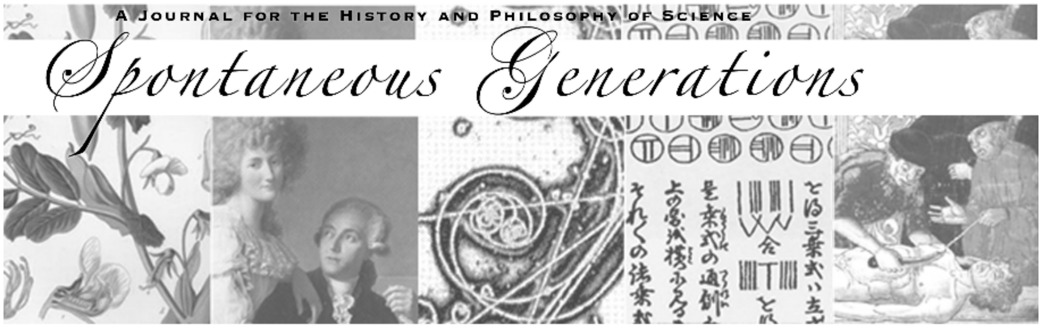

Between Theory and Craft: Exploring the Role of Co-operation within Scientific Research Labs

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Between Theory and Craft: Exploring the Role of Co-operation within Scientific Research Labs*

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This article explores how researchers in a scientific research lab co-operate with each other and value these co-operations, using a case study of a life sciences lab as an illustrative example. It explores how researchers within the lab co-operate in three main ways: through their ideas, methods and resources. A core contention of this article is that the values researchers attach to these different ways of co-operating can be assessed on two dimensions: *goals* and *ways of understanding*. The *goals* dimension moves from group goals, manifested in the vision of the lab defined by its principal investigator, to the goals of individual researchers within the lab, often achieved through work on individual projects. Individual goals were more highly valued by researchers in this case study. The *ways of understanding* dimension moves from theory-based and theory-building research activities, to craft-based activities related to the research lab's experiments. Theoretical *ways of understanding* are more highly valued by researchers in this case study. Combined, these two dimensions mean that researchers will value co-operations that support individual goals and theoretical ways of understanding more highly. Idea-based collaborations, individualistic and theoretical in nature, were the most highly valued. Collaborations based on resources, communal and craft-centered, were the least valued in this case study.

I. Introduction

Ethnographies of scientific research labs have historically been used to open the black box of scientific research by exploring the minutiae of scientific activity.

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Since the mid 1970s, the majority of such ethnographies have been dominated by a constructivist paradigm that focused on the micro conditions of truth creation and validation within the research lab (Hess 2001; Amann and Cetina 1989; Gilbert and Mulkay 1984; Latour and Woolgar 1979). Focused on the sociology of knowledge, often these studies overlooked the social organization of laboratory work (Heinze et al. 2009; Owen-Smith 2001; Barley and Bechky 1994). While collaboration and competition were often part of these studies, analysis generally focused on how they related to truth creation and validation as opposed to the day-to-day social organization of the laboratory. Other non-ethnographic studies analysed scientific co-operation, but generally focused on collaborations between scientific research labs (see, for example, Shrum 2007; Tuire 2001; Atkinson et al. 1998; Katz and Martin 1997), excluding analysis of the types of day-to-day collaborations that occur within scientific research labs. A key aspect of work within any organization is co-operation between its members (Barnard 1948). This is particularly true of scientific research within laboratories where co-operation between lab members can be seen as the "elemental form of scientific collaboration and knowledge production" (Hackett 2005, 788) as members share work, space, materials, technologies, objectives and hypotheses.

This article explores how scientists collaborate in the social organization of laboratory work. In doing so, I examine two dimensions that I believe are key to understanding how scientists co-operate within research laboratories. The first moves from communal to individual goals within the research lab. The second moves from theory-based to craft-based ways of understanding and explaining nature that are used within the research lab. In what follows, I examine how these dimensions affect in-lab co-operations through the literature and using a case study of a life sciences lab in a top ranked North American research university as an illustrative example. The lab is run by Sarah Brown,[1] the principal investigator (PI) and a university professor. The study analyses how the PI created the lab's identity and how researchers co-operate within this context. From my case study, researchers appeared to co-operate within a unique "ensemble of research technologies" that, combined, shape the group and determine how it will work within a research field. Co-operation within this ensemble appeared to occur within three broad areas: performing service functions to help maintain the lab as a facility (resources), sharing technical expertise (methods), and collaborating on the intellectual components of a researcher's project (ideas). This paper explores the relation between resources, methods, and ideas and co-operation within a research lab by mapping specific examples of resources, methods, and ideas onto the two dimensions of goals and ways of understanding. Researchers value these co-operations differently depending on how well the collaborations support group or individual goals and craft or theoretical ways of understanding.

[1] Pseudonyms are used to protect the privacy of the individuals involved in this case study.

II. Introducing the Brown Research Lab

Sarah founded her research lab in October 2005 after being recruited from a post doctoral position in San Francisco. As this is her first research lab, Sarah is slowly building it from the ground up: buying equipment, hiring employees, and finding students to supervise who would work within the lab. At the time of this study, the lab employed approximately eight people including one post doctoral researcher (Nancy), who had worked there almost from the start; a part time technologist (Alison); three PhD students (Dave, Erin and Andrew); and two Masters students (Katherine and Ray). The lab also included two part-time undergraduate students, Carrie and Sheryl.

The research of the lab is focused on synapses. Synapses act as transmitters between neurons, the core components within nervous systems. The Brown lab explores these processes using the pre-embryonic mouse and rat hippocampal neurons as their model. The hippocampus is a major component of the brain in humans and other mammals and is known to play an important role in long-term memory and spatial navigation. In Alzheimer's disease, for example, the hippocampus is one of the first regions of the brain to suffer damage. The hippocampus is also a popular model system for studying neurons and synapses because different neuronal cell types are neatly organised into layers within the hippocampus. The ultimate goal of the Brown lab research is to better understand how the brain is formed, how we learn and remember, and how neurodegenerative diseases take place.

The Brown lab work specifically explores the role that particular proteins play during cellular and molecular processes involved in the formation, stability, improvement and elimination of synapses through a variety of projects. Synapses are composed of hundreds of proteins, and different synaptic functions are achieved through the recruitment and assembly of different combinations of these proteins. To understand the role that different proteins play in synaptic functions, most Brown lab projects add or subtract specific proteins from neuron cellular cultures and analyse how this change affects synapses within the culture. Thus hippocampal cellular cultures form the basis of most of the lab's research.

Within this area of focus, each lab member works on one or more specific projects. Nancy takes live images of the movement of synaptic proteins in and out of synapses and also explores the role of specific proteins in modulating synapse formation. Using a specially developed mouse model, Dave explores whether a specific protein increases synapse loss in Alzheimer's disease. Andrew explores the role of specific membrane proteins in promoting the formation of synaptic connections. Similarly, Katherine, Erin and Ray analyse the role of specific proteins in synaptic contacts between neurons.

Because the Brown lab is still relatively small, it is made up of three laboratory benches within a larger workspace. Dave, Katherine, Andrew, Nancy, Erin and Ray are arranged in that order, each with their own "side" of a laboratory bench. On one side of the benches is a large window and on the other two rooms, one with the lab's confocal microscope and the other used as a cell culture room. Both these rooms are highly used by the lab's researchers. The cell culture room represents the initial stage in the lab's experimentation process. It is used weekly to harvest and process new cells for analysis and to subsequently culture these cells in an incubator for two to three weeks. After cells are grown and manipulated, the majority of the lab's imaging is done using its confocal in the second room. Sarah does not have her own space at the laboratory benches but has an office outside of the lab, located within an adjacent hallway. Within another hallway, the group has an additional office, which functions as a work/study space, lunch room and hangout room. The laboratory space is flanked by three other labs similarly headed by relatively new PIs. Members of all four laboratories socialize together through summer barbeques and drinks nights. However, as discussed in more detail below, members of the Brown lab appear to predominately interact with other members of the Brown lab.

Interviews and observational data on the Brown lab were collected during a three month period between September and November 2008, approximately three years after the lab was founded. I conducted participant observations of the day-to-day activities of the research lab and attended lab meetings. My session notes were recorded in a field notebook for later analysis. While not formally coded, my field notes were repeatedly read, reread, and consulted in formulating my interview questions and conducting analysis. Six semi-structured interviews were conducted with Sarah, Nancy, Dave, Andrew, Ray, and Katherine. Respondents were asked to discuss their perception of scientific culture generally as well as the scientific culture of the Brown Lab, their goals for pursuing scientific research; and how they interacted with other people within the lab. To further explore interactions within the lab, one question was included in each interview for social network analysis: "Which three people in the lab do you work with the most on your research?" Interviews were digitally recorded and transcribed then coded to build themes using Atlas.ti qualitative analysis software. Names generated through the network analysis question outlined above were graphed manually into a directed sociogram[2] (See Figure 1).

III. Ways of valuing researcher co-operation within laboratories

From the case study, coupled with a literature review, I developed two broad dimensions that were helpful in characterizing how researchers valued the ways in which they co-operated within the research lab. I refer to these dimensions as *goals* and *ways of understanding* (See Figure 2). *Goals* refer to the ultimate motives for working. Variation along this dimension ranges from group to individual goals. Barnard (1948) argues that individuals co-operate in order to

[2] See Scott (2001) for a description of how to graph a directed sociogram.

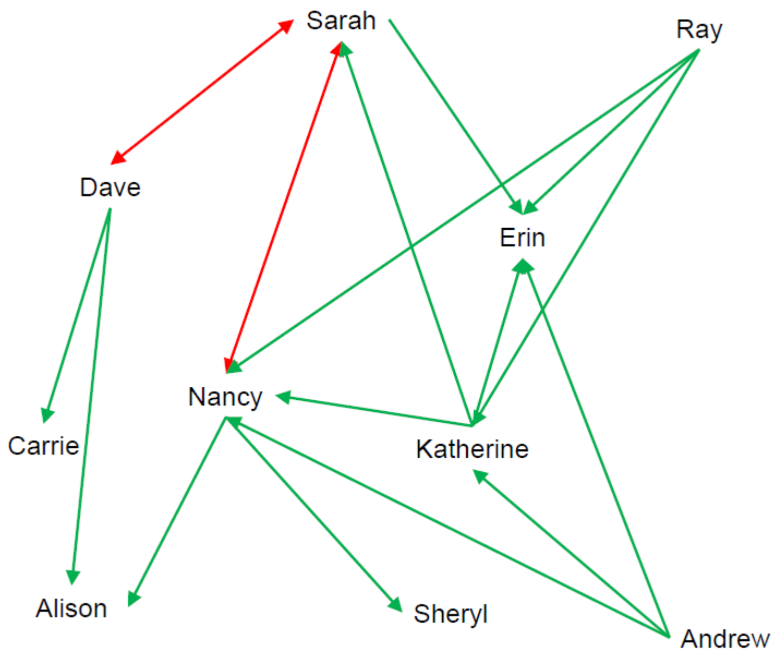

Figure 1. Lander, Bryn. Directed sociogram of Brown lab.

achieve goals that they are unable to achieve independently. This motive creates an inherent tension in co-operation: although individuals co-operate to achieve individual goals, in co-operation an individual's autonomous goals are necessarily sublimated to those of the group. Co-operation within a research lab can be used to increase the power, speed and efficiency of scientific research (Thagard 1997) but it sublimates individualism, a highly valued scientific norm (Hagstrom 1965). In the case-study setting, group goals were manifested in the person of Sarah Brown, while individual goals were held by the graduate students, post docs, and technicians working within her lab.

In her analysis of two molecular biology laboratories in Germany, Cetina (1999) argues that life science research labs exist on two different levels: the communal and the individual. The communal level is embodied by the PI who depends on the lab's success for his or her own success; the PI views the lab in a holistic fashion, shaping it according to his or her views and delegating projects to individual researchers within the lab. Hackett (2005) labels the process of creating group goals as a quest for a research lab's identity. In choosing a unique lab identity, a new PI creates a unique "ensemble of research technologies" comprised of materials, techniques, instruments, ideas and theories that will define her research lab, shape a group and determine how it will work within a research field. The connection between the PI and the lab's identity can be seen in the fact that labs are named their PI's last name (Cetina 1999). Individual research projects

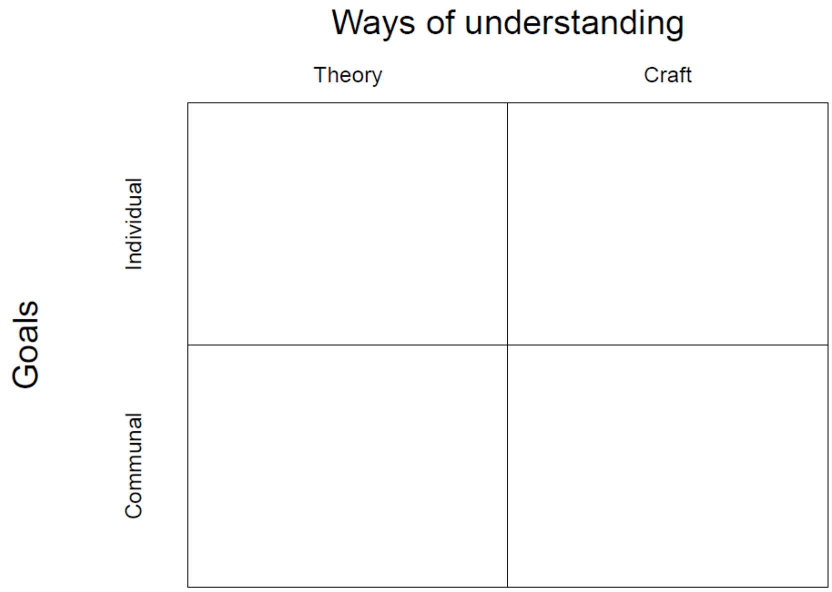

Figure 2. Lander, Bryn. Modes of researcher co-operation within a scientific research lab.

within a scientific lab will then support its ensemble of research technologies. Thus a lab's identity becomes a source of stability even as research projects or researchers working within the lab change over time (Hackett 2005; Cetina 1999; Etzkowitz 1992). The ultimate goal of a PI in choosing an identity has traditionally been to choose an ensemble of research technologies that can explore distinctive and relevant set of research questions that will yield publishable results now or in the future (Hackett 2005).

On the individual level researchers work within a PI's research lab on specific, often individual, projects with the goal of learning techniques and theories while obtaining publications. Their ultimate goal is to acquire enough experience to leave the research lab and establish an independent career (Hackett 2005; Etzkowitz 1992; Hagstrom 1965). Researchers depend on their own specific project's success for their own success; if their project fails, they will be unable to obtain the publications needed to further their own career. Labs give their researchers a high degree of autonomy to pursue their own goals (Owen-Smith 2001; Hagstrom 1965), but individual researchers still must partly subsume their own goals and contribute to the lab's common goals. Illustrating this tension between individual and communal goals, Cetina (1999) argues that while individuals work together in order to share products, information or work, it is ultimately through the autonomous and individualistic lens of their own project that they view the research lab. Similarly Owen-Smith (2001) believes that researchers act independently within the general goals of the PI, who actively tries to ensure general goal compliance.

The overarching goals of the PI and individual researcher remain the same: generating publishable results. However, different focuses or strategies may support group goals more than individual goals or vice versa. Hackett (2005, 806) argues that PIs often try to maintain a mix of projects that are certain to yield publications and others that are more speculative. While speculative projects are more risky, their payoff is often higher. For a junior scientist working within the lab and dependent on publications, they would prefer the less important projects with more certain yields (Hagstrom 1965).

Many studies of the nature of scientific understanding, truth creation, and validation focus on how new scientific theories are formed, either within the laboratory (i.e. Hess 2001; Amann and Cetina 1989; Gilbert and Mulkay 1984; Latour and Woolgar 1979) or within scientific communities (i.e. Calmers 2007; Kuhn 1970; Popper 1959). In this paper, the *ways of understanding* dimension does not focus on how scientific theories are formed but on how theories and techniques are used by researchers as they interact and try to make sense of their day-to-day work within the lab. This dimension ranges from craft- to theory-based ways of understanding. In a study of technicians working in research labs, Barley and Bechky (1994) differentiate between two ways of understanding that exist in experimental scientific research labs: contextual- (craft) and substantive- (theory) based. Similarly, Fujimura (1996) differentiates between scientific work and scientific knowledge and Etzkowitz (1992) between manual and intellectual labour. Craft-based understanding is focused on hands-on experience; the technical aspects of experimentation; and involves materials, instruments and techniques (Hackett 2005; Barley and Bechky 1994; Price 1983). Craft-based understanding views science as a manual and technical process. Theory-based understanding views science as a knowledge system focused on increasing understanding of nature through the generation of theory (Strum et al. 2007; Barley and Bechky 1994; Price 1983). Theory-based understanding involves the world of representation and the work of developing theories, writing grants and publishing.

Within a research lab, individuals work together on craft- and theory-based ways of understanding. Gaining access to technologies and mastering techniques is the basis of much of the co-operation within and between scientific research labs (Strum et al. 2007; Katz and Martin 1997). Other collaborations are based on intellectual contributions from different collaborators. What is key is the differing importance given to craft- and theory-based ways of understanding by scientists. Barley and Bechky (1994) argue that scientific society is stratified to value theory-based over craft-based ways of understanding, a division that goes back to the historic hierarchical differentiation between mental and manual work. This finding has been reinforced in other studies (see for example Hong 2008; Doing 2004). However, the two forms of understanding remain intimately linked. Because scientific theories are normally empirically-based, they must draw on craft-based knowledge to exist.

These dimension of *goals* and *ways of understanding* are explored below within the Brown lab. Particularly, I explore how the identity of the lab is shaped by Sarah and how three components of its ensemble of research technologies—resources, methods and ideas—are valued by lab members and map onto the *goals* and *ways of understanding* dimensions.

IV. The PI: an embodiment of group goals and lab identity

In his interview, Ray described the stereotypical structure and organisation of a research lab:

> [The PI] knows enough about the field to guide the philosophy of the lab...our ideas and questions. Most labs have a lab technician who implements the knowledge of the experimental techniques and a post doc who's on a slightly lower level than the PI...and they help to guide lower members of the lab like PhD students and Masters students. We have interests that pertain to the lab and the PI's philosophy so we're there to learn and have our interests nurtured...and so I think that it is kind of a hierarchical functioning, starting with the PI. The science, the questions, and the projects all stems from the PI and then disseminates throughout. Everyone has a smaller project that collectively, hopefully, works towards answering these questions of the lab.

In constructing a sociogram of the research lab (Figure 1), I had assumed that the results would follow this stereotypical model, with the most popular person for collaboration—known in social network analysis as the central node (Scott 2001)—going to Sarah, as the lab's PI and leader. However, results did not follow the hierarchy and Sarah's centrality score ranked third.

I believe that the PI was not listed more often because she holds a different sort of relationship to the lab than that of the researchers, a trend Cetina (1999) also notes. On the one hand, labs can be seen as embodiments of their PIs where, as Ray states, everything occurring within the lab stems from its PI. Through forming the lab's identity, Sarah chooses the ensemble of research technologies that are used by the lab (Hackett 2005). At the same time, few PIs have time for bench work; Sarah does not perform her own experiments but guides the experiments of others and spends most of her time in the office. As a result, the lab's PI and its researchers are, to a certain extent, not part of the same lab. Two of the students did not list Sarah as someone that they work with often. Though both enjoy a strong relationship with her, neither considered Sarah as "part" of the lab as they viewed it. This perception of PI as outsider was echoed by Sarah herself. Commenting on laboratory culture, she states: "As a PI it's...harder for me to judge it because *I'm kind of looking in from the outside*" [emphasis added].

Sarah, however, remains the person who shapes the laboratory, creating its group goals. Her time is taken up with what has been described as articulation work (Fujimura 1996). This includes tasks such as management, administration, writing grants and articles, helping students with their research, going to conferences, and networking with other research labs (Hackett 2005; Cetina 1999). She depends on her researchers' ability to generate publishable results (Hagstrom 1965). Ultimately, her academic future is tied to the number and quality of publications that her lab generates (Owen-Smith 2001). Aware of her dependence on the lab and its researchers, Sarah has fostered a collaborative identity which, she believes, will help her succeed. As she states "I haven't necessarily gone out of my way to pick really aggressive people who want it, if you know what I mean? They're just nice people." In addition to picking "nice" people, Sarah encourages her researchers to help each other on projects and work together on the lab's maintenance. This appears to be part of a larger trend where researchers working within a lab increasingly work not only with its PI but co-operate together (Etzkowitz 1992). The collaborative culture of this lab seems, in part, to embody Sarah's personality. She is a warm, friendly and helpful person and has brought many of these qualities into the culture of the lab. Researchers describe the lab's culture in much the same terms as Sarah, calling it a "nice" or "friendly" place to work. Sarah's ability to shape the lab is helped, in part, by the relative inexperience of her team, which makes them more "naive" to other management styles and more willing to accept her approach.

Several of the interviewees contrasted this congenial lab structure with a more competitive model known to them, which is based on survival of the fittest in a highly competitive environment. Sarah described it as a place where "everyone was really hungry" and "there was a lot of fighting, you know, a lot of puffing up your feathers." Many PIs adopt this alternative type of structure to try and ensure success. Cetina (1999) argues that PIs often encourage competition as a management strategy. By assigning lab members to similar and often competing projects, PIs are spreading their risks in the inherently uncertain world of scientific research. Even if one project fails another should succeed and the lab, as a unit, will generate publishable results. In adopting this strategy, PIs also create a larger divergence between the group and individual goals. In my own interviews, researchers discussed other labs in which they had worked where interactions between researchers were minimal; rather, interactions were focused on the PI. Others mentioned hearing stories of competitive labs where people would make their own research solutions and label them incorrectly to ensure that no one else borrowed their materials.

V. The researcher works towards communal good and individual gain

> *I think the supervisor kind of shapes the lab a lot...but it's basically just the ins and outs of what's done in each lab that sets the tone*

(Dave).

Researchers work at a different level than the PI (Cetina 1999). Their work must balance the group goals, defined by Sarah, with their own individual goals (Barnard 1948). In such a way each researcher helps to constitute the lab as a whole and also works autonomously within its structure (Cetina 1999). On the communal level, each researcher represents a repertoire of technical expertise that the lab draws from and is involved in service functions that help maintain the lab as a facility. Each researcher works on their individual projects, fragmenting the lab into autonomous units within a larger communal framework. As Nancy states, "everybody might feel a little bit isolated in the way that, you know, you solve your own problems." While work is individual, much of how the lab functions is collective. Researchers appeared to co-operate in three broad areas of its ensemble of research technologies: performing service functions to help maintain the lab as a facility (resources), sharing technical expertise (methods), and collaborating on the intellectual components of a researcher's project (ideas).

VI. Working together to maintain the lab

Most people in the Brown lab share the material components needed for experiments, such as cells, assays, and proteins. As Dave says "many hands make light work" and everyone pitches in to perform time-consuming and labour-intensive specialized duties such as cell culturing that provide the necessary tools for experimental work. Similarly, everyone is assigned specific chores essential for laboratory maintenance. The process through which cells are cultured and harvested, a highly time-consuming and technical process, serves as an example of how members of the lab co-operate. In any given week, work on processing the cells begins before they are even harvested. On the weekly chore list, one or two scientists are assigned the task of preparing the plates that will be used for culturing. Ray then sacrifices the rats and removes their pups. Nancy, Erin, and Alison take the pups and prepare them for dissection, dissect their brains and separate the necessary cells from other brain cells. Nancy then processes these cells for culturing. This dissection and separation process requires a high degree of manual skill that only a few members in the lab have and these tasks usually take Nancy, Erin and Alison one morning each week. After the cells have been harvested, they are put on plates that each have the name of a different researcher working in the lab written on them. These plates are placed in the incubator for two or three weeks. During that time, the cells must be kept at a consistent temperature and their medium changed every few days. Changing the medium is done by different people in the lab who are assigned the task through the lab chore list. Only at the end of this culture period are the cells ready to be used for experiments.

By working together in performing these tasks, the efficiency of the lab is increased, its day-to-day operations run more smoothly (Thagard 1997) and more junior lab members are able to learn highly technical practices (Nersessian 2006). As Dave states, "If I had to do it all on my own, there's no way I could be doing it right now…I'd have to do all of the prep work and background for cell culture which keeps an entire lab totally busy. It's really labour-intensive, the various things, and there's so much that can go wrong." While the cells are produced communally, they are ultimately used individually on different projects. After the cells are cultured, each researcher collects the plates with their names and uses them for their own experiments, transferring ownership from communal to individual.

VII. Sharing technical expertise

Researchers in the lab often talk to each other informally regarding their experiments and the techniques that they are using, brainstorming on why an experiment might be failing. A large amount of the work that occurs in labs involves discovering or perfecting experimental techniques (Price 1984). Through interviews and participant observation, I learned that conducting experiments is long, hard, and time-consuming, with most of the time spent perfecting techniques and modifying methods and protocols. Proficiency in tools and techniques therefore become an important part of scientific work and, illustrating its craft basis, people discuss whether someone has "good hands" for science. Thagard (1997) argues that most of the collaborations involving the technical aspects of science occur within employer/employee and teacher/apprentice relationships and involve the PI training other people to do the more mundane, time-consuming, and routine work, giving the PI more time for more "important" matters. Within the Brown lab researchers would consult with all other lab members on their techniques and how they might be improved. As Katherine states, "let's say…something's not working, then you generally just go around to lab members…so everyone makes it a joint effort to brainstorm why it wasn't working or gives you advice."

While techniques are performed by individual researchers on their specific projects, each researcher also represents a repertoire of technical expertise that the lab can draw from (Cetina, 1999). As such, technical expertise represents the nexus between the communal and individual role of researchers within a lab. Techniques can also unify researchers working on individual projects that are exploring different theories. As Dave stated, "a technique is pretty universal but the theory behind each project is more specific." Through co-operation, researchers working within a lab are able to learn tacit knowledge of the laboratory and problem solve, ultimately creating a community of practice within the lab (He et al. 2009; Neressian 2006; Etzkowitz 1992; Brown and Dugid 1991). However, it is unclear if explicitly collaborative labs have more technique-based collaborations than more competitive labs. Some participants cited previous lab experiences where researchers only discussed techniques with the PI, while others seemed to think wider collaborations were normal. Perhaps because this lab appears to foster co-operation, people helped each other more willingly on techniques.

VIII. Sharing ideas

While techniques were shared between projects in the Brown lab, intellectual content was particular to each project, since Sarah has assigned each person to different projects. As one researcher stated "everybody has their own project and there's not much cross-thinking, you know like brainstorming other people's projects." While researchers appear willing to consult with each other on techniques, they tend to interact only with Sarah on ideas, although intellectual collaborations within the lab are not unknown. As Katherine stated, "Sarah is definitely the only person who's more [about] ideas rather than techniques because she's the one that has the idea for the project, she's the one that decides where the project should go." Researchers also perceived intellectual collaborations as the most important types of collaborations. While projects may share methods, it is through ideas that the significance of a project becomes clear and the projects are set apart. Ideas are also most closely related to theory building, the most highly valued aspect of science. The differentiation between technical and intellectual collaboration was echoed by Sarah when she discussed collaborations between her lab and other labs. Intellectual collaborations, while rarer than technical collaborations, were more significant for her because they involve collaborators in significant dialogue, creativity, and understanding. In her mind, technical collaborations aren't 'true' collaborations.

IX. Linking types of co-operation to goals and ways of understanding

As seen from the Brown lab, group goals are tied to the identity of the research lab and manifested in its PI. However, the PI is not part of the day-to-day activities of the research lab, working instead in her office on the articulation work of the lab. All laboratory work is influenced by the ensemble of research technologies chosen by its PI. While the ensemble of research technologies is an important facet of lab identity, the role that Sarah's own personality and vision seemed to play in forming the Brown lab's identity hints that lab identity may be more than this ensemble. Figure 3 outlines the relation between lab identity and the ensemble of research technologies used by its members. Within what Owen-Smith (2001) calls the constraint of the PI's goals, researchers work towards their own goals. To fulfill their own goals researchers co-operate within the lab's ensemble of research technologies. For researchers involved in the day-to-day activities of the lab, group goals become manifested in the communal activities of the lab, such as cell preparation, while activities directly related to individual research projects are associated with individual goals. As a co-operation becomes more closely

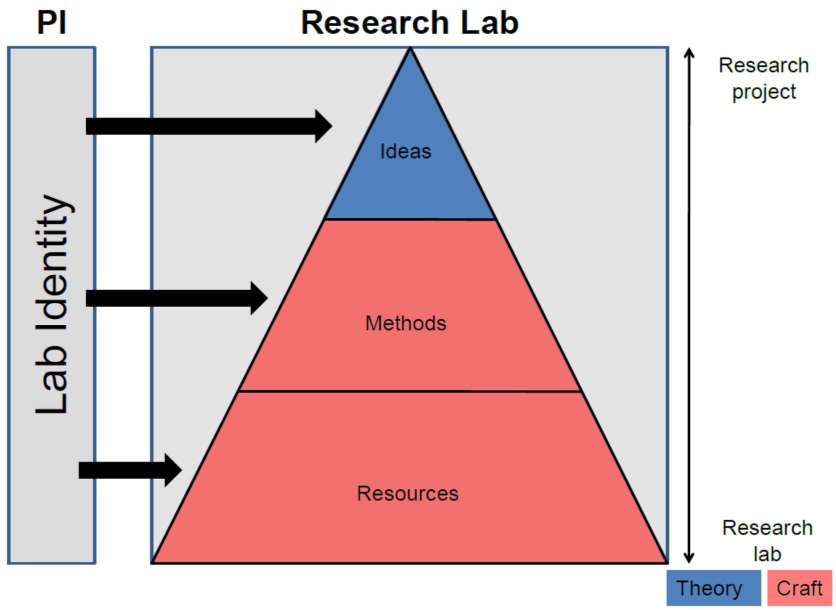

Figure 3. Lander, Bryn. Relation between lab identity and individual researcher lab activities.

associated with individual research projects and individual goals, it becomes more highly valued by individual researchers.

Figure 4 maps the three examples of co-operation between lab researchers (performing service functions, sharing technical expertise, and collaborating on the intellectual components of a project) onto the dimensions of *goals* and *ways of understanding*. Researchers appear to value types of co-operation differently because of the different values assigned to the two dimensions. For researchers working within a lab, co-operations that support their individual goals will be more valued than co-operations that support communal goals. Similarly, co-operations that support theory building will be more valued than co-operations that support craft work. Cell culturing is a craft-based group activity supporting communal goals. As such, it is the least valued form of co-operation between lab members. This work is also closely related to administrative work and may share its problems of invisibility identified by Fujimura (1996). Techniques are also craft-based but occur at the nexus of the communal and individual role of the researcher, making technical co-operations more valued than laboratory service activities. The highest valued co-operations within the research lab appeared to relate to theories used on individual projects.

Generally, when asked about how they interacted with other researchers within the lab, researchers would begin by discussing their intellectual collaborations and only when pressed would expand their discussions to interactions that involved discussing techniques or helping in lab maintenance. Intellectual collaborations were seen as "formal" collaborations. This may be

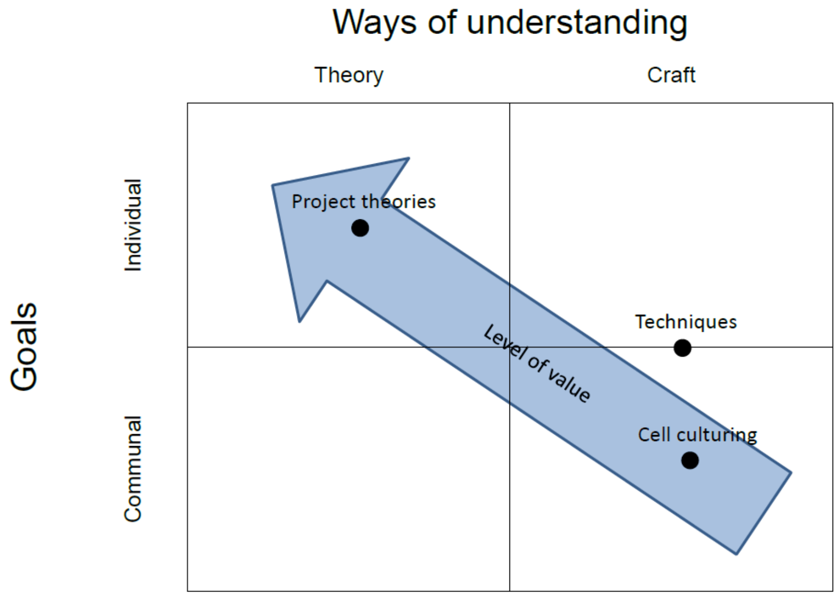

Figure 4. Lander, Bryn. How co-operation is valued by researchers within a scientific research lab.

due to the fact that intellectual content is more closely tied to a researcher's individual role as opposed to their more communal role in the lab. In addition, intellectual collaboration is often connected to co-authorship within the life sciences. Cetina (1999) argues that many of the other interactions within a lab that are more communally-based, such as lab maintenance work, won't merit authorship on a paper. Because publication can be seen as the ultimate goal of research, collaborations that lead to co-authorship would likely be valued more highly.

X. Conclusion

This article explored how researchers in a scientific lab co-operate and value these co-operations by looking at how researchers within the Brown lab interacted with each other intellectually, to share techniques, and to help run the lab. These interactions help to form the Brown lab's ensemble of research technologies, create the Brown lab's identity, shape the lab internally, and determine how the lab fits within the larger scientific community. However, there appeared to be an implicit assumption that certain types of interactions were more valued than others, moving, in descending order, from intellectual to techniques to lab maintenance. A core contention of this article is that the importance which lab members place on these interactions can be understood by mapping interactions onto the two dimensions: *goals* and *ways of understanding*. The *goals* dimension moves from individual, project-based goals, held by graduate students, post docs and technicians, to communal goals, created by and manifested in the PI. The *ways* *of understanding* dimension moves from theory-based, which views science as a knowledge system, to craft-based, which views science as a manual and technical process. As shown in Figure 4, value placed on interactions decreases for the *goals* dimension for interactions more focused on communal goals and for the *ways of understanding* dimension for interactions more focused on craft-based ways of understanding. Thus more communal craft-based types of interactions are valued less than individualistic theory-based types of interactions within the lab.

How and how much people worked together in terms of these three areas of collaboration may have a certain amount to do with how the lab is organised. For example, within the Brown lab, a perceived collaborative nature combined with diverse project allocations may lead its researchers to believe that they are not competing for the same publication, encouraging them to work together on lab maintenance and techniques, while constraining their intellectual collaborations. More competitive labs, or labs where researchers collaborate more closely on related projects, may have increased intellectual collaboration but also increased competition between their members.

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