology organizations provide many of the models for community labs. The degree of tension that exists between community labs and organizations in other fields seems dependent on the nature of the niche that the organizations carve out – greater niche overlap with existing organizations seems to lead to more conflict. I also suggested that community labs have begun to make the first steps to establishing a community lab field, which could help them coordinate and develop resources.

All new organizations must fit within their environments, but emerging organizations must justify their value as separate entities. I illustrated how community labs fit within a complicated organizational environment. I demonstrated how they use narratives to differentiate themselves from existing organizations, the sorts of resources that they acquire from particular areas of economic life, and how the labs are beginning to develop shared resources across labs. Some of the narratives that appear in the organization's attempts to situate themselves in their environment help to illustrate the ideologies behind some of their founding and structuring choices detailed in earlier chapters.

Limitations

My contribution is, of course, limited by certain factors. Of the methodological limitations, the most regrettable is that I was unable to interview subjects from four of the fifteen community labs in the United States. Though I tried to read about them in any news articles or interview transcripts that are publicly available and I asked members of other labs about them, I cannot be sure that I captured all of the variation in community labs. I suspect that several of these labs are a little bit different from the labs that I did manage to reach – a few were showing signs of collapse. These organizational cases could have provided insight into which strategies do not work well for labs. I also, of course, may have failed to identify community labs in the

United States – though I made every effort to find any mentioned to me, ever mentioned on any public forum, or that mentioned key terminology on their websites or through digital platforms. If I have missed community labs, I believe that they are likely inactive.

In addition, my findings about emerging forms may not easily generalize to all emerging forms. Community labs, for instance, are largely modeled on collectives and/or nonprofits. They seldom produce market goods (though members of the organizations may). For this reason, they are different in many ways from startups geared toward manufacturing or marketing goods. Their success is measured in something other than sales – perhaps in sustainability and growth. Consequently, this emerging form may be shaped by different economic considerations and may be able to take into account ideology in ways that would be different from organizations with different emerging forms.

II. Reflections on Amateurs and Professionals

The dissertation was originally to be an examination of the relationship between amateur and professional biologists. I want to turn briefly to this theme as I wrap up to help illustrate why the emergence of the community lab form in particular may be important. As I argue in Chapter 4, community labs are places in which amateurs have begun to renegotiate their relationship with professionals in biology. Not only did the recession destabilize the professional biology field, it also enabled community labs by providing experts and supplies. Within community labs, amateur biologists are able to gain expertise and access wetlab space. Though professionals still claim cultural authority over science (even within labs), the cheapening of supplies, availability of the Internet as a new platform for coordination, participation, and knowledge dissemination, and the access possible in community labs suggests that the cultural authority of professional

biologists may soon weaken. In fact, given the enthusiasm of amateurs and their belief in their ability to do biology work, the cultural authority of biologist may already be challenged.

At the same time, community labs also provide a place for scientists to reinforce that authority. Trust in science among conservative groups in the United States has decreased over the past 35 years, potentially undermining the cultural authority of science and tying perceptions of science ever more closely with political ideology (Gauchat 2012). In Chapter 4, I also outlined some ways in which professionals reconstructed the boundary between professionals and amateurs – by emphasizing what amateurs are not able to do well. Community labs are a place where, through interaction with the public, professional biologists can demonstrate their expertise in person to members of the public, members of the public who may be most likely to challenge their professional authority through doing their own work.[81] Professionals also provide instruction and mentoring in the lab spaces, which reinforces traditional boundaries between professionals and laymen. Biologists are able to maintain cultural authority in most ways because their formal training has helped them develop systematic ways of approaching their work. Professionals also benefit from many years of constant, structured experience designed to help them develop these skills, while amateur biologists must accrue experience in their free time, with little structure to help them move through the biology literature. While professionally trained biologists have shown themselves to have superior skill at designing experiments and troubleshooting them and have a vast knowledge base and superior ability to process publications compared to those in the lab who were not professionally trained, community lab

[81] Though these are also members of the public that are very engaged in science and believe in the value of science, not the members of the public most likely to be suspicious of science. Still, labs are a site where scientists must defend the boundary between scientists and non-scientists and where they can interact with members of the public, some of whom may be resistant to authority.

members are still challenging biologist's cultural authority in small ways. Though they may be less effective at accomplishing biology work, amateurs in community labs have nonetheless shown that even those who do not receive professional training can interlope into areas of biology that previously were the sole purview of professionals. Though they are not as effective as they would wish, DIYers have introduced the notion that the untrained can and should participate in the exploration of biology. They have developed a powerful narrative about the transformative potential of public participation in biology. This narrative has spurred more individuals to take up DIYbio. While community labs are places in which professional boundaries can be reinforced, they also present an ongoing challenge to the cultural authority of professional biology.

Community labs also help amateurs develop new collaborative kinds of relationships with professionals. Though amateurs have long helped with certain kinds of crowd-sourced science – like bird counts or star observations, at community labs they can become increasingly involved with the projects of professionals. In several labs (though not all), amateurs did basic work for professional scientists' projects. This included not just counting, but some manipulations as well. Amateurs also are able to contribute to the projects of professional (or professionally trained) biologists by contributing their own expertise in technology or other relevant fields. Community labs may help amateurs become more involved in the work of professionals in biology than they have been since biology professionalized.

Community labs are an unusual form because they merge the efforts of professionals in a field with the efforts of amateurs in the same field. In future research, it may be useful to examine the ways in which organizational forms emerging on the boundary between amateurs and professionals influence the cultural authority of professionals in the field. Such forms are

likely to exist at the boundary of science and medicine, as citizen science and self-investigation have become increasingly more viable and more popular. uBiome, for instance, is a company that exists at the intersection of biology, technology, and medicine. Crowdfunded to start up, uBiome is a company that specializes in sequencing the microbiomes of various parts of peoples' anatomies (fecal matter, eye goo, mouth, and more). They send a kit to each customer, who sends a sample back. They collect that data for their studies, but also send a report back to the customers. This organization was founded by a combination of technologists and entrepreneurs, though ostensibly the organization is interested in biology and health. There are few medical and biology experts on staff. The organization has recently hired a "Citizen-Scientist-in-Residence" to lead research projects of his own (Taylor 2016). This hybrid organization drawing from multiple areas of professional expertise and thoroughly involving the public in research is similar to disease interest group research endeavors. It may be another fruitful area to view the intersection of professional and amateur research.

III. Offline Peer Production

I contribute to the literature on peer production by detailing offline contexts of peer production. Peer production, or the social production of knowledge and artifacts enabled by networked individuals, is thought to be vastly more possible since the advent of the Internet (Benkler 2006). The argument is that the Internet reduces the cost of producing and of distributing information, which enables more cooperative production of information by networked people. Though much of the literature on peer production concentrates on digital artifacts produced on the Internet, like Wikipedia, some scholars have considered the possibilities for peer production in offline communities like hacker spaces and maker spaces (Moilanen 2012). In my analysis of community labs, I illustrate how the Internet, through

platforms like Meetup.com and Google groups, enables the building of organizations that specialize in peer production. I suggest that the Internet has also played an important role in networking and information dissemination for the face-to-face DIYbio communities. Community labs are local sites of peer production, much like hacker and maker spaces. Community labs facilitate a type of peer production in biology that had previous been quite difficult to achieve outside of professional organizations.

IV. The Future of Community Labs

Next Steps for an Emerging Organizational Form

Ruef (2000) outlines phases for founding of new organizational forms based on his review of the literature. These include: 1) ideas and intentions about the new forms are discussed, 2) resources are secured to develop the new organizations, 3) regulations appear that identify the forms as legitimate organizational roles, 4) the form is recognized as having a distinctive employment niche, and 5) the form becomes a viable supplier of goods and services. Based on these steps and other observation, I propose that the process of moving from an emerging form to an established form is likely to include some or all of the following:

1. Exemplars from within the form are increasingly used in the founding of new forms. Recombinations that differ significantly from those in the similarity cluster of organizations cease to be common.
2. Particular funding models stabilize (and these funding models have shaped other aspects of the form).
3. Centralized organizations may emerge that network the members of the form through conferences, trade associations, or partnerships. This may include the establishment of a set of best practices for the organizations.
4. Regulations simultaneously recognize the existence of the new form and impose constraints on the shape of that form or the activities conducted in the organizations.
5. The common shared identity becomes stronger. Organizations identify as similar to each other. The range of constituencies within the organizations lessens.
6. Organizations of the same form come to have similar relationships to each other in terms of connections to other organizations in their fields.

Of course, not all potential new forms will successfully move through these steps. Some may become incorporated into existing forms, like the library in San Diego that has built its own community lab. Potentially, future community labs could all become parts of existing organizations. In addition, during any of the processes described above, the form can diverge into different forms, as I illustrated in Chapter 3. Community labs have both diverged into two forms and been subsumed by existing organizations.

The oldest community labs have been in existence just under seven years and the majority of labs are two or three years old. It is hard, as yet, to predict whether community labs will stand the test of time. On the one hand, cooperatives are famously difficult to maintain. On the other hand, the hacker space form, which suffers from similar cooperative struggles, has become very common across the globe. Community labs have additional hurdles to overcome. Their equipment can be costly. The necessary expertise for participation may be more challenging to acquire. In many ways, biology may be easier to regulate than the digital world has turned out to be, and so the organizations may face different regulatory pressures than their digital counterparts have faced.

If community labs survive, it is equally difficult to be sure which lab structures will prove to be sustainable. Once again, cooperative rule requires sustained emotional energy and often is difficult to maintain. For this reason, more bureaucratic practices may become more dominant. As the organizations become more recognizable as a form, new funding avenues may become available, which may change the funding models that community labs currently use. Many community labs have just begun to express a realization that fundraising will be a part of their ongoing funding structure. In all likelihood, in order to survive, community labs will need to

become better able to coordinate among themselves in order to more effectively learn. This may result in field wide organizations like journals, funding sources, suppliers, and centralized lobbying organizations (particularly if regulation threats become more immediate).

Community members could be right – amateur participation in biology, coordinated through community labs, may be the next great revolution in how we live. However, I would not count on it just yet. Community labs are young and they face further legimization challenges, ongoing funding struggles, and trouble helping amateurs actually become expert enough to accomplish significant projects on their own.

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